Helping HANDSS for Sorting Waste

The HANDSS system is a modular technology that automates opening waste containers, sorting their contents, reducing waste volume, and repackaging waste materials for disposal.

By Reuel Smith

The Idaho National Engineering and Environmental Laboratory (INEEL) is demonstrating a new technology that automates radioactive and hazardous waste sorting. This technology advances the U.S. Department of Energy's environmental cleanup mission by enabling the Savannah River Site (SRS) in South Carolina to safely prepare waste for shipment to a geologic repository.

Better known as "HANDSS-55," the handling and segregating system, designed for use with 55-gallon drums, is a modular technology that automates opening waste containers, sorting their contents, reducing waste volume, and repackaging waste materials for disposal.

Historical Perspective

In the 1940s, with the race to build the world's first nuclear weapon, radioactive waste began to accumulate at several government sites. As the Cold War escalated over four decades, by-product wastes within the nuclear weapons complex were stored where they were produced or were shipped elsewhere.

Much of the waste generated is familiar—rags, clothing, tools, and plastic containers. Some items were contaminated with transuranic radioactive elements, mostly plutonium, and hazardous materials such as cleaning solvents. For years, a national effort has been under way to permanently dispose of this transuranic waste at the Waste Isolation Pilot Plant (WIPP) geologic repository in New Mexico.

Meeting this goal is more or less straightforward in some cases—loading waste drums and boxes into specially designed shipping containers and trucking them to the disposal facility. However, because the WIPP waste acceptance criteria are very stringent, such objects as aerosol cans and other containers holding liquids must be sorted and removed before the waste can be repackaged and shipped.

Today, a worker physically sorting wastes would wear personal protective equipment and work through a glovebox to guard against exposure to contamination. This manual approach can put workers and the environment at risk. To reduce risk, the DOE encourages the development of innovative technology to safely automate the handling of hazardous materials.

Advancing Remote Technology

HANDSS-55 technology is needed to safely process SRS's high-activity transuranic waste stored in 55-gal drums. These containerized wastes must be screened for items that don't meet disposal requirements. And, workers screening the wastes need to be protected from potential exposure.

The INEEL-developed sorting module is the key element of this waste handling system. The capability to sort highly radioactive mixed wastes automatically and remotely eliminates the need for workers to use hand-operated remote manipulators.

"HANDSS-55 provides an opportunity to demonstrate new technologies with the prospect to reduce worker dose, improve production rates, and potentially be used throughout the DOE complex," says Colin Austin, head of projects for BNFL/Savannah River Corp.'s Solid Waste Division.

"Two new core technologies involving 3-D imaging and bagless transfer capabilities have been incorporated into HANDSS-55. These innovations appear to have significant potential and could be part of the solution for many wastes that need to be handled remotely," notes Austin.

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Teamwork

The DOE's Environmental Management Office of Science and Technology (OST) provided funding for this project because they saw an opportunity to develop a system to solve SRS waste-sorting problems and potentially help other sites, as well.

Project managers from the OST direct the design and development of the HANDSS-55 modules. "They chose the INEEL to work with Savannah River Site's Solid Waste Division because of INEEL's ability to engineer sophisticated systems and equipment to safely handle transuranic waste," says Christy Frazee, an INEEL representative for HANDSS-55.

The INEEL coordinates its HANDSS-55 development effort with and is supported by the Savannah River Technology Center (SRTC), Pacific Northwest National Laboratory, the Western Environmental Technology Office, the University of New Mexico, the University of South Carolina, and the International Union of Operating Engineers.

"Because of the overlapping nature of the operating systems built into the HANDSS-55 technology, it literally takes scores of software and mechanical engineers to keep the development of this system on the cutting edge of integrated automation," says Marcela Stacey, INEEL project manager and coordinator.

Following separate demonstrations of individual system modules, the entire HANDSS-55 system will be tested through the DOE's National Energy Technology Laboratory at its Western Environmental Technology Office in Butte, Mont. When approved and ready, the modules will be shipped to the SRS for use by 2005.

Shared Development Costs

"The INEEL formed additional partnerships with private industries to create the technology needed to meet Savannah River Site requirements," says Stacey. These partnerships involved VX Technologies Inc. of Calgary, Alberta; Barrett Technologies of Boston; and Serapid of Sterling Heights, Mich.

Developing and adapting VX Technologies' StarCam measurement system to meet the INEEL's design requirements for the project was initially estimated to cost more than half a million dollars. After many discussions, VX Technologies agreed to share development costs. As a result of this donation, the DOE's financial commitment was reduced to less than half the total cost.

Similar negotiations with Barrett Technologies to develop an industrial-grade, three-fingered grasper resulted in an agreement in which Barrett contributed engineering dollars equivalent to the funds provided by the DOE.

Modular Design

HANDSS-55 consists of four separate modules. They are system integration and control, waste sorting, transuranic waste repackaging, and process waste reduction modules. These modules can be used individually or together as a complete handling and segregating system (see Fig. 1).

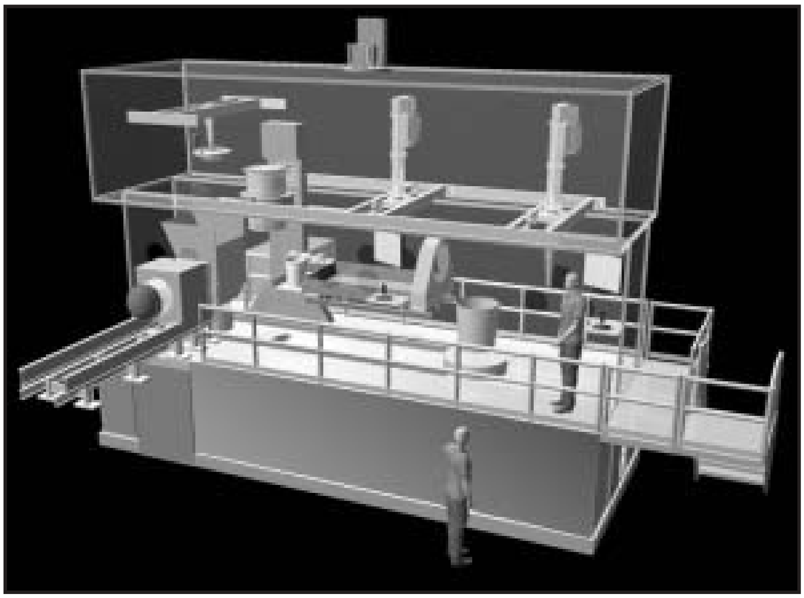

Fig. 1. An illustration of HANDSS-55 modular components that receive and open 55-gal drums, empty contents onto a sorting table, help an operator sort and remove noncompliant items, and repackage the wastes for shipment.

Operating the system involves any one of three control systems—touch screens, voice activation, and joy-stick maneuvering. Commands given by any of these methods direct a robotic arm equipped with specialized tools to identify, pick up, and dispose of wastes. These integrated features are unique because they emulate human functions to see, reason, integrate random information, and take physical action.

Watching INEEL software engineer Miles Walton at the controls verifies the ease and flexibility of operating the system from the control module. (See Fig. 2.) Walton explains the sophistication of HANDSS-55's operating software this way: "The imagery of the technology used in the Buck Rogers and Star Wars movies is just that—imagery. The HANDSS-55 imaging system is the real thing at the cutting edge of visual technology. It's remarkable."

Fig. 2. Miles Walton demonstrates the use of touch-screen and voice-activated controls that initiate HANDSS-55's automated and remote robotic functions.

System Integration and Control Module

The system integration and control module can be operated from either a central control system or an individual control module. The touch-screen menu-based control system provides a user-friendly environment that is simple and powerful for the operator. The control system format allows operator flexibility to use the equipment in either a fully automated or manual control mode. In addition, the system integration and control module allows all modules to function as one seamless system.

Waste-Sorting Module

The waste-sorting module is composed of a remote drum and liner opener and the waste-sorting station. The remote drum and liner opener component is an au-

Fig. 3. The gripper, located at the end of the Z-Mast, positions a bag of simulated wastes as pneumatic scissors get ready to cut the bottom of the bag, allowing the contents to drop onto the sorting table.

Fig. 4. To provide a three-dimensional profile of table contents, waste items on the sorting table are measured using stereo cameras and projected arrays of light from the StarCam imaging system.

tomated system that opens 55-gal metal drums and accompanying polyethylene liners and places the contents of the drums on the waste-sorting table. The waste-sorting station receives the waste and accommodates the visual identification to see if the items comply with WIPP's waste acceptance criteria (see Fig. 3).

The system utilizes the advanced StarCam three-dimensional imaging system jointly developed by the INEEL and VX Technologies to identify the boundaries of objects. It develops a picture, or contour map, each time waste items are placed on the table to define their size, shape, and relationship to other objects (see Figs. 4 and 5).

Unlike preprogrammed robotic systems that perform repetitive functions in structured environments, this system is designed to react to different situations and conditions each time a drum is opened.

The imaging technology used to identify unknown objects is unique and differs from most imaging systems designed to recognize objects using a reference library. In the world of waste sorting, the system must be capable of identifying an object well enough to quickly pick it up—even though there is no reference to compare it with.

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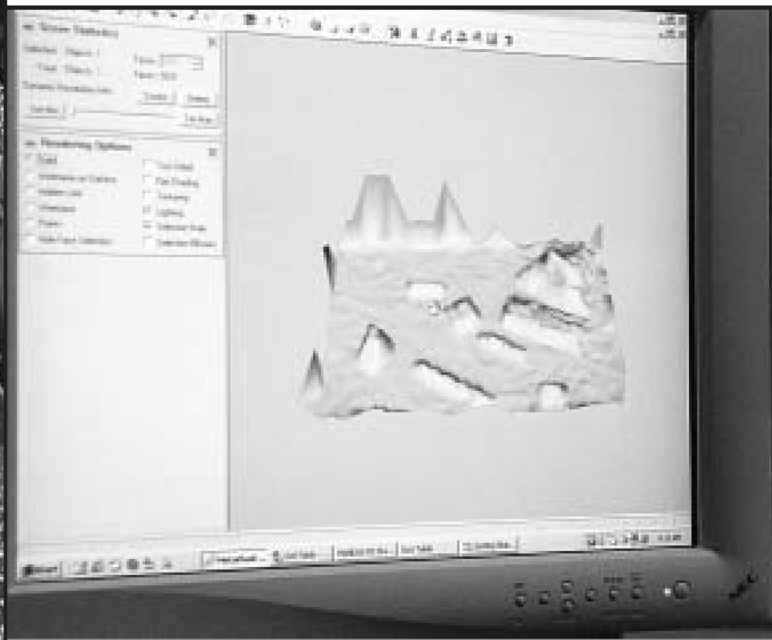

Fig. 5. The measurements taken by the StarCam imaging system, along with computer screen images of the wastes, are sent to a remote computer where an operator uses the information to remove noncompliant items.

After the operator identifies an object to be removed and activates the system, INEEL-developed software algorithms allow the system to decide how to remove the waste item by orienting one of its exchangeable tools on its robotic arm and then moving vertically or horizontally. The robotic system also decides how tightly to grip objects to accommodate their weight, size, and outer surface strength (see Fig. 6).

Each item is classified as acceptable or not acceptable for a specific waste stream. Those items identified as not acceptable are removed using remote automation. The noncompliant items removed from the waste stream are then tracked in a database and set aside for final disposition. The remaining waste is classified and weighed for disposal records.

Transuranic Waste Repackaging Module

The transuranic waste repackaging module uses a bagless transfer port designed by the SRTC to eliminate the ring of surface contamination common to other methods of waste item transfer. The bagless transfer moves waste from the sorting table's contaminated environment into a new 55-gal drum or other acceptable shipping container. Radioactive materials may be bagged or placed di-

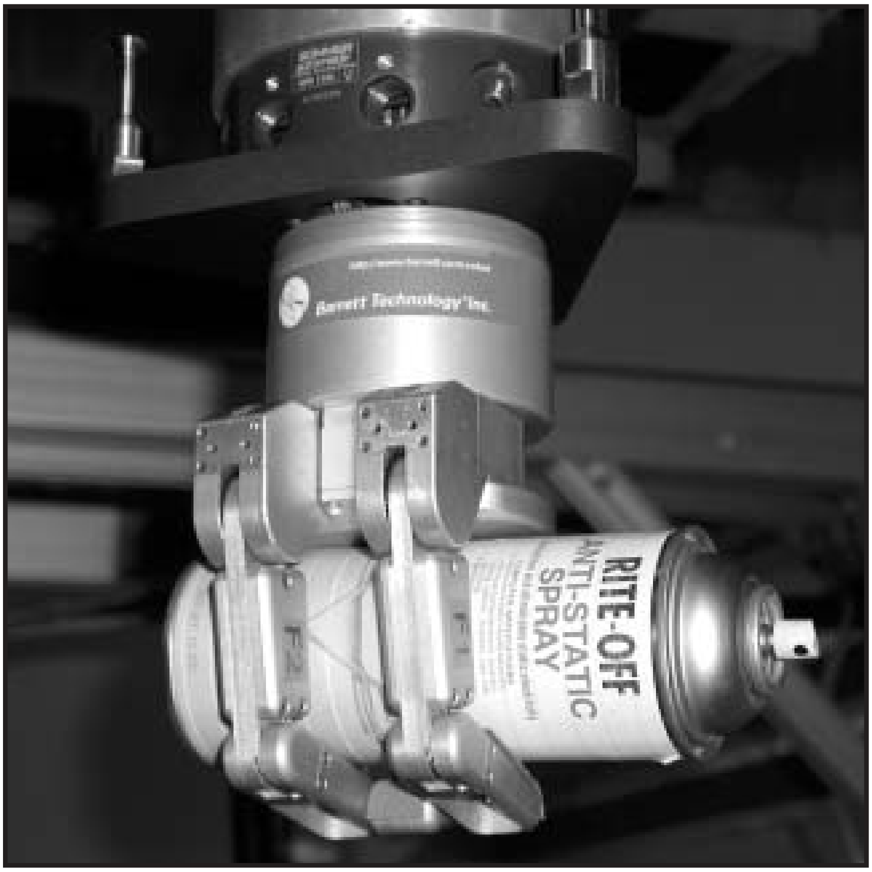

Fig. 6. A closeup of the three-fingered gripper used to lift waste bags out of drums and remove waste items from the sorting table.

rectly in the container. The automation of the loading process reduces labor, costs, and worker exposure.

Process Waste Reduction Module

The process waste reduction module shreds the original 55-gal drum and liner to reduce waste volume and make disposal more efficient. The process also results in reduced shipping and storage costs. The processed drums and liners will be disposed of as low-level waste in separate containers.

MAJOR SYSTEM COMPONENTS

Where possible, standardized components were used in the system to simplify parts inventory and to capitalize on existing designs and experience without significantly compromising performance or reliability. Following are notable features:

- *XY Deployment System*: The overhead rail system that supports the Z-Mast robotic arm movements in sideways and forward-and-backward directions is unique in that it has very few serviceable components. Extending the rails on which it glides increases the range of motion along the X-axis to any length. The Y-axis is limited to the open distance between the rails. The system's stainless steel construction makes it impervious to corrosive atmospheres and applicable to many industrial settings.
- *Telescoping/Rotating Z-Mast*: The robotic arm that telescopes up and down has the added feature of being able to push objects on the sorting table, if necessary. This robotic arm uses a special type of chain system manufactured by Serapid that allows the mast to push as well as pull.

The end of the Z-Mast contains a "smart module" or distributive control system, which simplifies cabling and provides flexibility for interfacing future end-effectors or detachable tools. The smart module controls the end-effectors that mount on and disconnect from the Z-Mast. The sorting station control system communicates with the smart module through an Ethernet connection specifically designed for glovebox/hot cell maintenance.

- *The Gloveport and Safety Interlock System*: A device designed to be compatible with standard industry gloveports, it protects personnel and robotic equipment. The interlock physically blocks the gloved operator's hands from entering the glovebox space and provides an electronic indication that the gloveport is closed. Motion systems are functional until a gloveport interlock is breached, at which time the robotic system motion in the vicinity of that gloveport is frozen until the interlock is restored.
- *StarCam Imaging System for 3-D Profiling:* This uses automation to identify the boundaries of unknown objects and coordinates the robotic system to pick up the objects. This unique system works without a "reference library" of recognized objects.
- *End-effectors or Detachable Tools*: The three-fingered grasper was developed to allow the flexibility, geometry, strength, and reliability necessary for waste sorting. Currently no suitable industrial grasper exists for these conditions. Other quick-couple tools are the electromagnetic/suction cup, laser alignment tool, and manual sort bin end-effectors (see Fig. 7).
- *Waste-Sorting Table*: This stainless steel table has the built-in capability to tilt and vibrate waste into approved waste containers.

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Beneficial Applications

"Every national lab within the DOE complex that has to repackage waste is a potential user of this technology," says Rod Shurtliff, INEEL advisory engineer. "The three-fingered grasper, the StarCam measurement/imaging system, the XY deployment system, the telescoping Z-mast, and the gloveport and safety interlock systems are all novel in their design and application."

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These innovations created by the INEEL and its partners have other humanitarian applications, too. For example, says Shurtliff, "The StarCam imaging hardware technology is currently in use at the Princess Margaret Hospital under the auspices of the University Health Network, where it is used to automatically correlate a CAT scan image with a body profile. This allows medical technicians to accurately position a cancer patient during radiotherapy. The StarCam is the only technology available that has sufficient response time and resolution to perform the task."

The StarCam imaging system is also slated to map and monitor body profiles in the detection of adolescent scoliosis (an abnormal sideways shift of the spine) because of its quick and benign measurement system. Prior technologies using X rays and laser scanning were found to be detrimental to a patient's health and difficult to use on children who have a hard time remaining still.

A need for HANDSS-55 technology has also been expressed in the area of rescue operations. "Following the September 11 tragedy, it was extremely dangerous for rescue workers operating in the rubble to attempt to find survivors and, later on, bodies of victims. If the tragedy had involved radiation hazards, rescue personnel would not have been able to safely enter the area," says Shurtliff.

"Someday, the capabilities engineered for the HANDSS-55 technology may also be used to aid rescue workers in distinguishing and gently—yet firmly—retrieving construction debris or injured people involved in natural and human-caused disasters."

Plans also are under way to involve National Aeronautics and Space Administration and industry partners in a business venture to move from operator-assisted sorting to intelligent sorting with little operator interaction. This could open new technology advancements that would be useful in a variety of applications. ■

Reuel Smith is communications program liaison in the Environmental Technology, Engineering, and Life Sciences Division at the INEEL.

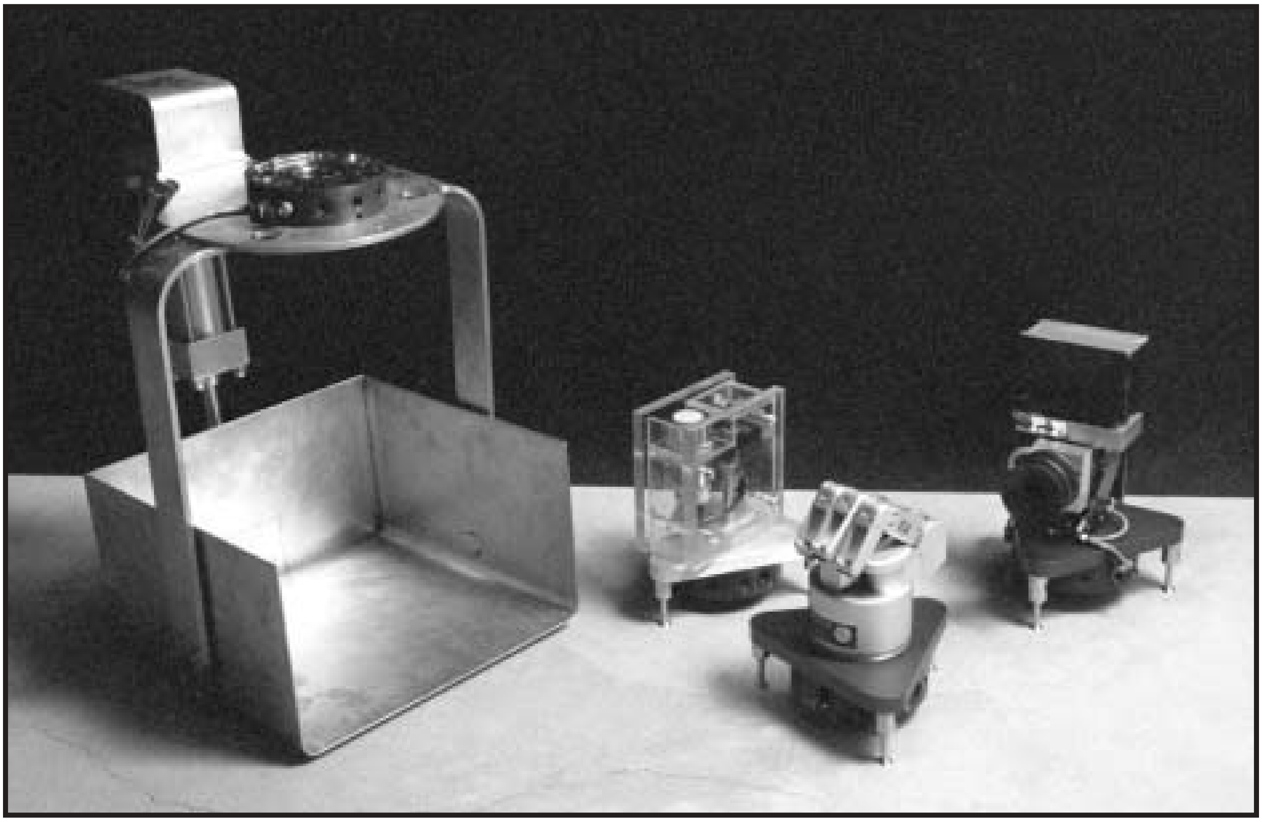

Fig. 7. The detachable end-effectors that quick-couple to the robotic arm are (from left to right) the manual sort bin, laser alignment tool, three-fingered gripper, and electromagnetic/suction cup.