# Accurate Sonar and LiDAR Inspections in GPS-Denied Environments

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In recent years, the development of smaller form-factors for geophysical survey equipment, as well as larger payload capabilities on small video-class ROVs has brought to the table new opportunities for imaging in flooded tubes, tunnels, and culverts. Inspection companies, government municipalities, and utility operators are all driving the increase in the demand for inspection of tubes and tunnels using small ROVs equipped with sonar and LiDAR systems capable of in-situ condition inspections that previously required drainage, or the use of divers at great risk and expense.

There are several challenges to overcome when conducting imaging and mapping operations in GPS-denied environments. The first of which is the issue of positioning underwater without GPS or traditional sonar ranging tools. Secondly, the shape and composition of the tube provides additional challenges to the standard geophysical tools that need to be addressed. The combination of the latest in INS technology, 360-degree sonars, digital cable counters, and powerful mapping software provide solutions for this that produce clear images of the condition of these tunnels and tubes. This presentation will outline the challenges that may be encountered in these types of environments as well as some solutions to overcome those challenges, and show some results of inspections in flooded tunnels, tubes, and culverts using various combinations of equipment.