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Robotic Challenges and Deployments in an Active Fume Exhaust Tunnel

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I. Abstract

The Savannah River Site (SRS) is a United States Department of Energy facility located near Aiken South Carolina. The site covers approximately 777 square kilometers and employs over ten thousand people. The SRS primary mission from the 1950s to the 1980s was to produce nuclear materials for national defense. SRS used five nuclear reactors, two chemical separations facilities, a tank farm, and support facilities for this mission. In the late 1980s, the SRS mission changed to include maintaining the Tritium stockpile and environmental management at the SRS.

The Savannah River National Laboratory (SRNL) is located at the SRS and employees about 900 people. The SRNL has provided technical support to the SRS facilities since SRS began operations in the 1950s. SRNL has engineers and scientists with chemical, ceramic, mechanical, electrical, nuclear and software backgrounds. The Research & Development Engineering (R&DE) section, within the SRNL, designs, builds, tests, and deploys custom equipment for SRS customers and other government agencies. The R&DE section frequently uses robotics and remote systems to solve problems in hazardous locations including radioactive environments.

H-Canyon is a chemical separation facility at SRS. The H-Canyon exhaust air is routed to a crossover tunnel and carried to a large sand filter through the Canyon Air Exhaust (CAEX) tunnel. The tunnel is below grade and made from reinforced concrete. H-Canyon and the CAEX tunnel were built in the 1950s and are still in operation. The CAEX tunnel is a relatively harsh environment with significant alpha contamination and beta-gamma dose rates to 10 milliSieverts. Also present are acid vapors, 11 to 13 meters/second air flow, concrete debris and several types of physical obstacles. H-Canyon is required to periodically inspect the CAEX tunnel and determine the tunnel structural integrity. Figure 1 shows a tunnel cross section which includes two metal ducts as shown.

In June of 2014, SRS deployed an Inspection Vehicle (IV) in the CAEX tunnel to inspect the walls and ceiling. The IV was a commercially available sewer inspection vehicle with a custom scissors lift and slide to maneuver the inspection camera up and over the large duct in the tunnel. Figure 2 shows the IV positioning the camera above the large duct during testing.

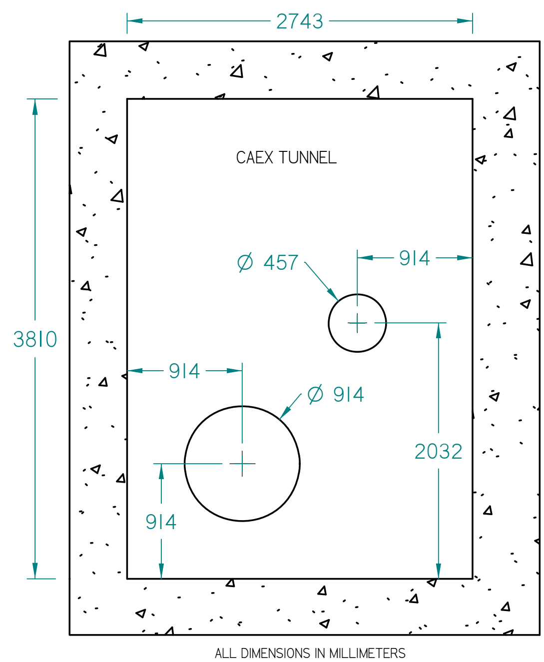

Figure 1. CAEX Tunnel cross section.

Figure 2. Inspection Vehicle during tesitng.

During the 2014 IV deployment, the IV camera extension jammed with debris causing the IV to be top heavy. As a result, the IV tipped over and came to rest on its left side with the inspection camera under the under the large duct. The IV was not able to stand itself back up, so it was left in the CAEX tunnel.

In 2015, SRS decided to procure, test, and deploy a remote vehicle to recovery the 2014 IV that tipped over in the CAEX tunnel. SRS wrote a procurement specification for a Recovery Vehicle (RV) and awarded a contract to a commercial company. The RV design was based on a standard sewer inspection vehicle with custom arms and forks added to the front. The arms and forks would be used to upright the 2014 IVSRS tested the RV in May of 2015 and made some modifications based on test results. Figure 3 shows the RV up righting a mockup IV during testing. The wood on the right represents the tunnel wall and the metal on the left represents the large duct in the tunnel.

Figure 3. Recovery Vehicle up righting the mockup Inspection Vehicle.

The team deployed the RV through the 762 millimeter diameter access port on June 9, 10, and 11, 2015 in the CAEX Tunnel. The RV struggled with some obstacles in the tunnel, including a large water puddle, a pipe hanger laying on the ground, expansion joint covers that had fallen to the ground, and the concrete debris (i.e. sand and gravel) on the floor. Figure 4 shows the large water puddle from the RV camera and the puddle was approximately 330 millimeters deep.

Figure 4. Large puddle in the CAEX tunnel.

The RV passed the obstacles and drove to the IV. The team spent approximately five hours working to upright the IV and eventually got the IV on its wheels. Figure 5 shows the IV on its wheels and note the IV camera is stuck under the large duct. The IV scissors lift and camera extension were not operating, so the team determined the IV would not be able to perform tunnel inspections in this condition. The plan was to move the IV out of the pathway and inspect the tunnel with the RV.

Figure 5. IV on its wheels.

The IV travelled approximately 3 meters and struggled to drive over a piece of sheet metal. Unfortunately the IV tipped over trying to pass this obstacle. The team decided to leave the IV in this location and inspect the tunnel with the RV.

The RV passed the IV and inspected tunnel for approximately 50 meters. The team drove the RV past the entry port for an additional 55 meters. The team removed the RV from the tunnel, decontaminated the RV, and stored it for potential reuse.

The RV deployment confirmed the IV was not in a condition to perform useful tunnel inspections and would need extensive work to get it in inspection ready condition. The RV traveled approximately 200 meters in the tunnel to capture and record video of tunnel and ceiling wall surfaces that were not blocked by existing ducts. This deployment also documented the tunnel obstacles for future inspections. Overall, the RV deployment was a success.

The presentation will summarize the 2014 IV inspection, give details about the 2015 RV deployment, and include select video clips from the IV inspection and RV deployment.