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Summary of Findings of the R&D Committee

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ABSTRACT
In March 1995, the Department of Energy's (DOE) Nuclear Materials Stabilization Task Group (NMSTG) chartered a committee to formulate a research and development (R&D) plan in response to Sub-recommendation (2) of Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 94-1. The NMSTG was established as an organizational unit operating under the auspices of the DOE Office of Environmental Management. As a result of its efforts, the Research Committee concluded that, in general, the technology needs for stabilizing 94-1 nuclear materials are being adequately met by existing or planned DOE programs. At the same time, the committee, in the form of recommendations, noted specific R&D program areas that should be addressed by the NMSTG. These recommendations are documented in the R&D plan and formulated based on: (1) existing "gaps" in DOE's R&D stabilization program, (2) the relative maturity of various technologies, and (3) other important R&D program issues that, in the judgement of the committee, should be addressed by the NMSTG. A systems engineering approach, derived from the aerospace industry, was applied to the various stabilization technologies to assess their relative maturity and availability for use in treating 94-1 nuclear materials.

INTRODUCTION
On May 26, 1994, the DNFSB issued Recommendation 94-1, which expressed the Board's concern about nuclear materials left in the manufacturing "pipeline" after the United States halted its nuclear weapons production activities. The DNFSB emphasized the need for remediation of these materials. DOE accepted DNFSB Recommendation 94-1 on August 31, 1994. After establishing the Nuclear Materials Stabilization Task Group, DOE issued an implementation plan to address these concerns ("Defense Nuclear Facilities Safety Board Recommendation 94-1 Implementation Plan," February 28, 1995).

As part of Recommendation 94-1, Sub-recommendation (2) stated "that a research program [should] be established to fill any gaps in the information base needed for choosing among the alternate processes to be used in safe interim conversion of various types of fissile materials to optimal forms for safe interim storage and the longer term disposition. Development of this research program should be addressed in the program plan called for by [the Board]."

Consequently, in March 1995 the NMSTG chartered a committee to accomplish the following: (1) assess the nuclear materials stabilization program outlined in the implementation plan, (2) formulate an R&D

plan to address the technology and core program needs of the stabilization program, and (3) prepare task statements defining R&D activities required to accomplish program objectives.

The methodology used by the committee to formulate the plan included a review of the Implementation Plan and Site Integrated Stabilization Management Plans; visits to the Savannah River Site (SRS), the Hanford Site (Hanford), Lawrence Livermore National Laboratory (LLNL), and Los Alamos National Laboratory (LANL); and regular meetings of the Research Committee, including ex-officio members and technical advisors.

In developing the plan, the committee addressed five of the six material categories discussed in the 94-1 Implementation Plan, which consisted of plutonium solutions, plutonium residues and oxides (< 50% Pu), plutonium metals and oxides (> 50%), uranium metals, and special isotopes. R&D efforts related to spent nuclear fuel stabilization, the sixth category, were specifically excluded from consideration in the plan. These efforts are being coordinated through the Technology Integration Technical Working Group established by the Office of Spent Fuel Management in June 1993. In addition, issues related to funding, schedules, logistics planning, and facilities were not within the scope of the plan and are being addressed by the Integration Working Group and by other groups as designated by the Director of the Nuclear Materials Stabilization Task Group.

The committee selected to develop this R&D plan consists of 10 members: 2 independent consultants serving as co-chairmen and 8 technologists representing five DOE national laboratories and three production sites. In addition, ex-officio members from the DOE Office of Fissile Materials Disposition; the Office of Environment, Safety and Health; and other national laboratories were invited to attend the Research Committee's meetings. Organizationally, the Research Committee reported directly to the NMSTG Director.

In responding to DNFSB Recommendation 94-1, DOE committed to complete specific nuclear materials stabilization tasks assigned to 3- or 8-year timeframes. The Research Committee focused its review on existing technologies and on technologies currently under development to determine their adequacy relative to the 3-year commitments shown in Table 1. The committee also outlined R&D requirements to address technologies needed to support the Department's 8-year commitments.

Table 1. Three-Year Stabilization Commitments

Commitment	Date
Transfer PUREX solutions to tank farms (Hanford)	August 1995
Stabilize plutonium residue sludge (Hanford)	September 1995
Stabilize 220 kgs of residues (LANL)	October 1995
Vent 2,045 drums of residue (RFETS)	October 1995
Process F-Canyon plutonium solutions (SRS)	January 1996
Stabilize 46 packages of ash (Hanford)	March 1996
Repackage all metal in contact with plastics (All)	September 1996
Vent inorganic and wet/miscellaneous residues (RFETS)	October 1996
Remove and ship high enriched uranium solutions (RFETS)	December 1996
Stabilize high-hazard pyrochemical salts (RFETS)	May 1997
Stabilize high-hazard sand, slag, and crucible residues and graphite fines (RFETS)	May 1997
Process H-Canyon Pu-242 solutions (SRS)	November 1997
Convert HEU solutions to stable oxide (SRS)	December 1997
Stabilize remainder of high-hazard pyrochemical salts (RFETS)	December 1997
Stabilize sand, slag, and crucible residues (SRS)	December 1997

The Research Committee's first objective was to identify technology baseline requirements for all categories of nuclear materials and for related issues that must be addressed by the plan. These requirements are presented in the R&D plan and provide the formal basis for all technologies needed to address nuclear materials stabilization, regardless of the status of the required technologies. Programs that are either in place or are currently being developed are discussed in the plan, but are too voluminous for presentation in this paper. The format used for plutonium residues was based on the outline of categories established in DOE-STD-Draft-SAFT-0045, "Criteria for Safe Storage of Plutonium-Bearing Materials." By comparing baseline requirements with existing programs, the committee identified technology "gaps" that must be addressed if DOE is to implement a thorough and effective nuclear materials stabilization program.

The technology "gaps" identified by the Research Committee will be translated into task statements that will be issued separately, as needed. In addition, a systems engineering approach was used to evaluate the relative maturity of technologies now under development at various DOE facilities. The results of the analysis are also presented in the plan. These systems engineering data were used to determine (1) whether certain technologies designated as part of the baseline for stabilizing various categories of nuclear materials are sufficiently mature to require minimal attention from NMSTG and (2) whether certain competitive alternative or backup technologies should be pursued to ensure that methods for stabilizing nuclear materials will be available in a timely manner. The resulting maturity scores were based on information available at the time the plan was prepared and should be updated, as appropriate, before being used to support important programmatic decisions.

Table 2. Recommendations to Address Technology "Gaps" in the Stabilization Program

RECOMMENDATIONS	COMMENTS
Develop standards for the stabilization and storage of each of the special isotopes (Pu-238, Pu-242, and isotopes of Np and Am/Cm).	Site-specific rather than DOE-wide standards should be acceptable for each of these materials. Am/Cm isotopes will be stored in a highly shielded facility. Neptunium will require additional shielding because of its decay product. Pu-238 will require heat removal, venting to prevent helium buildup, and shielding.
Develop analytical methods for determining moisture content, gas composition from radiolysis, and reactive metals present in pyrochemical salts.	A process will be required to characterize moisture and reactive metals in salts treated for stabilization and to analyze the effects of radiolysis on stored salts.
Develop a flowsheet for stabilizing neptunium solutions at SRS.	Neptunium flowsheet development will require some R&D; however, the development of major new technologies should not be required.
Develop large-volume storage containers for low-assay (<10%) plutonium residues.	Existing storage configurations include containers that are larger than those prescribed by DOE-STD-3013-94. Larger containers (which will minimize the number of storage positions required) must be compatible with vaults planned for storage.
Evaluate the need for corrosion-resistant containers for halide salts and other corrosive residues.	Pyrochemical salts may either be processed for actinide separation or stored. If stored, corrosion-resistant containers must be used to ensure the long-term safe storage of salts.
Develop a surveillance system for monitoring Am/Cm and Pu-238 in storage.	Because of the high radiation levels for Am/Cm and the high heat generation rate for Pu-238, additional surveillance measures will be needed for storing these materials.

To ensure the timely development and implementation of the technologies outlined in the plan, the NMSTG will continuously track the progress of the R&D program. If a baseline technology seems unlikely to achieve the desired results or if a single competitive alternative technology must be selected, the NMSTG may, at its discretion, charter a trade study as part of the decision basis for that technology.

The plan was based solely on those nuclear materials stabilization requirements available to the committee at the time the plan was developed. In part because these requirements are still evolving, the nature of the R&D required to support this effort will change over time. Thus, the plan represents a snapshot in time and will need to be updated on a regular basis. The Research Committee was disbanded as of the issuance of the R&D Plan. Responsibility for tracking the information contained in the plan and for preparing updates to the plan will fall to the Plutonium Focus Area, an organizational unit charged with fulfilling the functions formerly assigned to the Research Committee. At present, the NMSTG plans to issue the first major update of this document in November 1996.

CONCLUSIONS

As a result of its efforts, the Research Committee concluded that, in general, the technology needs for stabilizing 94-1 nuclear materials are being adequately met by existing or planned DOE programs. At the same time, the committee has noted specific R&D program areas that should be addressed by the NMSTG. The recommendations summarized in Tables 2, 3, and 4 address these issues. To accomplish its objectives, the committee developed a comprehensive set of technology baseline requirements against which existing stabilization technologies should be measured. This comparison resulted in the identification of technology "gaps" in DOE's R&D stabilization program. These gaps are identified as recommendations in Table 2. Using a systems engineering approach, the committee also developed recommendations based on the maturity score of each technology considered. The recommendations listed in Table 3 relate to those technologies that, because of high maturity scores (low relative maturity), should be closely tracked by NMSTG to ensure their availability to meet 94-1 commitments. The recommendations provided in Table 4 identify important R&D program issues that, in the collective judgment of the committee, should be addressed by the NMSTG. These recommendations are offered to provide direction in key areas related to R&D and to identify potential programmatic weaknesses that may require attention from NMSTG management.

The recommendations offered in Tables 2, 3, and 4 are constrained by the following caveats:

- If significant changes are made in DOE-STD-3013-94, “Criteria for Safe Storage of Plutonium Metals and Oxides,” or in DOE-STD-Draft-SAFT-0045, “Criteria for Safe Storage of Plutonium-Bearing Materials,” significant changes in R&D needs may result.

- The ranking of technologies is based on meeting near-term goals (3 or 8 years) for stabilization. Since facility readiness and operational safety readiness for new or modified facilities may not be completed within a 3-year (and perhaps within an 8-year) schedule, new technologies are identified but are not ranked.

- Economic evaluation of alternative process options was not conducted.

Table 3. Recommendations for Tracking Technologies to Meet Stabilization Commitments

RECOMMENDATIONS	COMMENTS
Complete the timely development and startup of the vertical calciner at Hanford.	Although backup technologies are more mature, the vertical calciner will eliminate generation of a byproduct waste stream. This technology has been accepted by Hanford stakeholders.
Continue the concurrent development of multiple processes for stabilizing all categories of hazardous combustibles containing plutonium.	Multiple technologies are required if all hazardous combustible materials are to be treated (e.g., pyrolysis for other combustibles, catalyzed chemical oxidation, polycube pyrolysis, ion exchange denitration, chemical oxidation). Incineration is the most mature of these technologies; however, institutional issues currently preclude its use. Consequently, less mature technologies should be closely tracked by NMSTG management.
Continue the development of the modular concept at LANL as a means to eliminate startup of processing facilities at various sites.	Successful implementation of this innovative technology could produce substantial savings, allowing facilities that would otherwise be needed for accomplishing 94-1 goals to shut down.
Continue the development of technologies to address U-233 criticality safety issues at the MSRE facility.	Multiple technologies are being evaluated to determine the best option for addressing U-233 criticality safety issues associated with the MSRE Remediation Project.
Continue development of the bagless transfer system as a baseline technology and of electrolytic decontamination as a close-coupled backup technology for plutonium packaging.	The bagless transfer system is costly and needs to be demonstrated. Electrolytic decontamination coupled with manual loading and packaging could be a less costly alternative that is more readily implemented.
Complete development of digital radiography and/or digital radiography/tomography for monitoring plutonium packages in storage.	Noninvasive surveillance systems will minimize the need to sample and analyze materials in storage.

Table 4. Other R&D Program Recommendations

RECOMMENDATIONS	COMMENTS
Evaluate the institutional issues—particularly, negative public perceptions—that prevent deployment of incineration technology, which the RC believes to be the most viable method for treating combustible residues.	Incineration is the preferred technology for treating combustibles. Institutional issues preventing its use require further investigation. A favorable resolution of these issues can reduce R&D related to the stabilization of combustibles.
Maintain an ongoing core technology program to support stabilization technologies, to address unforeseen problems associated with long-term storage, and to provide technology for predicting the long-term behavior of nuclear materials.	As long as nuclear materials require stabilization and storage, R&D support will be needed to provide a better understanding of their behavior in order to address anomalies that may occur.
Provide R&D to identify and support the development and implementation of an interim storage standard for residues.	The interim storage standard is in a state of change. R&D support will be required to establish a technical basis for the standard.
Continue basic R&D studies of plutonium oxide behavior in support of DOE-STD-3013-94 (>50 and <80 wt % plutonium.)	Pure plutonium oxides (>80 wt % plutonium) can be stabilized at lower calcination temperatures and can contain higher levels of moisture for long-term storage. Less pure oxides should be evaluated to determine whether they can also be stabilized at lower temperatures.
Approve a DOE-wide storage standard for uranium metals and oxides and for other corrosive residues.	A site-specific standard is being used at the Oak Ridge Y-12 Plant, where most of DOE's high enriched uranium is stored. A DOE-wide standard, now under consideration, needs to be approved.
Develop an integrated approach for the storage and surveillance of plutonium packages, using nonintrusive technologies that minimize personnel exposures and maximize safeguards and security.	Although surveillance procedures are being developed for specific items, no systematic overall approach has been developed to monitor plutonium materials in storage. Noninvasive surveillance should be emphasized, minimizing the need for labor-intensive activities.

The approach used by the Research Committee to develop the plan involved a review of those technologies applicable to 94-1 Implementation Plan issues. Thus, this document does not reflect an R&D plan in the traditional sense, but rather it illustrates the breadth of technologies available to the NMSTG for addressing 94-1 requirements. The plan also identifies gaps in technological information that should be considered in order to ensure the successful and timely stabilization of DOE's nuclear materials.

This process used in developing the R&D Plan is consistent with the problem-solving approach endorsed by the Secretary for examining a wide range of issues faced by the Department in the post-Cold War era. By emphasizing cooperation and information sharing within the Complex and by adopting proven techniques from a variety of external sources, DOE has been able to allocate its limited resources more efficiently. This R&D plan is also an integral part of the Department's commitment to ensure the health and safety of workers and the public through the responsible management of its inventory of nuclear materials.

Based on the results of its efforts, the Research Committee concluded that, in general, the technologies necessary to address 94-1 issues are currently available, are under development, or have been identified as gaps that should be addressed by NMSTG management. Thus, the committee concludes that new initiatives involving costly R&D programs for extensive technology development are not necessary. However, the NMSTG must establish the funding and tracking mechanisms to ensure that baseline and competitive alternative technologies are implemented to meet 94-1 commitments. The systems engineering approach used in formulating the plan offers an effective model for tracking and decision making and should prove valuable to the NMSTG in ensuring the timely implementation of these technologies.

DISCLAIMER
The views expressed in this paper are those of the authors and do not necessarily reflect any biases, proposed actions, or decisions of the United States Government or any agency thereof.