



Photo: SRNL

From left: Jay Tilden, the National Nuclear Security Administration's associate administrator and deputy undersecretary for counterterrorism and counterproliferation; Jeff Allison, deputy manager of the NNSA's Savannah River Field Office; and Bill Swift, SRNL Mark-18A program manager, tour the mock-up of the Mark-18A facility where SRNL staff will train to use equipment to eventually extract valuable Pu-244 from existing waste material at the site.

# SRNL robotics and remote systems for nuclear applications

*Savannah River National Laboratory's robotics and remote systems are used in the lab, beneath the earth, and in the sky.*

Since 1953, Savannah River National Laboratory has designed, fabricated, and deployed robotic and remote systems to perform diverse tasks in environments that are hazardous or inaccessible to workers, including nuclear environments. Three recent examples are described below.

**Recovery of plutonium-244.** SRNL is conducting a campaign to recover the rare and valuable plutonium-244 that is contained in reactor target rods stored at the Savannah River Site. SRNL has designed or adapted equipment and processes to safely transport and remotely unpack, size-reduce, and dissolve the target rods

and to separate, package, and store the nuclear material.

Pu-244 is a highly valuable nuclear material used in applications such as nuclear forensics and medical research, and it is extremely rare. The material is thought to exist in nature in almost undetectable quantities as a relic of the violent galactic activity that contributed to the formation of our solar system over 4.6 billion years ago. It has a half-life of 81 million years.

The only Pu-244 known to have originated through human activity, other than that dispersed from nuclear weapon explosions, was produced in the high flux reactors, now decommissioned, that oper-

ated at SRS during the Cold War. Only 20 grams of this material exists in only one place: the Mark-18A "targets," or nuclear material assemblies, stored at SRS. In 2011, the Department of Energy asked SRNL to preserve the valuable, rare, and irreplaceable Pu-244. Recovering the materials from the Mark-18A targets, however, is no easy task. They are mixed together in each assembly and must be chemically separated before they can be used.

H Canyon at SRS is the only operating production-scale, radiologically shielded chemical separations facility in the United States. However, the facility is designed to handle large quantities of nuclear ma-



Photo: SRNL

A robotic arm adapted by SRNL for the Pu-244 recovery campaign with associated equipment in the mock-up facility at SRS.

materials, so recovering the relatively small quantity of Mark-18A target material there is impractical.

SRNL decided to process the targets in a special facility at the laboratory that contains cells providing the shielding and confinement necessary to work with radioactive materials. A specially trained operator stands safely outside each cell to perform tasks remotely inside the shielded workspace.

The laboratory has designed equipment to enable processing of the 14-foot-long Mark-18A target bundles inside the 6-foot-by-6-foot workspaces of the SRNL shielded cells. One such piece of equipment is a shielded cask that will safely package, transport, and deliver a target from wet storage in L-Basin at SRS into a shielded cell. Another is a cell insert that will seal the open cell, align the target as it is inserted into the cell from the transport cask so a saw can slice pieces to be processed in the limited workspace of the cell, and provide shielding during operations in the cell.

SRNL also has adapted a commercial robot typically used in the automotive industry to remotely remove the radioactive material from the shielded workspace and place it in a shielded container for trans-

port. SRNL has outfitted the robot with machine vision to enable remote operation and with several grippers for the various tasks it must perform.

In August 2019, SRNL hosted a ribbon-cutting ceremony for the Mark-18A mock-up facility in which equipment testing and operator training will be conducted to prepare for an expeditious start of Pu-244 recovery operations. The actual recovery operations are scheduled to begin in 2021.

*Structural integrity inspection of subterranean exhaust tunnel.* Incorporating lessons learned from previous years' inspections, the SRNL-designed tethered vehicles deployed in March 2019 were able to more thoroughly examine the structural integrity of the over 1,000-foot-long H Canyon exhaust tunnel at SRS, parts of which are over 60 years old.

The H Canyon exhaust tunnel contains and directs the exhaust air flow from the canyon process areas to the sand filter system, which removes radionuclide particles prior to the release of the air to the environment. Initially, technology for inspecting the tunnel consisted of a camera attached to a pole manually inserted through ports into the tunnel interior. That method was not ideal in the harsh conditions of the

tunnel, which include radiological and chemical hazards and physical impediments. Over the years, SRNL methods for inspecting the H Canyon exhaust tunnel have evolved from the very basic to the sophisticated: the "crawler."

The first tunnel crawler was deployed in 2003. Since then, SRNL has developed and adapted crawlers for the particular conditions of the air tunnel, making improvements in the design of each new crawler based on experiences with previous tunnel crawlers. Earlier crawlers had limitations in performing full inspections, such as the inability to traverse or view some tunnel areas and poor camera image resolution.

SRNL developed the latest crawler in collaboration with multiple organizations in H Canyon. Conceptual design of the crawler began in March 2018, and the crawler was deployed in March 2019. The crawler design demonstrated increased terrain handling capability, greater range of camera motion to enable the inspection of previously inaccessible areas, and increased resolution of the captured imagery.

This year's inspection of the H Canyon exhaust tunnel also was the first time that two crawlers were deployed simultaneous-

ly in the tunnel, allowing for a more thorough, end-to-end tunnel inspection.

*Remote aerial surveillance and remediation of entombed reactor buildings.* In 2018, SRNL began deploying a more efficient and less expensive method to locate and eliminate potentially damaging vegetative growth on the entombed nuclear production reactor buildings at SRS: unmanned aerial vehicles (UAV).

The successful entombments completed in 2011 of the P and R nuclear production reactor facilities at SRS were the first in the DOE complex and the largest nuclear facility *in situ* decommissioning achievements in the world. A long-term maintenance plan ensures the integrity of the entombed structures over time.

Initially, a helicopter crew and a site photographer were used to determine the amount of growth and to spray the plants. At the request of the SRS management and operating contractor, Savannah River Nuclear Solutions, in February 2018, SRNL remotely captured high-resolution, close-up video of the roof tops of the entombed P Reactor building using a commercial UAV, providing a more thorough inspection than was possible by the helicopter crew, at half the cost. SRNL was also asked to perform UAV surveillance of the entombed R Reactor.

SRNL then partnered with Virginia Tech to build a special hexacopter equipped with a targeted herbicide spray apparatus to treat unwanted vegetation on the rooftops of the reactors. The SRS unmanned aerial systems team, which included SRNL, SRNS Area Completion Projects, and DOE-Savannah River Operations Office personnel, received the 2019 DOE Sustainability Award for the innovative use of drones for post-closure waste site maintenance and surveillance. **NW**



Photo: SRNL

SRNL's tethered robotic crawler inspects the H Canyon exhaust tunnel at SRS in 2019.



Photo: SRNL

An unmanned aerial vehicle view of SRNL operators from above an entombed reactor building at SRS.



Photo: SRNL

Troy Lorier (left), SRNL's unmanned aerial systems (UAS) operations manager and aviation safety officer, accepts the 2019 DOE Sustainability Award on behalf of the SRS UAS team.



Photo: SRNL

Potentially intrusive vegetative growth on an entombed nuclear reactor building.