United States Department of Energy
Office of Environmental Management

Office of Deactivation & Decommissioning and Facility Engineering

Innovative Technology Development Program Summary

Fiscal Year 2015

safety ❖ performance ❖ cleanup ❖ closure

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2015
A Breakthrough Year

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With excess facilities awaiting final disposition, the scope of the Deactivation & Decommissioning (D&D) challenge is extensive. Many of the facilities to be decommissioned are one-of-a-kind, with unprecedented scope and complexity.

The DOE Office of Deactivation & Decommissioning and Facility Engineering Innovative Technology Development (EM-13) remains resolute in its objectives. The Department of Energy Office of Environmental Management (DOE-EM), in conjunction with Savannah River National Laboratory (SRNL), DOE field offices, other DOE national laboratories, numerous academic institutions and private industry, continually pursues viable, achievable solutions through advanced science and technology. This remains a core doctrine for DOE to achieve facility disposition.

EM-13 saw some remarkable scientific and technical innovations in 2015. From virtual reality to robotics, advances have been both exciting and beneficial to the DOE complex. Processes that used to take many weeks and months have now been whittled down to time frames of hours, minutes and seconds. At the same time, these innovations serve to increase workplace safety, while greatly eliminating inefficiency and error. They are adaptable to workforce training and field applications, and are functional for either independent use or cross-platform applications. High-risk task planning and execution is minimized, completion times are reduced, and project cost effectiveness is greatly improved.

Nuclear facilities eventually go through the *D&D Transition Pathway*. Sites transition from nuclear operations to an extended surveillance and maintenance period. Following deactivation, the next step is decommissioning. The final step is end-state management. These new innovations assist at every stage of the transition pathway. In addition, these developments enable solutions-driven programs, allow for test scenarios of situations yet unseen, and open doors for other adaptations that will only serve to improve the effectiveness of the D&D and DOE missions. These innovations are thrilling, but there is much more – just beyond the horizon.

Andrew P Szilagyi

Sites transition from industrial operations

to a period of extended surveillance, maintenance, and decommissioning

to facility end-state status.

The D&D Transition Pathway

Virtual Reality

3D Visualization & 3D Mapping technologies generate an interactive environment that provides users with a representation of a nuclear facility's structural, material, and hazard conditions. From construction design and safety training to project management and intuitive presentations – the applications and benefits of this technology are limitless.

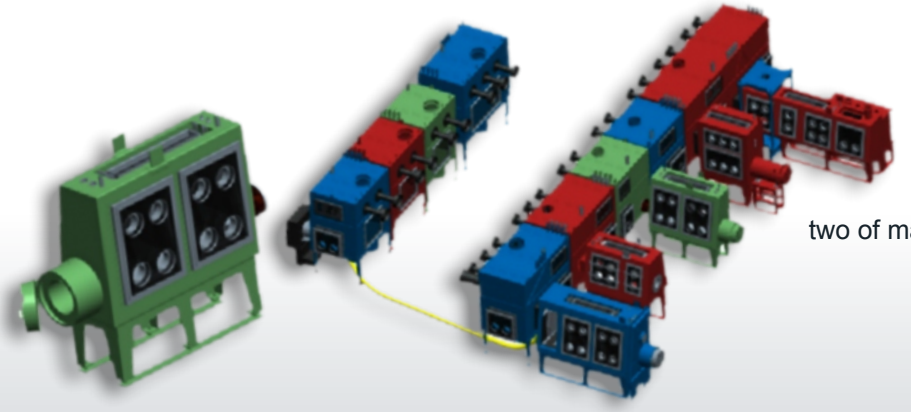
Savannah River National Laboratory has spearheaded this technology, along with the full visualization platform and a suite of applications.

While research and advancements are ongoing, this modernization easily allows for direct, in-process applications that only serve to generate additional discoveries.

Adaptable to PC/Laptop use, large-screen display and presentation, and the immersive virtual reality headset.

Facility Visualization

Facility visualization is a composite visual rendering based on data compiled over any facility's lifetime. The various visualization tools (*right*) can be used in standalone applications or incorporated with one another for a full, complete rendering.



235-F Risk Reduction Project

Plutonium Fuel Form Facility visualization recreates internal facility components and configurations. This technology helps to efficiently plan project execution, while operating in a benign environment. Worker training scenarios and detailed task analysis are just two of many potential applications.

Glovebox / Process Cell Scanner

This innovative device can be inserted into a glovebox to scan and capture the configuration and contents, and then produce a real-time digital 3D image. This digital image is readily usable for task planning and workforce training. As it allows for the representation of tools, equipment, and hazardous materials, this capability is ideal for on-the-spot management interface and preventive safety measures.

GrayQb™
Radiation Mapping

With the ability to generate near-to real-time results, GrayQb™ is a 2D radiation mapping device that integrates radiation with digital photography. By capturing gamma radiation, and then producing detailed radiation contour maps, this helpful instrument shows accurate source locations and displays relative radiological contamination levels.

In other words, GrayQB™ allows users to 'see' the unseen. As a result, decontamination operations can be pursued more efficiently and more effectively.

GrayQb™

- Captures Gamma radiation
- Produces radiation maps
- Shows radiation levels & locations
- Helps to 'see' radiation & contamination
- Amazingly inexpensive

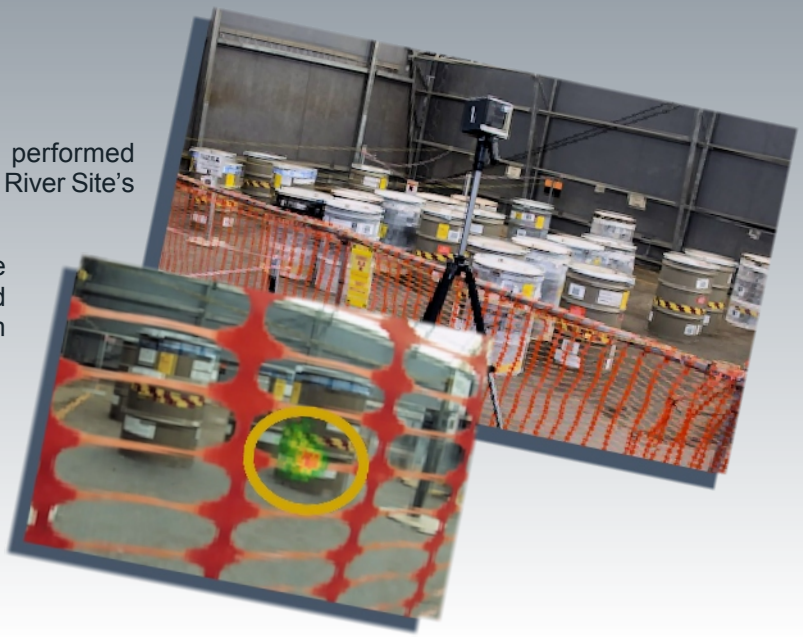
GrayQb™
Field Tests & Deployments

Since its development, GrayQb™ has been field tested against a variety of environmental scenarios. Field deployments have been roundly successful, and GrayQb™ is ready for full deployment and commercialization.

SRS Waste Storage Area

In an open-environment field test, GrayQb™ performed successfully on a cluster of waste drums at Savannah River Site's E-Area storage facility.

One radiological drum was 'hidden' among a large group of mock drums. GrayQb™ successfully located and displayed the emissions from the 'hidden' drum (*lower right*).



Hanford Plutonium Facility

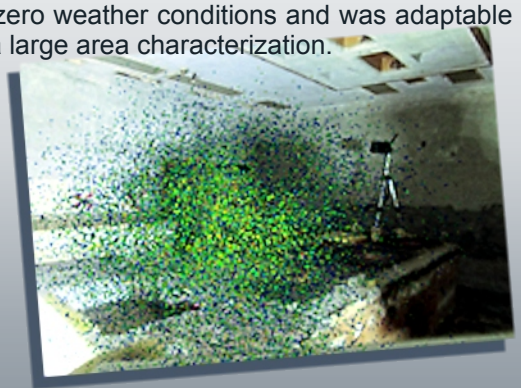
At the Hanford Plutonium Reclamation Facility, GrayQb™ was utilized in a 5-day, field deployment. This field deployment used a cluster of four GrayQb devices mounted on a crane fixture for remote operation (*left*). GrayQb™ effectively mapped contamination distribution and critical hot-spots.

By revealing previously unidentified hot-spots (*top photos, previous page*), the GrayQb™ findings significantly altered the original decontamination approach.

Canada's Chalk River Laboratories

The Savannah River National Laboratory conducted field tests with the GrayQb™ radiation mapping device at the Canadian Nuclear Laboratories' Chalk River Laboratories in Ontario, Canada. The Chalk River Laboratories' field tests were focused on deploying the GrayQb device in sub-zero weather conditions and large area deployment. Field test results were very promising (*below*), as GrayQb™ performed reliably in sub-zero weather conditions and was adaptable in locating hot-spots within a large area characterization.

The SRNL test team at Chalk River



In addition to the GrayQb™ success, this project provides technical platforms which showcase the application of DOE-sponsored technologies and approaches, and strengthens Canadian and U.S. liaisons.

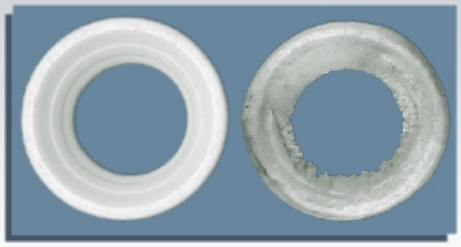
Materials
Research

The pursuit of continual improvement is at the heart of the EM-13 research mission. Materials of many forms play a critical part in every stage of the Deactivation & Decommissioning process. Within the field of materials science, promising developments and advancements are underway.

Radiation Resistant Polymers

Advanced Radiological Waste Containment Bag

Typical radiological waste containment bags are made of polyethylene (PE) material. These bags have a limited effective life, as radiation causes rapid bag degradation. As such, extensive man-hours have to be spent to repackage waste for final shipments.



A Seal Showing Before / After of Radiological Degradation

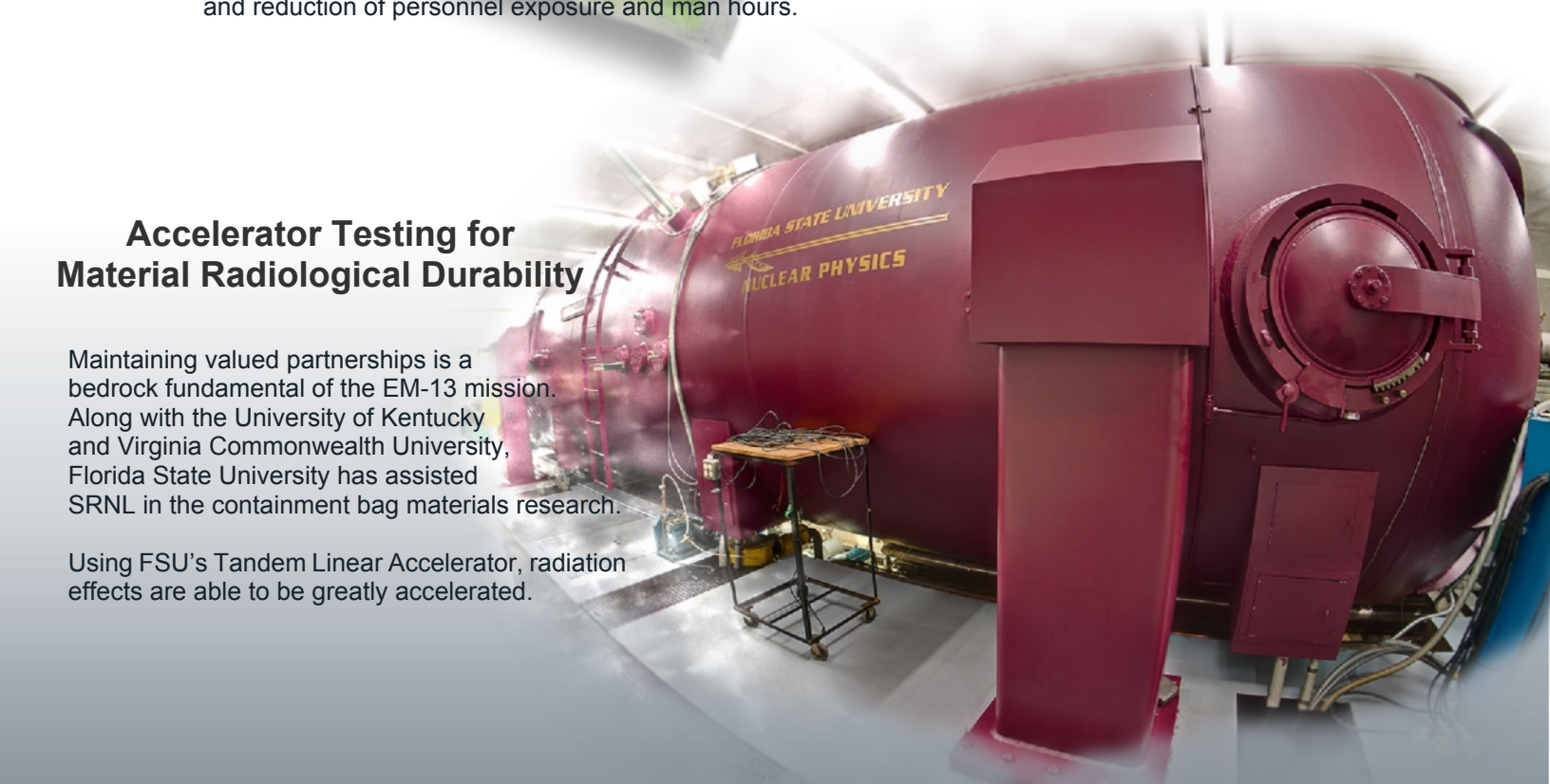
Using modeling software and laboratory testing, the EM-13 program is conducting ongoing research on several advanced materials that will greatly enhance the performance of waste bags. Thus far, the results have been significant. The prototype bag was 10X more durable than the current PE bag.

Further developments in this research will translate to safer, more stable packaging and reduction of personnel exposure and man hours.

Accelerator Testing for Material Radiological Durability

Maintaining valued partnerships is a bedrock fundamental of the EM-13 mission. Along with the University of Kentucky and Virginia Commonwealth University, Florida State University has assisted SRNL in the containment bag materials research.

Using FSU's Tandem Linear Accelerator, radiation effects are able to be greatly accelerated.

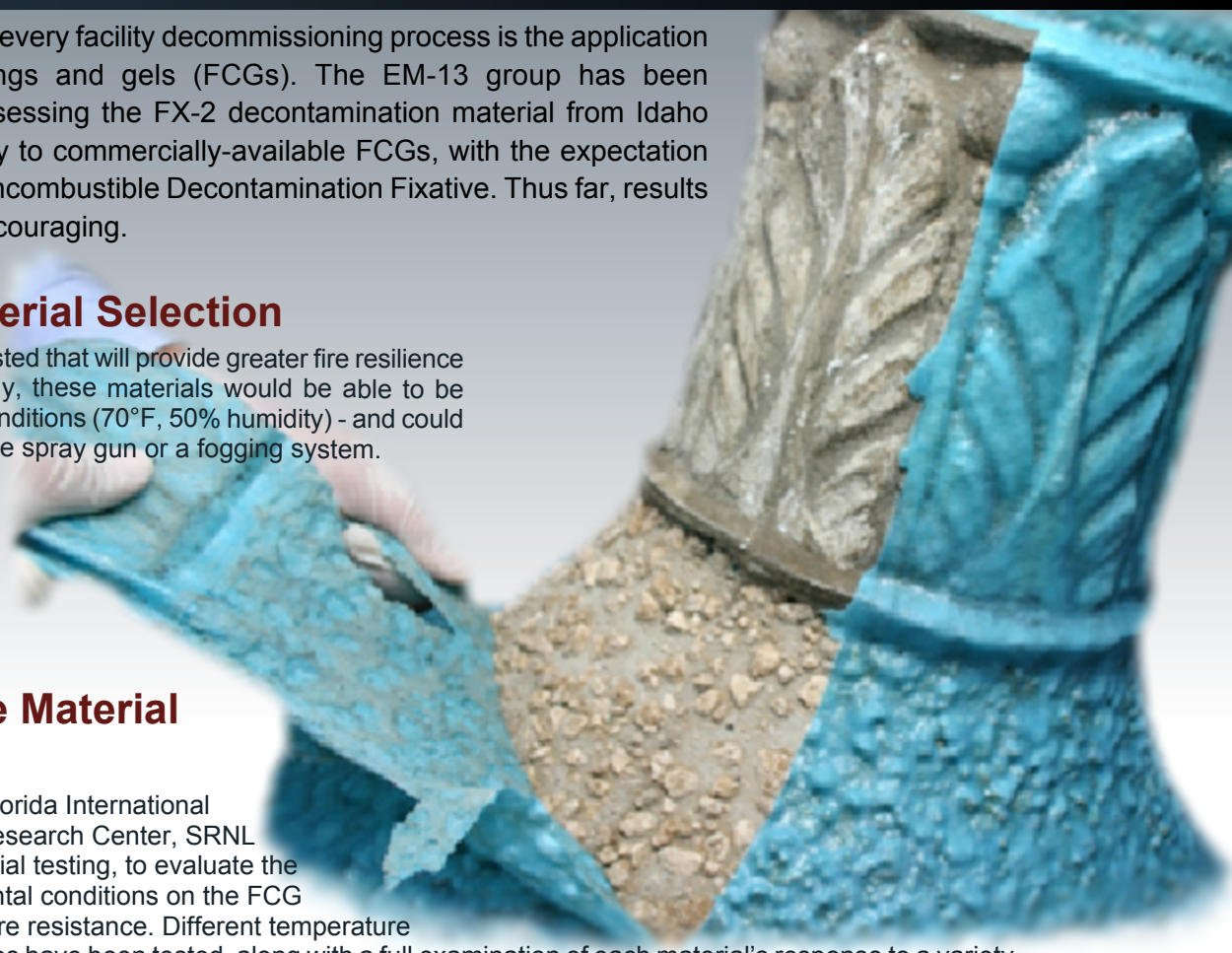


Materials Research

Essential to almost every facility decommissioning process is the application of fixatives, coatings and gels (FCGs). The EM-13 group has been comparing and assessing the FX-2 decontamination material from Idaho National Laboratory to commercially-available FCGs, with the expectation of engineering an Incombustible Decontamination Fixative. Thus far, results have been very encouraging.

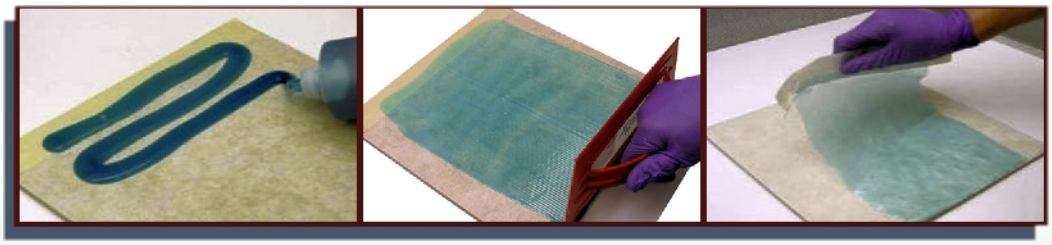
Candidate Material Selection

Materials are being tested that will provide greater fire resilience and resistance. Ideally, these materials would be able to be applied under ideal conditions (70°F, 50% humidity) - and could be applied via a simple spray gun or a fogging system.



Combustible Material Testing

In conjunction with Florida International University Applied Research Center, SRNL has conducted material testing, to evaluate the impact of environmental conditions on the FCG curing process and fire resistance. Different temperature and humidity scenarios have been tested, along with a full examination of each material's response to a variety of radiation types. In response to these preliminary results, additives to the FCGs have been tested to improve the initial findings.



A simple 1-2-3 process for sampling new fixatives

FCG Dispersal Systems

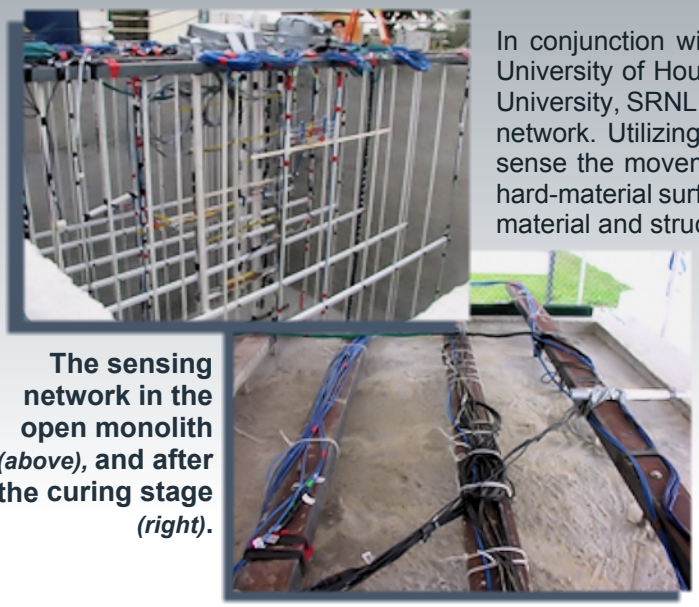
To support the need for various application scenarios, EM-13 is testing several different dispersal systems. Both hand-held, direct spray (*right*) and fogging devices (*left*) are being tested.

For use in less safe environments, remote spray and fogging systems are also being tested.

Remote Systems
& Robotics

Robotics and remote systems are real, viable alternatives to having D&D personnel working in and around hazardous conditions. These invaluable tools allow for the completion of critical tasks, and increase worker and workplace safety.

Remote Sensing Network Testbed



The sensing network in the open monolith *(above),* and after the curing stage *(right)*.

In conjunction with Idaho National Laboratory, Mississippi State University, the University of Houston, the University of South Carolina, and Florida International University, SRNL designed and successfully tested a remote-capable fluid-sensing network. Utilizing an array of specific-capability sensors, this network is able to sense the movement and density of fluid and moisture in both soft-material and hard-material surfaces and structures. This innovation also helps to identify internal material and structural changes and crack formation.

Each collaborating university and organization was able to monitor the network remotely, from their respective 'home' locations. This also means that critical D&D facilities and structures can be remotely monitored - from one or from many locations.

Successful testing scenarios involved the fully-networked monitoring of a grout-filled concrete monolith, similar to D&D applications. Fluid and moisture activity was examined through the entire grout curing process. 15 months later, results were again successful, as the same location was used for fluid injection testing. Test results showed moisture movement within the monolith.

Acoustic Emission Sensing System

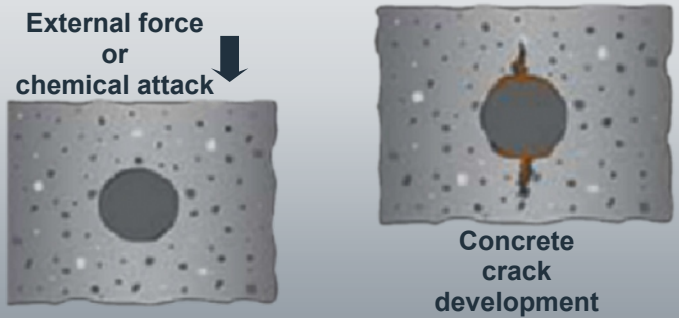
The Acoustic Emission Sensing System uses the projection, capture, and interpretation of sound waves to help 'visualize' information that would otherwise remain undetected. The sensing network testbed results proved the acoustic emission sensing was ready for field demonstration.

A field demonstration of the system was completed at the SRS 105-C Reactor Facility and yielded promising results. Primarily, it is used to detect microscopic and early-stage stress fractures and cracking in critical facility structures. As with any early-phase alert system, issues are revealed much sooner in the deterioration cycle. This information can then be used to more safely address effective solutions.

In a crane maintenance area, active crack development was found 25 feet above ground level (left).

This would be impossible to find or detect without this technology.

The stages of stress / crack development (*right*)



Remote Systems
& Robotics

Remote Robotic Silo Extractor

EM-13 is working with DOE Idaho Field Office to demonstrate the applicability of an integrated remote system approach for the retrieval of radioactive material from large silos.

The approach uses multiple existing systems in a sequential manner to initially cut and remove the silo 'fill tubes,' remotely weld risers to the silos, cut access holes, and then retrieve the material using an innovative planar snake-arm robot from the United Kingdom.

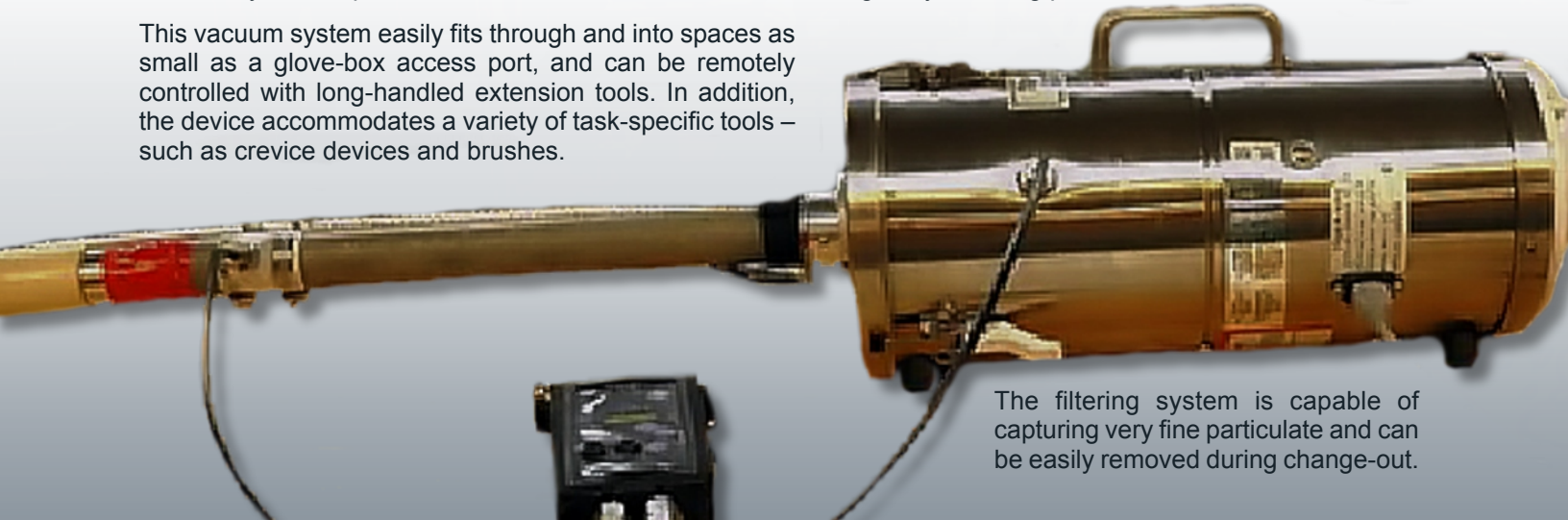
Global Remote Systems & Robotics Database

EM-13 has supported the development and commercialization of a comprehensive, interactive, web-based database that contains more than 1200 remote systems from various industries around the world. The database has filters to enable detailed searching of systems, in terms of their application, Technology Readiness Level (TRL), operational experience, usage locations, and the like. This expansive reference tool can be used to educate and to inform about the availability of systems. In a facilitated workshop setting, the database can identify available systems which can address critical D&D challenges.

Remote Vacuum System

Along with such technologies as 3D visualization and mapping, the application of robotics and remote systems is quickly becoming critical to high-risk and hazardous work environments. SRNL has modified a HEPA-filtered vacuum system to perform remote decontamination tasks, thus greatly reducing personnel-related hazards.

This vacuum system easily fits through and into spaces as small as a glove-box access port, and can be remotely controlled with long-handled extension tools. In addition, the device accommodates a variety of task-specific tools – such as crevice devices and brushes.



The filtering system is capable of capturing very fine particulate and can be easily removed during change-out.

D&D Technology

Near Term Outlook

As many DOE complex sites prepare for closure, a large number of buildings and facilities must be deactivated and decommissioned. These facilities contain many complex systems, and many issues that require labor intensive deactivation and decommissioning methods. Although many technologies currently exist, continued research, development, and adaptation are needed to address unique scenarios – and to increase efficiency and worker safety.

From the extraordinary staff, researchers and scientists of the Office of Environmental Management – to firm international relationships – to an extensive network of university students and liaisons, the Office of Deactivation & Decommissioning and Facility Engineering thrives on a talent pool that is unrivaled around the globe. The development of the next generation of scientists and researchers plays an important role in maintaining an active pipeline of resources. This community keeps the research fresh, the technology ahead of the curve, and the DOE mission in firm grasp.

The return on steady investment into research and technology, such as in the preceding pages, is significant. Project efficiency is greatly increased, meaning deadlines are more easily met and multiple projects can be handled more easily. Workers have less 'hands on,' direct involvement in hazardous tasks, and safety is improved across the board. In the final calculation, the returns on program costs are more than significant, and the savings benefits are substantial. The end result is the desired one - a healthier and cleaner environment.

These advances and breakthroughs only serve to inspire and motivate the DOE EM-13 Office even more. Many of the current and most recent innovations have generated, or will create, greater cross-platform use. This adaptability, along with an enhanced capability to visualize that which is unseen to the naked eye, lends itself to more comprehensive and more effective D&D solutions.

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