Robotics in Hazardous Environments - Real Deployments by the Savannah River National Laboratory

Steven Tibrea,[a] Thomas Nance[b] and Eric Kriikku[c]

[a] *Savannah River National Lab, SRS Building 730-A, Aiken SC, USA. Fax: 803-725-1744; Tel: 803-725-3978; E-mail: steven.tibrea@srnl.doe.gov*
[b] *Savannah River National Lab, SRS Building 781-A, Aiken SC, USA. Fax: 803-725-4873; Tel: 803-725-5842; E-mail: thomas.nance@srnl.doe.gov*
[c] *Savannah River National Lab, SRS Building 773-A, Aiken SC, USA. Fax: 803-725-7369; Tel: 803-725-1433; E-mail: eric.kriikku@srnl.doe.gov*

The Research & Development Engineering (R&DE) section in the Savannah River National Laboratory (SRNL) engineers, integrates, tests, and supports deployment of custom robotics, systems, and tools for use in radioactive, hazardous, or inaccessible environments. Mechanical and electrical engineers, computer control professionals, specialists, machinists, welders, electricians, and mechanics adapt and integrate commercially available technology with in-house designs, to meet the needs of Savannah River Site (SRS), Department of Energy (DOE), and other governmental agency customers. This paper discusses five R&DE robotic and remote system projects.

Introduction

The SRS is a Department of Energy (DOE) facility located near Aiken South Carolina. The site covers approximately 310 square miles 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 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 R&DE section, within the SRNL, designs, builds, tests, and deploys custom equipment for SRS customers, other government agencies, and commercial companies. The R&DE section frequently uses robotics and remote systems to solve problems in hazardous locations including radioactive environments.

The following sections describe five example of R&DE robotic and remote system projects.

Large Diameter Pipe Crawler

The SRNL R&DE section developed a unique large diameter pipe crawler that delivers a plasma arc cutting torch to remote hazardous locations. R&DE successfully removed a section of the ventilation duct using the pipe crawler in the SRS F Canyon separation facility.

Problem

The SRS F Canyon facility separates special nuclear materials from reactor fuel rods in a remote chemical process. F Canyon reconfigured process equipment and this created new air flow requirements. In order to alter the airflow properly, a section of duct work needed to be removed from a highly radioactive area. Radiation levels, high air flow, and physical restraints precluded performing this task manually. The ventilation duct contained horizontal and vertical sections as well as several 90 degree turns between the access point to the desired cutting point. The duct was 36 inches in diameter, 1/4 inch thick, stainless steel pipe and had to be cut from the inside.

Solution

R&DE developed a large pneumatically-powered inch worm type pipe crawler for this application. The crawler used a custom plasma arc torch to cut the ventilation duct 230-feet from the installation point. Cameras and lights were used to navigate the crawler in the duct and monitor cutting operations. Figure 1 shows the crawler cutting a 36 inch diameter duct during testing.

Fig.1 Large Diameter Pipe Crawler

R&DE personnel worked with F Canyon personnel to successfully deploy the crawler, remove a section of ventilation duct, and remove the crawler from the duct.

DWPF Melt Cell Vehicle

The SRNL R&DE section developed a custom remote vehicle for cleaning the DWPF Melt Cell floor. The vehicle has one gripper that is used to hold simple tools like a broom and a dust pan. R&DE successfully cleaned the DWPF Melt Cell with

this remote vehicle.

Problem

The DWPF at SRS uses a large melter to mix radioactive liquid waste with molten glass. The molten glass is poured into a large stainless steel bottle and allowed to solidify. The stainless steel bottles are welded shut and the radioactive material is permanently encapsulated in glass. During melter operations, the molten glass sometimes gets clogged in the melter pour spot. DWPF personnel use a large robotic arm to remove the clog and the glass fragments fall to the Melt Cell floor.

When Melter #1 reached the end of its design life, DWPF entered into an outage to replace the melter. During this outage, DWPF asked R&DE section to design, build, and deploy a vehicle that would clean the radioactive glass from the Melt Cell floor in a three week period.

Solution

R&DE designed a tethered vehicle with several custom tools for this application, see figure 2. The vehicle uses Inuktun (TM) tracks to move, a single actuator to raise the arm, electric gripper to grab tools, and cameras to help navigate. The large lifting bail allows the DWPF crane to move the vehicle into the Melt Cell.

Fig. 2 DWPF Melt Cell Vehicle

Once in the Melt Cell, the vehicle successfully cleaned the Melt Cell floor. Figure 3 shows a top view of the vehicle holding a broom tool and the black debris are pieces of glass on the floor.

R&DE worked with DWPF personnel to successfully clean the Melt Cell floor with the vehicle in the required time frame.

Cesium Source Recovery

The SRNL R&DE section developed a unique system for retrieving a Cesium source in the SRS Instrument Calibration Facility. The system used a commercial vehicle and several custom tools to remotely dismantle the source handling equipment and retrieve the source. R&DE successfully retrieved the Cesium source in the Instrument Calibration Facility.

Problem

The SRS Instrument Calibration Facility uses a Cesium source to calibrate instruments. The radioactive source is normally stored in a shielded room under the calibration room. When needed, the source is pushed with air through a pipe into the calibration room. When the air pressure is removed, the source drops back into the shielded room. On one occasion, the source got jammed in the calibration room. The source gives off so much radiation, 6,000 Rad/hour at 6", that people couldn't enter the calibration room to dislodge it.

Fig. 3.Vehicle in DWPF Meltcell

Solution

R&DE designed several tools and cameras to mount on an existing remote vehicle for this application. The tools and cameras allowed the operator to remotely unscrew a set screw, remove the pipe end stop, place a retrieval tool over the end of the pipe to catch the source, and place the source in a shielded container. Figure 4 shows the vehicle with the cameras, lights, and the custom tooling.

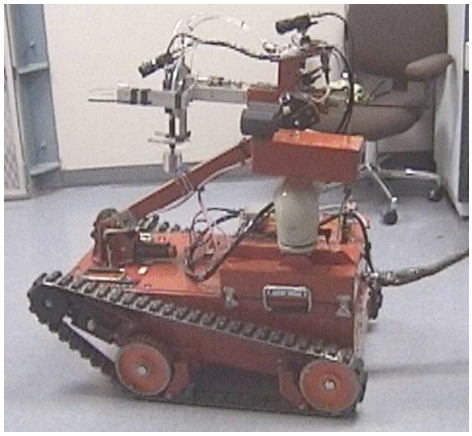

Fig. 4. Cesium Source Recovery Vehicle

R&DE worked with the Instrument Calibration Facility personnel to successfully remove the source from the jammed position.

World Trade Center Support

The SRNL R&DE section had a contract with the National Institute of Justice (NIJ) to provide technical support to the Urban Search and Rescue (US&R) teams and other law enforcement agencies. When the World Trade Center was attacked, NIJ requested the SRNL R&DE section to provide on

site technical support during the search and rescue operations.

Problem

The US&R teams were working in new conditions and needed new camera systems developed to meet the new requirements of this rescue effort.

Solution

R&DE sent several people, tools, and equipment to New York City on 9/15. R&DE engineers set up a workshop near the scene and provided equipment to US&R teams, Fire Department of New York (FDNY), and National Traffic Safety Board (NTSB). This equipment included; infrared cameras, pole cameras, drop cameras, dog cameras, and surveillance cameras. All these systems were used to search the rubble pile for survivors and evidence. Figure 5 shows a view from a surveillance camera provided by R&DE.

Fig. 5 Camera View of Rubble Pile

R&DE personnel worked with US&R, FDNY, and NTSB teams to develop and deploy several systems during the days following the 9/11 attack.

Tank 18 Sample Crawler

The SRNL R&DE section developed and deployed the first robot into a High Level Waste (HLW) tank at SRS. This robot delivered multiple unique waste samplers to remote hazardous locations within the million-gallon waste tank. R&DE successfully obtained multiple samples from within Tank 18 using the sample crawler.

Problem

The SRS Tank 18 contained thousands of gallons of HLW deterring a human operator from accessing the interior of the tank to obtain samples due to the high radiation field inside of the tank. Sampling of waste is necessary for processing and is obtained by using available access risers on top of the tanks and sampling beneath the risers. This method provides samples for chemical and radiological analysis while also minimizing the exposure of operators to the radiological contents of the waste tanks. Tank 18 also had anomalous material, or material not demonstrating the same mechanical characteristics as the waste observed on the majority of the tank floor. This anomalous material in Tank 18 also needed to be sampled and was located out-from-under the access riser in two piles approximately 40 feet from the two foot diameter access riser. This material had to be sampled to provide input for processing.

Solution

R&DE developed a sample crawler with two on-board samplers, two drive tracks and cameras. Figure 7 shows the sample crawler before it entered Tank 18.

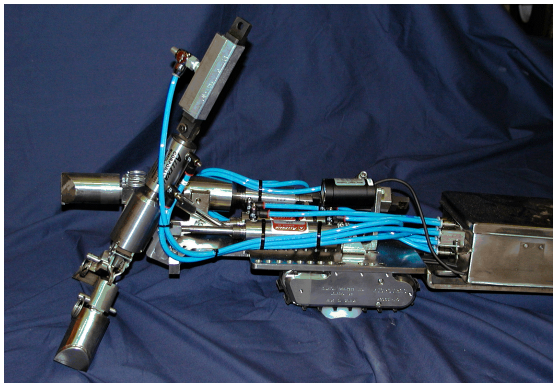

Fig. 7 Tank 18 Crawler

The electrical tracks were controlled by R&DE from outside of the tank to navigate through the sludge-like waste on the tank floor. The two on-board samplers were designed to pneumatically obtain snap samples of the targeted sludge waste piles. The samplers had specially designed jaws which were designed to be removed after sampling and replaced for additional samples to be obtained by the sample crawler. The sampler was deployed, traversed the tank floor, and snapped samples with each sampler. The sampler travelled back to below the riser, was retrieved up through the riser, where the sample jaws were removed and another set of jaws mounted for a second sampling. The sample crawler performed two sample runs to obtain data from both waste piles. R&DE worked with F Tank Farm personnel to make this deployment a success. Figure 8 shows the crawler sampling the Tank 18 south mound.

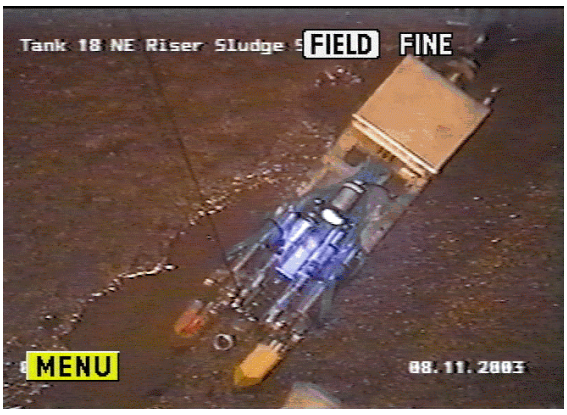

Fig. 8 Crawler in Tank 18

Conclusions

The SRNL R&DE section mission is to design, develop, fabricate, test, assist in the installation, and field operation of unique equipment systems for use in radioactive, hazardous, or

inaccessible environments. Employees from mechanical, electrical, and computer disciplines, along with machinists, welders, electricians, and mechanics adapt and integrate commercially available components with in-house designs to service SRS, other governmental agencies, and commercial customers.

References

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