WM'00 Conference, February 27-March 2, 2000, Tucson, AZ

AN OVERVIEW OF THE NUCLEAR MATERIALS FOCUS AREA RESEARCH PROGRAM

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The Nuclear Material Focus Area (NMFA) is responsible for providing comprehensive needs identification, integration of technology research and development activities, and technology deployment for stabilization, packaging, and interim storage of surplus nuclear materials within the DOE Complex. The NMFA was chartered in April 1999 by the Office of Science and Technology (OST), an organizational component of the U.S. Department of Energy's (DOE) Office of Environmental Management (EM). OST manages a national program to conduct basic and applied research, and technology development, demonstration, and deployment assistance that is essential to completing a timely and cost-effective cleanup of the DOE nuclear weapons complex. DOE/EM provides environmental research results, as well as cleanup technologies and systems, to meet high-priority end-user needs, reduce EM's major cost centers and technological risks, and accelerate technology deployments. The NMFA represents the segment of EM that focuses on technological solutions for re-using, transforming, and disposing excess nuclear materials and is jointly managed by the DOE Albuquerque Operations Office and the DOE Idaho Operations Office.

EM introduced the Focus Area concept in 1994 with the original set of Focus Areas including Mixed Waste, Tanks, Subsurface Contaminants, Deactivation and Decommissioning, and Plutonium. The NMFA is the newest Focus Area and is the successor of the Plutonium Focus Area. The Focus Area approach to research and technology deployment ensures that OST programs remain focused on EM's most pressing needs. Focus Areas are the primary management entities for implementing DOE-EM and OST mission and strategies as each Focus Area addresses one major EM problem area and provides responsible, technically defensible solutions for cleanup and environmental stewardship at DOE sites.

When EM chartered the Nuclear Materials Focus Area, scope of the Plutonium Focus area was replaced and broadened. The new mission includes conducting a research and development program to develop technologies to support the safe management and expeditious stabilization of nuclear materials by identifying and providing technical solutions to the broad range of challenges associated with the management of nuclear materials. Specifically, the NMFA's research and development program has the following objectives:

- develop and deploy new technologies for nuclear materials stabilization and disposition;
- enable progress towards meeting EM's Accelerated Paths to Closure objective;
- develop integrated solutions to obtain both multisite and multiprogram benefits; and
- provide research and development support for the Department of Energy's (DOE) responses to the Defense Nuclear Facilities Safety Board's recommendations.

The materials scope of NMFA responsibility is the inventory of nuclear materials "owned" by EM, Nuclear Materials "owned" by other DOE programs, but stored in EM facilities or sites, and will

include nuclear weapons components and materials not yet transferred to EM. The specific materials scope of the NMFA includes:

- transuranic isotopes (all forms of Pu, Np, Cf, Cm, Am, mixed oxides, and residues);
- uranium/thorium (all forms of U233, DU, Th, NU, HEU, and LEU);
- isotope materials and sealed sources (material such as Cr, Co, Pa, Ac, Sr, and Cs, standards and sources such as Cs, Pu-Be, Am-Be, Ra, and Co); and
- all material contained in the Defense Nuclear Facilities Safety Board recommendations 94-1 and 97-1.

One example of a material concern the NMFA is addressing is the 20 tons of unstable plutonium residues that remain in the weapons manufacturing pipeline. These unstable materials pose imminent environmental, safety, and health hazards at several DOE sites (e.g. Rocky Flats Environmental Technology Site, Hanford, and Savannah River). The Defense Nuclear Safety Board issued DNFSB Recommendation 94-1 in response to these significant safety concerns and the need for timely remediation action. Commitments were established by the DOE to provide technology developent and deployment of those technologies to resolve fissile material stabilization issues and stewardship integration of site-specific and complex-wide issues.

The NMFA supports the EM-60 DOE Nuclear Materials Stewardship Program. The major goal of the DOE Nuclear Materials Stewardship Program is the integrated management of DOE's excess nuclear materials. Management of these materials, which involves stabilization, safe packaging for storage and transportation, monitoring and surveillance activities, and ultimate disposition (re-use, transformation, or disposal as waste), presents significant challenges due to the varying amounts and multiple forms of materials, the associated health risks, accelerated cleanup commitments, reduced budgets, and non-proliferation concerns. In addition, there is a lack of knowledge and experience in dealing with many aspects of nuclear material management resulting in "technology gaps." Responsibility for nuclear materials management is highly distributed in the DOE. As a consequence, the NMFA has interface responsibility with a large number of programs within the Department of Energy. While many of these programs utilize the same types of nuclear materials, the programmatic use of these materials varies widely. Defense Programs (DP) uses nuclear materials in the nuclear weapons stockpile. Environmental Management intends to stabilize and store or dispose of nuclear materials. Fissile Material Disposition's (MD) goal is to dispose of surplus weapons materials Energy Research's (ER) goal is to use nuclear material for research and development of new energy sources. Nuclear Energy (NE) uses nuclear materials for the production of special isotopes and nuclear fuel cycles for future power generation. Each program uses nuclear material to advance its own goals and mission, and while not exactly the same, has commonalties that can be capitalized on to everyone's benefits. The NMFA must coordinate research activities with each of these DOE organizations and also involve universities and industry in the development of technologies. To evaluate the developed technologies, a systems engineering approach is used for selection of alternative solutions to problems and to identify optimal technical options; the status of relevant technology throughout the DOE complex is assessed and a core competency in nuclear materials management will be maintained in the Department supporting nuclear materials stewardship.

Overview of Research Program

The major goal of the NMFA is to provide solutions that satisfy the technology needs for removing DOE's excess nuclear materials from EM sites. Materials management involves stabilization, safe packaging for storage and transportation, monitoring and surveillance activities and ultimate disposition (re-use, transformation, or disposal as waste). This differs from other Focus Areas not only in the diversity of the materials, but in the quantity and form that each material may be found. Quantities of the nuclear material that remain within the complex can vary from small samples to substantial inventories.

The NMFA endeavors to develop and maintain a research program that addresses all stakeholder, regulatory, and safety concerns by bringing to bear the best and brightest talent available within DOE, national laboratories, universities, and, where applicable, industry. The NMFA's research program is designed to leverage technology development efforts to avoid duplication, while allowing for innovative technology options. Under the focus area centered approach, the NMFA leads the integration of EM-50's technology development that supports nuclear material stabilization, storage, and disposition. Five key elements distinguish the focus area centered concept:

1. **Integration.** The NMFA maintains continuous contact with other EM-50 programs in developing and executing technology development work supporting nuclear material stabilization, storage, and disposition. For the NMFA, these programs include Crosscutting, Industry, International, and University Programs. The NMFA maintains close working relationship with the Environmental Management Science Program to assure that basic research is directed toward technology development meeting the end-user needs. For each of these programs, the NMFA strives to ensure planned and ongoing technology development work that supports users needs effectively, efficiently, and without duplication.

2. **Expanding the Technical Assistance Role.** The NMFA seeks to be proactive in solving technical problems through the application of a Lead Laboratory. Beginning with its analysis of users technology development needs, the NMFA maintains an interactive posture with each user. The NMFAs goal is to ensure not only that the NMFA understands each need, but also to ensure that the user fully understands the ramifications of each need. The NMFA will align the needs with the appropriate expertise through the Lead Laboratory, identifying technology gaps. Throughout any year, the NMFA seeks to lead technical exchanges between technical researchers and users through various NMFA-led or NMFA-sponsored workshops will provide complex-wide technical assistance. The NMFA uses a "lead laboratory" approach to technology management and has designated Los Alamos National Laboratory as the Lead Laboratory. The broad scope of the NMFA, both in terms of materials and functions, requires a strong partnership between the Federal leadership, the Lead Laboratory, and the team of laboratories that will perform primary and contributing roles in the focus area. A panel of experts, the Technical Advisory Group, supplies review and recommendations to ensure the highest quality of performance and a defensible program. No single laboratory can effectively address all aspects of the focus area scope. It will require a team of technical experts residing in various laboratories across the complex, university collaborations, and interactions with industry.

3. **Maintaining the Highest Technical Capability.** The NMFA consists of a network of the most highly qualified federal and contractor technical and program management experts. The NMFAs technical core is drawn from seven contractors and national laboratories that regularly contribute to the program. The NMFA's User Steering Group (USG), Technical Advisory Group, and independent peer reviews ensure that the performers work meets the users needs and is of the highest quality. The NMFA uses performer selection criteria to select top quality organizations and principal investigators to carry out the NMFA's technical work.

4. **User Connection.** The NMFA is a consensus-driven program that formally includes users throughout program development and execution. The NMFA's planned program cycle shall include users throughout the process, including the annual kickoff meeting, technical response development to users' needs, midyear review, and Technical Task Plan review meeting.

5. **Communication of Science Results.** The NMFA is committed to maintaining lines of communication with both the sites and the EM-50 elements. Technology and science developments will be peer reviewed and published, and NMFA and principal investigators will present key achievements at appropriate meetings. The NMFA will host workshops, maintain a website, and assemble exhibit booths to inform customers, technology providers, and sponsors of progress, problems and other information pertinent to the focus area. Innovative Technology Summary Reports (ITSRs) will be written for newly developed techniques and technologies and will be presented at suitable focus area and Site Technology Coordination Group (STCG) forums to reach the widest potential user audience as possible.

The NMFA has initiated an aggressive effort to identify site technology needs consistent with its broadened scope. In FY99, 70 needs were identified from a total of 8 sites. Subsequent to the collection of needs, the NMFA has categorized research to be performed into Product Lines, which are made up of Work Packages. Each Work Package has related projects aimed at filling a technology gap. The Product Lines are as follows:

Stabilization: The largest concern associated with materials in interim storage is generation of gases. Plutonium contamination of uranium materials is also of concern because there is a need to reduce volumes in plutonium vaults. Work needed in this area includes development of gas generation measurement, analysis & modeling of gas generation, and separation of plutonium and uranium materials. The stabilization product line mitigates high-risk safety issues by addressing technology needs that are necessary to stabilize plutonium residues at Lawrence Livermore National Lab, Rocky Flats Environmental Technology Site, Savannah River Site, and Richland. In many cases, stabilization progress is a key element of site closure, as stabilization is required before materials can be shipped off the closure site to a receiver site. Stabilization technologies for the longer-term stabilization needs of contaminant removal from plutonium and uranium parts, processing of "off-spec" highly enriched uranium and stabilization of U233 will be addressed by deploying technologies from March 2002 through September 2008.

Packaging and Transportation: Many materials in interim storage require transport to other sites prior to stabilization. The generation of gases in the material packaging is frequently unknown and

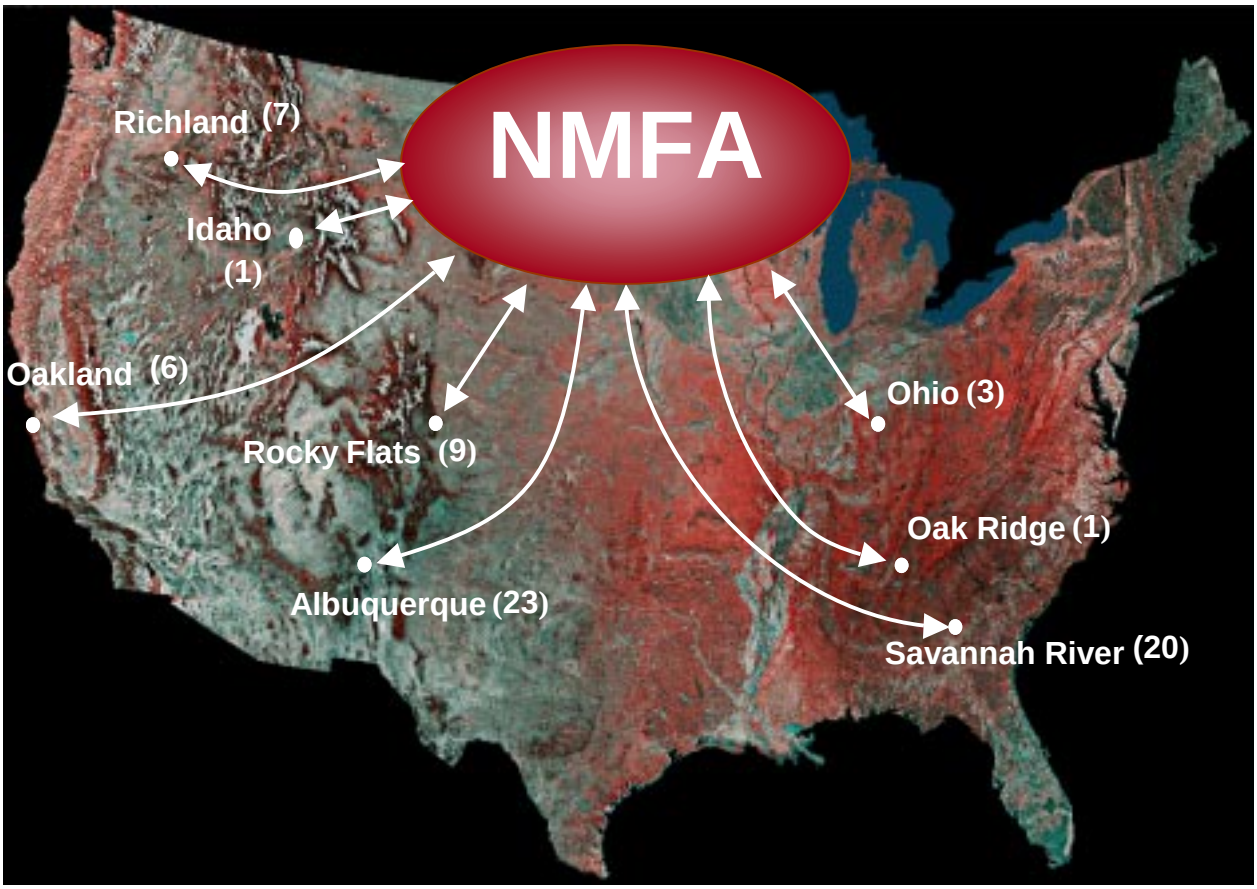

Figure 1: DOE Complex Sites that needs were collected from. The numbers of needs collected from each site are indicated in parentheses.

poses a risk for in-transportation. Work is needed in this area to address this potential for gas generation.

Packaging and transportation of nuclear materials is a critical element of the DOE ***Paths to Closure*** strategy. Removal of these materials is required prior to closing key facilities as identified by Defense Nuclear Facilities Safety Board commitments and stakeholder agreements, and to achieve mortgage reduction goals (including the stabilization of plutonium residues at RL, SRS, LANL, and RFETS).

Some nuclear materials exist in chemical and physical forms that were not historically transported in the complex. Their transportation is now necessary due to lack of processing capabilities at many sites. Packaging, and transportation technologies for other needs include a vacuum transfer system to repackage uranium residues at Fernald Environmental Management Project and glove box automation technology to increase throughput and reduce personnel exposure at closure sites by deployment of technology.

It is recognized that a purely manual repackaging operation is unlikely to meet site closure schedules. For automation and robotics efforts to be successful in nuclear materials processing, technologies that support this activity must be developed and tested to a high degree of surety.

Technologies identified to date include robotic hardware development, vision systems, creation of data and knowledge bases, high surety real-time sensor based control, and enhanced process and operations simulation capability.

International Coordination: In both Russia and the U.S., actinide solutions in various compositions need to be stabilized to minimize various risks. A new technique for solidification has been developed in Russia - it has been named "Gubka", the Russian word for sponge. Work is needed to complete the development dissemination of this technology. Research and development will continue on the joint Focus Area/Russian program to develop a porous crystalline matrix to stabilize problematic actinide solutions at Hanford and thorium-uranium solutions at ORNL. In addition to the INEEL, three Russian laboratories are involved in developing and testing the Gubka material – Khlopin Radium Institute at St. Petersburg, Mining and Chemical Combine at Zheleznogorsk (Siberia), and Institute of Chemistry and Chemical Technology at Krasnoyarsk (Siberia).

This product line will also identify and start new international projects to support NMFA needs. Work is to be conducted under the auspices of the Peaceful Uses of Atomic Energy Agreement and the Memorandum of Understanding between the Russian Federation of Atomic Energy and the United States Department of Energy for Cooperative Research on Waste Management and Environmental Remediation.

Material Processing: Beyond stabilization, many nuclear materials require further processing to meet acceptance criteria for transfer to other uses, long term storage, or final disposition. Several technologies are in various stages of development for the diverse types of materials that must be addressed.

Research and development is required on a number of materials processing techniques to address diverse chemical and physical forms of the materials currently in EM custody. In many cases development of alternatives to traditional methods of material processing is required due to facility closure or stakeholder agreements. The Material Processing Product Line mitigates high-risk safety issues by addressing technology needs to stabilize plutonium residues and solutions at Lawrence Livermore National Laboratory, Hanford Nuclear Reservation, Savannah River Site, and Rocky Flats Environmental Technology Site. Material processing technologies for other needs include innovative methods for decreasing radioactive lifetimes of nuclear materials, problematic uranium residues at Fernald Environmental Management Project, non-actinide sealed sources across the DOE Complex, Pu238 residues at Hanford, and high-fired Pu oxides from disassembled weapon parts at Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Savannah River Site.

Long Term Storage Issues: Concerns for long-term storage include the need to develop effective monitoring systems, standards for corrosion tolerance, improved long-term storage containers, and safety standards. Long term storage of Pu metal and oxide is currently anticipated for up to 50 years. Nuclear materials will be stabilized and put into stainless steel containers that must be monitored to determine environments within the storage cans and the effects of materials and stainless steel interactions. A variety of failure mechanisms can occur over this long storage period,

therefore, design requirements must be identified to support long-term storage.
The Long Term Storage Product Line mitigates high-risk safety issues by addressing technology needs that are necessary to meet two Defense Nuclear Facilities Safety Board 94-1 commitments to safely store stabilized plutonium metal and oxides at Lawrence Livermore National Laboratory and Savannah River Site. Also, it supports actinide storage vault improvements at Savannah River Site, Hanford, Lawrence Livermore National Laboratory, Rocky Flats Environmental Technology Site and Los Alamos National Laboratory.

Long term storage technologies for other needs include cesium capsules at Hanford. Current baseline methods for cesium capsule monitoring are labor intensive and tedious. The potential exists for a leaking capsule to contaminate a pool to the degree that worker entry is prohibited before the capsule can be identified and removed to an alternate shielded location.

Core Technology: NMFA has the responsibility of maintaining a core scientific understanding of behavior to reduce the risk associated with materials remaining in the EM complex.

Technology Support to Sites: Sites with small quantities of nuclear materials need support and leverage of insights gained from efforts at larger sites to gain the best technological implementation for available funding. The NMFA will provide an integrated effort to support needs of these sites.

As the NMFA continues to work with the sites, additional needs may develop that are not addressed by the currently planned Product Lines. As necessary, the NMFA will develop new product lines to address these needs.

A Look to the Future

The NMFA will strive to meet its goal to conduct a research and development program to develop technologies to support safe management and expeditious stabilization of nuclear materials currently under the purview of the Office of Environmental Management (EM). As a young focus area that is in transition, the unique challenges for the NMFA include the breadth of forms, quantities, and types of nuclear materials that have a broad range of disposition opportunities such as re-use, transformation, or disposal.

The NMFA is dedicated to identifying and providing technical solutions to these challenges.