Contract No:

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy.

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Proceedings of the ASME 2013 15th International Conference on Environmental Remediation and Radioactive Waste Management
ICEM2013
September 8–12, 2013, Brussels, Belgium

ICEM2013-96257

ENTERPRISE SRS: LEVERAGING ONGOING OPERATIONS TO ADVANCE RADIOACTIVE WASTE MANAGEMENT TECHNOLOGIES

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ABSTRACT

The Savannah River Site (SRS) is repurposing its vast array of assets to solve future national issues regarding environmental stewardship, national security, and clean energy. The vehicle for this transformation is Enterprise SRS which presents a new, strategic view of SRS as a united endeavor for "all things nuclear" as opposed to a group of distinct and separate entities with individual missions and organizations. Key among the Enterprise SRS strategic initiatives is the integration of research into facilities in conjunction with on-going missions to provide researchers from other national laboratories, academic institutions, and commercial entities the opportunity to demonstrate their technologies in a relevant environment and scale prior to deployment. To manage that integration of research demonstrations into site facilities, The DOE Savannah River Operations Office, Savannah River Nuclear Solutions, and the Savannah River National Laboratory (SRNL) have established a center for applied nuclear materials processing and engineering research (hereafter referred to as the ***Center***).

The key objective of this initiative is to bridge the gap between promising transformational nuclear materials management advancements and large-scale deployment of the technology by using SRS assets (e.g. facilities, staff, and property) for those critical engineering-scale demonstrations necessary to assure the successful deployment of new technologies. The ***Center*** will coordinate the demonstration of R&D technologies and serve as the interface between the engineering-scale demonstration and the R&D programs, essentially providing cradle-to-grave support to the R&D team during the demonstration. While the initial focus of the ***Center*** will be on the effective use of SRS assets for these demonstrations, the ***Center*** also will work with research teams to identify opportunities to perform R&D demonstrations at other facilities. Unique to this approach is the fact that these SRS assets will continue to accomplish DOE's critical nuclear material missions (e.g., processing in H-Canyon and plutonium storage in K-Area). These demonstrations can be accomplished in a more cost-effective manner through the use of existing facilities in conjunction with ongoing missions. Essentially, the R&D program would not need to pay the full operational cost of a facility, just the incremental cost of performing the demonstration.

Current ***Center*** activities have been focused on integrating advanced safeguards monitoring technology demonstrations into the SRS H-Canyon and advanced location technology demonstrations into K-Area Materials Storage. These demonstrations are providing valuable information to researchers and program owners. In addition these demonstrations are providing the ***Center*** with an improved protocol for demonstration management that can be exercised

across the entire SRS (and to offsite venues) to ensure that future demonstrations are done efficiently and provide an opportunity to use these unique assets for multiple purposes involving national laboratories, academia, and commercial entities.

Key among the envisioned future use of SRS assets is the demonstration of new radioactive waste management technologies critical for advancing the mission needs of the DOE-EM program offices in their efforts to cleanup 107 sites across the United States. Of particular interest is the demonstration of separations technologies in H-Canyon. Given the modular design of H-Canyon, those demonstrations would be accomplished using a process frame. The demonstration equipment would be installed on the process frame and that frame would then be positioned into an H-Canyon cell so that the demonstration is performed in a radiological environment involving prototypic nuclear materials.

INTRODUCTION

In 2011, the Savannah River Site (SRS) started on a journey to transform its heritage of service in environmental stewardship and national security into a bold new approach that will renew and revitalize SRS's reputation as a national asset for solving the complex challenges facing the United States. This strategic vision, referred to as Enterprise SRS (E·SRS), is premised on a unique partnership among all of the various entities at SRS working together towards a single goal: to revitalize and repurpose SRS assets to solve the challenges for the United States in environmental stewardship, national security, and clean energy. Singular among those challenges is the expertise and capability needed to manage of nuclear materials. SRS has met that challenge for the past six decades, and with E·SRS, SRS will continue to embody "Nuclear Knowledge for the Nation" as it provides solutions to the Nation's critical missions in the future.

As a first step in this transformation, E·SRS identified several strategic initiatives (SIs) that were logical extensions of SRS historic and current expertise and facilities in nuclear materials management and were targeted at specific national concerns. Among those SIs was a concept to use SRS operating facilities to serve as test beds for novel, game-changing technologies that need to be demonstrated in relevant nuclear conditions prior to their field deployment. Those demonstrations will close the gap between the research and the deployment of transformational nuclear technologies across the entire spectrum of nuclear materials management including the disposition of nuclear waste and the processing, monitoring, and packaging of nuclear materials and used nuclear fuel. That concept has matured in 2012 and led to the establishment of the Center for Applied Nuclear Materials Processing and Engineering (hereafter referred to as the ***Center*** r) with the Savannah River National Laboratory having the responsibility to manage the ***Center*** due to its focus on research demonstrations.

NEED

A number of recent high-profile reviews and workshops have clearly highlighted a national need for robust research, development and deployment (RD&D) programs in key areas of nuclear technology, especially nuclear separations science and engineering [1, 2, 3, 4]. Two critical areas of RD&D emerged from these reviews:

- The need for access to and use of multi-purpose demonstration test facilities that can support testing with radioactive material at relevant scales and

- The need for collaborative research enterprises that encompass government research organizations (e.g. national laboratories), commercial industry and the academic community. Such collaborative enterprises effectively integrate theory and modeling with the actual experimental work at all scales, as well as strengthen the technical foundation for research in critical areas.

The arguments for engineering-scale collaborative research facilities are compelling – facilities capable of supporting test programs and demonstrations conducted with actual nuclear materials are essential to program success. It is widely recognized, however, that such facilities are expensive to build and maintain; creating an imposing, if not prohibitive, financial burden on an individual sponsoring office. Given that, success for the current and future nuclear separations missions is dependent on a concerted effort to develop new, creative, approaches that effectively use existing facilities in a manner that supports current missions and facilitates the development and deployment of technologies to meet the near- and long-term needs of national programs.

RESPONSE

The ***Center*** SI proposes to bridge the gap between promising transformational nuclear materials processing discoveries and large-scale deployment of the technology. The ***Center*** is not intended to replace existing R&D programs within the DOE offices (EM, NE), NNSA, or work currently being performed at other DOE laboratories or universities. Rather, it is viewed as an integrating 'force multiplier' to existing DOE programs, especially when coupled with the engineering-scale demonstration capabilities at SRS facilities (e.g., H-Canyon or the Modular Caustic Side Solvent Extraction Unit (MCU)) and will serve as an integrator for collaborations supporting DOE missions related to nuclear waste disposition, nuclear materials management, and advanced fuel cycle technologies. These SRS assets (facilities and experienced personnel) provide a singular framework for the validation and demonstration of

technology under relevant conditions of scale, environment, and materials.

The ***Center*** will provide a unique focus and mechanism for cooperation and collaboration among SRNL, SRS organizations and programs, and other research entities (i.e., universities, national laboratories and commercial entities) for integrated demonstrations using SRS assets. Essentially, the ***Center*** will be the Gateway to SRS Assets for those research entities. The SRS demonstrations will be tailored to meet customers' needs to allow promising new technologies to be tested in a relevant (i.e., radiological) environment at a relevant experimental scale with relevant materials (i.e., actual nuclear materials) prior to their field deployment. This type of applied development testing and engineering-scale demonstrations is crucial to provide successful technology deployment across the entire range of cradle-to-grave nuclear materials management which encompasses critical national concerns in nuclear waste disposition, nuclear nonproliferation, and nuclear energy.

The ***Center*** will coordinate the demonstration needs of the research team with the requirements of the operating facilities. Those facilities will provide the relevant conditions (e.g., radiological environment, nuclear materials, relevant scale) to advance the maturation of the laboratory-tested technologies so that those technologies can be successfully deployed. For example, there is the potential that treatability studies could be done at a relevant scale using actual waste materials. This approach will change the paradigm for how nuclear material technologies are developed. The ***Center*** will integrate and couple the basic R&D with the applied R&D and thereby will deliver a more robust final technology for deployment. This collaborative research approach will iterate results from the laboratory-scale testing, applied development, and engineering-scale demonstration. The feedback from that type of integrated technology demonstration is essential to identify gaps and unexpected phenomena that can only be revealed by the relevant conditions of the demonstrations (Fig. 1).

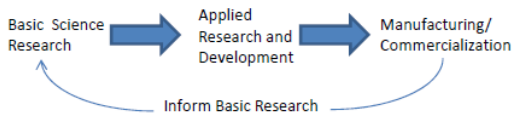

Fig.1. Interplay of Basic Science Research and Applied Research and Demonstration

An essential attribute to the viability of this proposed use of SRS assets for demonstrations is the cost advantage of multiple uses of operating facilities. The baseline costs of an operating facility would be borne by the core mission of that facility. The R&D program would be required to bear only the incremental cost needed to prepare, conduct, and clean-up the particular demonstration. For example, if the SRS H-Canyon had a core mission to disposition material for DOE-EM, its baseline costs would be provided by DOE EM. By inserting a technology demonstration into H-Canyon, the demonstration cost would be a fraction of that required for the research program to support the entire baseline cost of the H-Canyon facility. Thus, the R&D programs can take advantage of the nuclear materials being processed in H-Canyon, the radiological environment of H-Canyon, and the ability to insert relevantly-scaled experiments into H-Canyon to mature emerging technologies without the need to support the entire operational suite of activities in H-Canyon.

Another critical aspect of these demonstrations is the impact on the pipeline of next generation of nuclear and radiochemical scientists and engineers. According to the 2012 National Academy of Science study [5], there is an urgent need to encourage more students to specialize in nuclear chemistry and radiochemistry to meet the projected needs of nuclear medicine, nuclear power generators, and national security. By facilitating academic research institutions to collaborate with SRS facilities in these demonstrations, the ***Center*** will be expanding the opportunities for students to be exposed to nuclear chemistry and radiochemistry and help avoid the workforce gap in critical areas due to the retirements of the current expertise in those areas.

In 2012, the ***Center*** identified three mission opportunities as initial areas of research demonstrations:

Advanced Fuel Cycle Technologies

Advanced Safeguards Technologies

Advanced Location Technologies

Within those three mission opportunities, a suite of tasks will be selected as candidates for the ***Center*** involvement in FY13 to validate the ***Center*** concept.

There is a long term need in the United States to develop a variety of novel alternative technologies to support the sound management of commercial power reactor used nuclear fuel and the potential for recycle of fuel material resources (including alternative(s) to PUREX commercial used nuclear fuel separations technologies and supporting accountability measures for used fuel recovery). Critical to the successful deployment of those new technologies is the ability to conduct demonstrations under relevant conditions (e.g., radioactive environment with actual materials, relevant scale). The SRS presents unique operations and assets, such as H-Canyon and L-Area which can be used to provide those relevant conditions for demonstrations of Advanced Fuel Cycle Technologies such as off gas treatment and capture technologies, fuel reprocessing technologies, and dry storage technologies.

The DOE/NNSA has recognized the need for the development and implementation of Advanced Safeguards Technologies. This need is acknowledged through the NNSA's Next Generation Safeguards Initiative (NGSI), where one of the main pillars is technology development. New detectors and detector materials open the possibility of operating in a more efficient and cost effective manner, thereby strengthening national and international safeguards objectives. In particular, such detectors could serve the DOE and International Atomic Energy Agency in improving timeliness of detection, minimizing uncertainty and improving confidence in results.

To move novel detector technologies for nuclear materials from the laboratory into operation, there is a need to find suitable locations to conduct field trials of these devices. As identified in the NGSI program plan, there is a lack of fully operational facilities that allow for full-scale testing of new technologies. The SRS H-Canyon has been identified as a location for establishing such a test bed. H Canyon is unique in that it is the nation's only operational nuclear chemical separations plant and offers several areas where full scale testing could be conducted. This facility and SRNL provide the needed expertise and operational environment for deploying, testing, and evaluating advanced detector technologies.

The availability of Advanced Location Technologies will enhance the effectiveness, efficiency and assurance in securing nuclear materials by DOE and other U.S. government agencies. The need to track and monitor high-value materials (not just nuclear materials) is prevalent throughout industry and governments both in the United States and internationally. The SRS plutonium storage facility presents the opportunity to demonstrate and validate these advanced location technologies in a relevant radiation environment. Furthermore, the SRS general site offers the ability to test and validate other attributes advanced locations technologies in variety of natural and man-made environments in a secure and controlled manner.

A preliminary governance structure/model for the ***Center*** is being developed which includes a high-level structure for the ***Center*** (Figure 2), charter, roles and responsibilities of the ***Center*** in its interactions with researchers and facility teams.
Each individual research demonstration project will have its own project team consisting of representatives from the off-site research team, key facility personnel (e.g., operations, maintenance, radiological control, etc.). Critical to the success will be the ***Center*** representative who maintains the momentum of the team's progress and is knowledgeable of the facility's operations. As more research demonstrations are identified, the ***Center*** will serve as the logistics manager to assure that facilities can accommodate the requested demonstrations in the desired time frame and then will prioritize the execution of the research demonstrations.

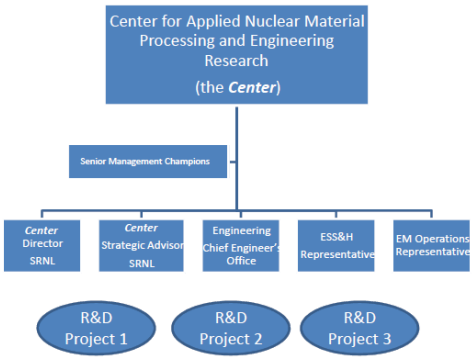

Figure 2. High-level organizational structure for the ***Center***

In 2013, the ***Center*** started working with researchers on demonstrations for H-Canyon to test the validity of the ***Center*** concept and to provide a more robust governance structure. One demonstration of advanced safeguards technologies provided the opportunity for the ***Center*** to develop a lessons-learned document for facilitating successful interactions among the off-site researcher team, the on-site research point of contact, and the operating facility. In addition, the ***Center*** has been involved with the development of a plan for the H-Canyon demonstration of two promising technologies under development: The first technology involves the application of absorbance, Raman, and gamma spectroscopy for measurement of actinides in process solutions. The second technology involves the capture of volatile radioactive species (iodine-129, tritium, carbon-14, and krypton-85) that are created during the irradiation of fuel in the reactor. Both of these technologies have been successfully demonstrated at the laboratory scale. Operational testing at the plant scale is the next phase required to advance the technology. Using the H Canyon facility at the Savannah River Site, the ***Center*** will be a critical component to facilitate the operational testing needed to for equipment performance at an actual plant scale, assess technology robustness in a highly radioactive environment, and establish operational requirements and impacts associated with technology deployment.

CONCLUSION

The ***Center*** will be the Gateway to SRS Assets used to demonstrate emerging technologies in an operational environment. By providing the necessary integrating function between the research teams and the requisite facility organizations, the ***Center*** will assure that the demonstrations are conducted in a cost-effective and efficient manner. As the interface between the research teams and facility organizations, the ***Center*** will serve as the cradle-to-grave liaison for the demonstration including such items helping to identify potential demonstration locations, monitoring schedules, arranging meetings of research and facility personnel,

especially during the early stages of planning the demonstration, and addressing regulatory issues. This collaboration among academic institutions, national laboratories, and commercial research entities with the ***Center*** will result in the successful maturation of the transformational technologies and the technical workforce needed to assure that the United States maintains a strong leadership in nuclear waste disposition, advanced nuclear fuel cycle technologies, and nuclear materials processing, packaging, storage, and disposition.

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