Office of Deactivation and Decommissioning and Facility Engineering 2010 Prioritized Technology Initiatives to Improve D&D Operations

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ABSTRACT

The objective of the U.S. Department of Energy's (DOE) Environmental Management (EM) Technology Innovation and Development Program is to reduce technical risk and uncertainty in the Department's cleanup programs and projects[1]. To reduce those risks and uncertainties the Program will provide technical solutions where none exist, improved solutions that enhance safety and operating efficiency or technical alternatives that reduce programmatic risks (cost, schedule, or effectiveness).

The Office of Deactivation and Decommissioning (D&D) and Facility Engineering (D&D Program) supports this objective. EM's second highest cost center is in the area of D&D at an estimated $20-30 Billion. A main thrust of the D&D Program effort focuses on innovative application and timely insertion of existing commercially available technologies, processes and hardware systems to address the identified D&D risks and challenges. This is accomplished by adapting, modifying (for site-specific requirements), optimizing (for assured safety, better efficiency and lower cost), and demonstrating existing technologies and hardware to produce sufficient technical data and operating parameters to allow the site D&D operators to insert these technologies into their baseline operation with confidence.

During the summer of 2009, the Office of D&D and Facility Engineering held workshops to identify and prioritize EM's D&D technical needs and the supporting technology projects. Participants included representatives from EM HQ and field sites (both federal and contractor staff), academia, National Laboratories, and industry. A structured prioritization process developed and facilitated by Cogentus, Inc. was used to understand the magnitude, technical complexity, and intra- and inter-site linkages of D&D challenges across the DOE-complex and to evaluate and rank potential technology projects. The results of this workshop guided the selection and funding of the FY 2010 D&D development and demonstration projects.

This paper will present both the process utilized and the output from the process that comprises the prioritized list of technology development and deployment projects considered for funding in FY 2010.

INTRODUCTION

EM's second highest cost center is in the area of D&D at an estimated $20-30 Billion. EM's current life-cycle scope comprises over 3500 facilities, including over 1000 nuclear and

[1] U.S, Department of Energy, Office of Environmental Management, Engineering and Technology Roadmap, March 2008

radioactive buildings[2]. The portfolio includes multiple nuclear production reactors, over 100 test and research reactors, multiple-football field size gaseous diffusion plants, chemical processing plants, fuel and weapons component fabrication facilities, canyons and radionuclide separations facilities, laboratories, hundreds of miles of buried pipelines, and a myriad of other contaminated facilities. Historically, D&D activities have received a lower priority ranking than areas such as high-level waste (HLW) processing, due to key factors: (a) out year schedules, for most D&D activities lack regulatory drivers thus influencing the priority of funding allocated to D&D technology development; (b) multi-year constrained risk-based funding profiles; and (c) the lack of appreciation for the difficulty of dealing with highly complex, highly contaminated, and often "one-of-a-kind" D&D challenges.

To directly support opportunities identified in the EM cleanup initiatives, the D&D Program's Multi-Year Program Plan (MYPP)[3] is aligned and driven by site cleanup priorities and corresponding technical needs at DOE's major cleanup sites: Savannah River (SR); Idaho (ID); Office of River Protection (ORP)/Richland Operations Office (RL), Portsmouth and Paducah Project Office (PPPO), and Oak Ridge (OR)—as well as at the smaller sites at West Valley (WV) and Brookhaven National Laboratory.

A large majority of the facilities to be remediated in the DOE Complex, that are reflected in the site technology needs statements, are one-of-a-kind and/or unique to DOE with unprecedented scope and complexity. In many instances the needed technologies are yet to be developed or will require significant re-engineering to be adapted to meet DOE-EM needs. With the more complex D&D projects scheduled into the out years an opportunity exists to address needed technical improvements and advancements if EM hopes to achieve cost and schedule expectations.

Today, the common perception for most of EM's D&D activities is that the D&D of industrial and low-level radiological facilities can be completed with relatively few new technical approaches or innovative technology insertions. However, good stewardship requires further evaluation to determine whether these activities can be conducted in a safer and more cost effective and efficient manner. Step improvements in technical approaches and in innovative technology can lead to greater enhancements in worker safety while offering improved D&D operational schedules with reduced cost profiles.

MAJOR TECHNICAL RISKS AND UNCERTAINTIES

Risks are known technical issues that could prevent project success. Uncertainties are indefinite or unpredictable technical aspects of a project. The major technical risks and uncertainties identified by Office of D&D and Facility Engineering are as follows.

- The extent of facility deterioration and contamination throughout the complex is not fully understood, leading to uncertainties in programmatic requirements. Improved information acquisition and management, and advanced characterization strategies are required to better define and manage requirements for facility maintenance and decommissioning.
- Facility deterioration and/or high radiation levels preclude safe entry by personnel, necessitating the development and deployment of adaptable robotic and remote data acquisition platforms. Demolition of such facilities requires similar technologies for disassembly and size reduction.

[2] Mark Gilbertson, Presentation of Waste Management Symposium, Phoenix, Arizona, February 2008
[3] U.S. Department of Energy, Office of Engineering and Technology, Applied Research and Technology Development and Deployment, Integrated Multi-Year Program Plan (FY 2008 - FY 2010) March 2008

- Identifying the quantity and location of radioactive and hazardous chemical contamination, and control and containment of contamination during decommissioning and demolition of facilities requires improved technologies and processes.
- Technologies to select and achieve the most appropriate and protective end states for facilities are needed to advance defensible strategies for facility decommissioning.

A National Research Council report[4] identified four broad areas of research where technologies could make significant contributions to solving D&D problems, decreasing lifecycle costs, and improving safety performance, including: 1) Characterization of contaminated materials; 2) Decontamination of equipment and facilities; 3) Remote intelligent systems; and 4) End state definition for facility D&D. The DOE Research and Development (R&D) Portfolio – Environmental Quality[5] report indicates that "site problem holders for facility D&D activities have identified 180 active needs that must be met to accomplish the current baseline". The broad categories of problem areas/needs identified generally match those recommended by the National Research Council, with added specificity (e.g., underwater characterization related to spent nuclear fuel pools and remote/robotic capabilities for hot cells/glove-boxes), and the inclusion of technology needs related to D&D of reactors and entombment end states.

STRATEGIC APPOACH

The D&D engineering and technology investment strategy is linked to EM's mission priorities as reflected in the Site Performance Baselines, corporate performance measures, Performance Management Plans, Risk Management Plans, and defined end-states. The EM sites have identified technical gaps in their cost and schedule baselines, which if resolved can offer significant improvements to current baselines and safety performance for both workers and the public. EM's challenge is to identify alternate technologies or technical approaches that will serve as "forcing functions" or "transformational advancements", impacting the baseline schedules or having significant potential for changing the dynamics of site D&D work scope.

Strategic investments are also made in the development of novel, innovative technologies to address unique site D&D challenges and enable site cleanup. These are high cost, high risk projects where a transformational change is necessary to enable improved D&D performance. The MYPP creates a logical case and vision for federal government investments in technology development and deployment, technical assistance, and applied research, focusing on three major goals: 1) reducing technical and safety risks in current site baselines; 2) reducing costs by accelerating cleanup; and 3) anticipating and providing early awareness of alternative technologies and practices for disposal pathways that are subject to uncertain regulatory outcomes. Technology alternatives, technical assistance, and applied research activities must deliver a return on investment and be compatible with existing facilities and infrastructure at the sites.

The D&D strategy recognizes that many facilities will be maintained in a surveillance and maintenance phase until appropriate levels of funding are made available to pursue deactivation and decommissioning work scope. The Office of D&D and Facility Engineering works with the site Federal Project Directors, project managers, and others to identify opportunities to insert new and improved D&D technologies that could potentially accelerate schedules so that long-term surveillance and maintenance costs can be avoided or minimized.

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[4] National Research Council Report: *Research Opportunities for Deactivation and Decommissioning Department of Energy Facilities*, 2001

[5] *DOE Research and Development Portfolio, Volume II, Environmental Quality,* February 2000

The Office of D&D and Facility Engineering is taking a corporate and holistic strategic approach to increasing technical understanding and reducing the technical risk and uncertainty of EM programs and projects by providing identification and advancement of alternative technologies, technical assistance, and lessons learned and best practices, combined with multi-disciplinary services of engineering consultation, guidance, expertise, and policy development. Our overarching goal is to improve planning, design, construction, and facilities and infrastructure management activities for D&D activities at the sites. A key element of this approach is working with the site Federal project directors, project managers, and prime contractors to identify technical needs, priorities, and gaps and, most importantly, to estimate the benefits, costs, and time frames of the technologies and technical approaches selected for investment.

Alternative technologies must be delivered in time for implementation during the life-cycle of a site cleanup schedule. For those technology needs and priorities identified by the sites, but not addressed by the prime contractors, EM-complex priorities and funding profiles are established for the out years. Cleanup technologies are often developed at national laboratories, universities, other academic institutions, and commercial providers through a competitive bidding process. The technology must stand on its own merits, be safe, cost effective, and offer significant and desired advantages over other approaches without introducing unacceptable technical risk. Although technical needs will exist until cleanup is completed in the future, specific, long-term technology planning becomes more difficult due to uncertainty of cleanup progress, delays with design and construction of already approved facilities/plants, and uncertain regulatory outcomes for certain disposal pathways.

The Office of D&D and Facility Engineering also provides technical assistance to sites to reduce the technical uncertainty and risk of site cleanup. It provides rapid response to address current technical problems impeding site cleanup that will result in significant cost savings or have a major improvement to the waste disposition pathway. Most importantly, a key component of this assistance is providing engineering and scientific expertise for External Technical Reviews to address difficult technical problems or for resolution of project management issues. Technical assistance includes activities such as: baseline and project reviews; technical workshops with experts on specific crosscutting issues; engineering consultation; site troubleshooting; scientific or engineering problem solving; technical analysis and studies; assistance with technology demonstrations; mockups; testing of alternative approaches; technical transfer and integration activities for the complex; and contract and acquisition support.

A critical aspect of increasing our technical understanding in D&D is working with the national laboratories and universities to identify critical and emerging issues and needs, analyze technical gaps, conduct applied research, and provide long-term oversight and guidance. There is also considerable D&D expertise residing in other Federal agencies, the commercial sector (nuclear utilities and commercial D&D contractor firms), and the international community. One of the key objectives in the D&D Program is to partner with these organizations to exchange lessons learned and best practices, identify subject matter experts, and/or to develop a leveraged applied research program that meets the technical needs for the sites.

PRIORITIZATION PROCESS

Development of strategic initiatives for the D&D Program is directly linked to EM's mission priorities at the sites. A structured prioritization process developed and facilitated by Cogentus, Inc. was used to understand the magnitude, technical complexity, and intra- and inter-site linkages of D&D challenges across the DOE-complex and to evaluate and rank potential

technology projects. In June and August of 2009, the Office of D&D and Facility Engineering held workshops to prioritize EM's D&D technical needs and the supporting technology projects. Participants included representatives from EM HQ and field sites (both Federal and contractor staff), academia, National Laboratories, industry, and the United Kingdom (UK) Nuclear Decommissioning Authority (NDA). The results of this workshop guided the selection and funding of the FY 2010 D&D development and demonstration projects.

The purpose of the first workshop held in June 2009 was to identify and prioritize DOE EM site D&D technology needs. Project managers (both Federal and contractor) from DOE sites responsible for EM D&D projects identified and described their D&D technical challenges and technology needs. These same managers, along with representatives from academia, National Laboratories, industry, and the UK NDA then identified and defined the criteria by which those needs could be evaluated (Table 1) and assigned weights to each criterion based on importance to each D&D Program stakeholder (Table 2). Since several sites shared the same technical challenges and technology needs, the needs were then consolidated and ranked based on the cumulative scoring from the criteria.

In preparation for the second workshop held in August 2009, the project managers were asked to define the scope, cost, schedule, and benefits for technology development, demonstration and/or deployment projects to meet their technical challenges and technology needs identified in the first workshop. At the second workshop the participants scored the technology projects against the criteria developed at the first workshop. The result of the process was a group of projects that give the best overall benefit for a given budget. These projects are identified in the Strategic Initiatives.

While this structured process is somewhat costly and time consuming, the process provides a defendable, traceable, prioritized list of projects that maximize the benefit to the DOE D&D community. The process also increases communication, collaboration, and knowledge sharing among the participants.

Table 1. Criteria Used to Evaluate D&D Technology Needs and Projects

Criteria	Sub-criteria
Cost	Cost to the D&D Program Cost to Implement Cost avoidance
Schedule	Time to implement Schedule savings Urgency Availability of human resources
Safety	Industrial safety Radiation safety/Exposure reduction Facility safety/Fit with safety basis
Regulatory	Regulatory compliance Safeguards and security
Multi Applications	Multiple applications within a project Multiple applications at one site Application at multiple sites
Feasibility	Technical feasibility Programmatic feasibility

Table 2. Stakeholder Weighting of Criteria

	EM30	EM1	Congress	Sites
Cost	20%	16%	50%	20%
Schedule	15%	16%	20%	30%
Safety	15%	16%	7.5%	30%
Regulatory	10%	20%	7.5%	20%
Multi Application	20%	16%	7.5%	0%
Feasibility	20%	16%	7.5%	0%

STRATEGIC INITIATIVES

The D&D Program concentrates on three strategic initiatives: 1) Characterization, 2) Deactivation, Decontamination, and Demolition, and 3) Closure.

Characterization

Current characterization methods are costly, accounting for approximately 25% of the total D&D costs, and are often labor intensive, exposing workers to radiation, hazardous materials, and other risks. Characterization often requires taking multiple samples for laboratory analysis or using contaminant-specific instruments to quantify each individual contaminant of concern (COC). This process is costly and time consuming.

The Characterization Initiative is focused on developing and deploying improved characterization and monitoring technologies for detecting and quantifying penetrating radiation

and other hazardous materials that reduce costs and schedule and improve worker safety. Characterization projects identified during the prioritization process include the following:

Hot Cell Characterization with RadBall – Remote characterization is needed in areas unsafe for human entry such as areas with high levels of radioactive contamination, confined spaces, and structurally deteriorated facilities. The RadBall currently under development by the UK National Nuclear Laboratory can locate, quantify, and characterize radiological hazards from a single position. This project will test the RadBall for application at DOE facilities.

Remote Off-gas Stack Characterization – The DOE Complex has numerous stacks associated with gaseous waste treatment operations and other elevated structures that need to be characterized and demolished. Many of these stacks are unsafe to access even for routine inspection. This project will fabricate and demonstrate a remote stack characterization system.

Robotic Platforms for Characterization - The process of characterizing the internal radiological conditions and subsequently initiating equipment, machinery, glove-box, pipeline, ventilation duct, and other material removal actions from highly contaminated hot cells is a slow, meticulous, and high risk activity based on the fact that direct human interface is necessary. This project will design low cost, modular robotic platforms with multiple capability task attachments and remote-intelligent interfaces for characterization activities to significantly reduce worker exposures, cost, and schedule.

Multi-analyte Field Analysis – Field instruments that require introduction of a sample are available for most individual contaminants of concern (COCs). The real interest is in a field deployable, multi-analyte instrument to find and quantify multiple COCs. This project will develop and demonstrate a field deployable instrument that can characterize for a number of different COCs.

Integrated Technology Suite for Facility Characterization – There are numerous large facilities (>100,000 square feet) within the DOE Complex that must be characterized prior to decommissioning. The current process is time consuming and labor intensive. This project will demonstrate a suite of systems that can rapidly scan, characterize, and map facility surface contamination.

Beryllium Characterization and Monitoring - Beryllium, even in small concentrations, can present a serious and long-term health risk to workers. A real-time, field-deployable air monitor and real-time, hand-held, field-deployable surface instrument that can meet regulatory and health risk requirements for beryllium is needed. This project will identify and evaluate potential beryllium detection technologies and technical approaches; evaluate the readiness of the technology and approach for field deployment; and identify any additional development and/or engineering necessary.

Non-intrusive Measurement of Films, Scales and Deposits - Simple, remotely operated tools that can provide discrimination of 'foreign' materials inside metal piping could simplify and reduce requirements for non destructive assay (NDA) for deposits if it can be confirmed that no deposits exist. Tools must be able to discriminate between metal of pipe and expected films or deposits at the level of resolution necessary to determine if NDA is required. This project will identify and field test tools for such non-intrusive measurements.

In Tank Characterization with Isotopic Discrimination - There are hundreds of tanks and sumps in the DOE Complex that require characterization prior to closure. Current protocols require

mixing of tank liquids and sludge and retrieving multiple samples for laboratory analysis. The cost can be as much as $200,000 per sample with turnaround times for sample analysis of several weeks. This project will design, develop, and demonstrate a characterization tool for assessing tank contents in high-radiation background environments without the need to collect extensive physical samples for laboratory analysis.

Mercury Detection - Elemental mercury and other forms of mercury are prevalent in many of the buildings and much of the equipment at the Y-12 Plant in Oak Ridge. Mercury presents a serious and long-term health risk to workers and the environment. A real time, field-deployable mercury characterization instrument is needed to accurately analyze mercury concentrations beneath surface (e.g. in concrete) and within piping and equipment, and within building material (e.g. insulation). This project will Identify and evaluate potential mercury detection technologies and technical approaches; evaluate the readiness of the technology and approach for field deployment; and identify any additional development and/or engineering necessary.

Deactivation, Decontamination, and Demolition

The Deactivation, Decontamination, and Demolition Initiative is focused on 1) developing and deploying improved deactivation, retrieval, size-reduction, and stabilization technologies that provide adequate personal protections and effectively achieve end-state requirements; and 2) developing and deploying advanced remote and robotic methods to rapidly access and assay facilities to determine optimal D&D approach. Deactivation, Decontamination, and Demolition projects identified during the prioritization process include the following:

Hot Cell and Glovebox Decontamination - The Savannah River Site is planning the decommissioning of facilities at which plutonium-238 was processed to support the National Aeronautics and Space Administration's deep space missions. Processing operations occurred in glove-boxes and hot cells, which became contaminated with the nuclear material. Significant portions of the contamination are known to occur as small particles in the range of a few microns to submicron in size. The relatively short half life, high energy, and small size of these particles presents unique challenges for decontamination relative to methodologies that have previously been used for decontamination of plutonium handling facilities. A set of initiatives will be pursued to develop and validate approaches that will achieve the decontamination objectives, while minimizing risk to workers and potential spread of contamination.

Asbestos Saw with HEPA Filter - The current method of removing asbestos insulation and other asbestos containing material is costly, time consuming, and labor intensive. A mechanical method for safely removing the asbestos that reduces the ergonomic strain and exposure potential to the worker is needed. This project will develop the technical requirements, determine what tools are currently available for asbestos removal, and determine if the need can be met using existing technology. If existing tools are not sufficient, plans will be developed to modify existing tooling or design, fabricate, and test a new tool.

Improved Electrical Safety and Illumination - Conducting D&D operations in facilities slated for demolition often requires isolating electrical systems and bringing in temporary power and portable lighting. Potential fires and electrical accidents are significant risk factors for worker safety. This project will identify, review, and evaluate the various applicable electrical and fire codes and standards and prepare recommendations for application of these codes to D&D operations; and develop the technical and functional requirements for a low-temperature lighting system and complete a small scale demonstration.

Improved Safety during Heavy Equipment Operation – There are occasions when the demolition of building structures requires reaching long horizontal distances to adequately perform demolition activities (i.e., 60 to 120 ft). Current high reach excavator technology is designed mainly for high reach applications such as demolition of tall buildings and not for significant horizontal reaching. At maximum horizontal reach the lifting capacity of the high reach excavators is reduced such that that they become ineffective for lifting and removing debris. Use of heavy equipment may also be limited by the application of contractor A&E standards for new building structures but overly conservative for the demolition phases of a building. This project will evaluate the application of A&E standards for new building construction that may be limiting the use of heavy equipment for demolition of facilities and prepare the technical and functional requirements, design, and build or manufacture an attachment to a long reach excavator capable of effective operation in a horizontal position when load factors restrict heavy equipment operations.

Long Reach Tap - Waste lines, which can read as high as 20,000 R/hr, contain residual liquid that is difficult to drain and presents a significant worker exposure risk. This project will design a method to remotely install a tapping mechanism for draining these pipes.

Hot Cell Dismantlement - A safe and remote means of dismantling/removing the contaminated tables and other equipment (>190 lbs) in hot cells, removing obstacles from drains to allow for inspection, and stabilizing drain lines which can have hot spots up to 20,000 R/Hr is needed. This project will develop the technical and functional requirements for a robust remote system to facilitate hot cell inspection, characterization, stabilization, and dismantlement.

High-temperature, High-pressure Pipe Sealant – In order to decontaminate and/or remove piping the pipe must first be sealed from the outside to allow it to be rinsed (must hold approximately 40 psi) without release of liquid to the environment. The gaskets in this piping may be dry and no longer provide a seal and the piping can have small leaks in other areas. In addition, piping often has radiation fields that do not allow personnel access directly to the pipe. This project will identify and test a sprayable sealant that can be applied to unprepared/dirty piping and flanges, soak into or coat the gaskets, and dry into an impenetrable seal.

Residual Water Decontamination - Residual water found in pipes, vaults, tanks, waste boxes, etc. during D&D operations is currently collected, solidified, and disposed of according to waste regulations. It is expensive and time consuming to handle the small amounts of water in this manner. This project will develop a field deployable method to quickly remove all radioactive or other contaminants from residual water and allow the water to be disposed of as sanitary waste.

Sodium Passivation - The residual sodium (e.g., remaining on walls and hydraulic low points) of the sodium cooled EBR-II nuclear reactor was passivated using moist CO_2. Most of the sodium was successfully treated, however, some of the sodium could not be reached, and in much of the piping, a bicarbonate layer formed which impedes treatment of the underlying sodium. A new method is required to safely but effectively treat the remaining residual sodium in the presence of sodium bicarbonate. Bench-scale tests will be performed with the intent to establish the chemistry, flow rates and temperatures and ranges thereof that are most conducive to safe and effective removal of sodium medal, sodium bicarbonate, and their residues and reaction products. If successful, this technique has potential utility at Hanford and other nuclear sites around the world.

Remote Retrieval Methods in High Hazards Areas - Historic operations and D&D interim storage practices have resulted in large, highly contaminated process equipment and debris located in

high hazard areas where remote retrieval methods are desirable due to high removable and airborne contamination levels and/or extremely high dose rates. Potential applicable existing technologies to characterize and de-inventory tunnels, basins, fuel pools, and other large structures will be identified to eliminate technical barriers and uncertainties, to reduce the life-cycle resources required for high-cost, high-risk work, and to improve safety performance by applying improved/new technology.

Manipulator Systems for Hot Cell Cleanout – There are many hot cell facilities that still contain volumes of highly contaminated equipment and waste which must be characterized and removed, however, through years of inactivity the hot cell windows have become opaque and the manipulators inoperable. A remote portable hot cell system with multiple cameras and manipulators and adequate shielding to reduce exposure to operators is needed. This project will design and test an integrated system capable of meeting these requirements.

Underwater Cutting and Packaging of High Activity Metals – Several reactor fuel pools, filled with hundreds of thousands of gallons of water for shielding, are being used to store highly radioactive materials. In order to disposition these materials and D&D the reactor pools, the metals must be size-reduced and packaged underwater to maintain the shielding. This project will identify and demonstrate technologies to achieve the cleanout of the pools.

Closure

The Closure Initiative is focused on developing the technologies and technical approaches for achieving informed end-state strategies and conditions to satisfy federal, state, and local stakeholders. In FY 2010 efforts will include support for In Situ Decommissioning (ISD) (Entombment). A comprehensive strategy has been developed and the most urgent technology challenges and concomitant technical solutions for the implementation of ISD have been identified. Technical challenges and technology needs identified include specialty grout formulation, grout delivery systems, remote characterization for high radiation areas, embedded sensors, remote monitoring, long-term performance analysis, and evaluation of alternative fill materials.

SUMMARY

The mission of the Office of D&D and Facility Engineering is to develop, demonstrate and facilitate the implementation of innovative technologies and approaches which result in safe, cost-effective, and timely D&D of DOE facilities. The vision is to become the ‘best-in-class’ D&D engineering and technology program through the provision of technical assistance, technology development, and applications engineering support to reduce technical risks and uncertainties to complete the EM mission. This goal is being accomplished through the implementation of strategic initiatives targeted at addressing the highest priority technical problems at DOE sites. The success of this program could have a substantial impact on the safety, cost-effectiveness and timely execution of D&D projects across the Complex.