SAFEGUARDS & SECURITY ISSUES FOR THE DISPOSITION OF FISSILE MATERIALS

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ABSTRACT

The Department of Energy's Office of Fissile Material Disposition (FMD) is analyzing long-term storage and disposition options for surplus weapons-usable fissile materials, preparing a programmatic environmental impact statement (PEIS), preparing for a record of decision (ROD) regarding this material and conducting other activities. The primary security objectives of this program are to reduce major security risks and strengthen arms reduction and nonproliferation (NP). To help achieve these objectives, a safeguards and security (S&S) team consisting of participants from Sandia, Los Alamos, and Lawrence Livermore National Laboratories was established. The S&S activity for this program is a cross-cutting task which addresses all of the FMD program options. It includes both domestic and international safeguards and includes areas such as physical protection, nuclear materials accountability and material containment and surveillance.

This paper will discuss the activities of the Fissile Materials Disposition Program (FMDP) S&S team as well as some specific S&S issues associated with various FMDP options/facilities. Some of the items to be discussed include the threat, S&S requirements, S&S criteria for assessing risk, S&S issues concerning fissile material processing/facilities, and international and domestic safeguards.

BACKGROUND AND INTRODUCTION

The DOE has established a program, Fissile Materials Disposition Program (FMDP) to address the disposition options applicable to the long-term storage and disposition of surplus fissile material. A number of different disposition alternatives are being considered and include facilities which provide for long-term and interim storage, convert and stabilize fissile materials for other disposition options, immobilize fissile material in glass and/or ceramic material, fabricate fissile material into mixed oxide (MOX) fuel for reactors, use reactor based technologies to convert material into spent fuel and dispose of fissile material using a number of geologic options.

A S&S team consisting of participants from Sandia (SNL), Los Alamos (LANL) and Lawrence Livermore (LLNL) National Laboratories, was formed to support the FMDP. The S&S team is providing integrated domestic safeguards and security (S&S) and international safeguards (ISG) support to FMDP during the PEIS process and the decision analysis process for the ROD to discriminate between alternatives. This is a cross-cutting task which is applicable to all FMDP facilities, alternatives and supporting tasks. The ultimate goal is to assure that safeguards, security and inspectability risks/impacts are considered in alternatives screening and design decisions. Integrated S&S and ISG systems are being evaluated against current and projected threats, and proliferation resistance with consideration for operations, costs and schedule.

SCOPE

There are two distinct areas to consider for each alternative, international safeguards (ISG) and domestic safeguards and security. Domestic safeguards and security (S&S) is comprised of two subsystems, physical protection and nuclear materials control and accounting required for protection of SNM and nuclear weapons against threats of diversion and theft and for protection

against radiological and toxicological sabotage threats. Requirements are established by the DOE and the NRC in this area. International Safeguards (ISG) is also comprised of two subsystems, materials containment and surveillance and nuclear materials accountancy required to satisfy international inspection agreements. Requirements in this area are derived from the IAEA Statutes and the Information circulars of the IAEA. The technologies associated with S&S and ISG have very different charters, so both areas must be considered for the FMDP.

Specific differences exist between the S&S and ISG in the risks/vulnerabilities, designs, technologies, and operations. Therefore an integrated systems approach for these is necessary. The S&S team provides unified input to the Programmatic Environmental Impact Statement (PEIS) and the Record of Decision (ROD) processes and performs necessary R&D in the areas of S&S and ISG. Support is alsogiven to other FMDP teams in the preparation of their input to the decision analysis process for the ROD, to the definition of S&S metrics for the screening criteria, and in the preparation of flow diagrams and optimization models.

Areas that will be addressed relative to S&S and ISG are:

- evaluation of nuclear measurement system requirements to support the alternatives,
- applicability of existing technologies and identification of areas requiring new technologies to support the alternatives,
- capability to meet third party international inspection agreements,
- safeguarding possible classified matter
- the ability to meet domestic materials control and accounting, and international materials accountancy requirements and
- proliferation risk.

Metrics will be developed to support the evaluation of the objective and subjective criteria, particularly those related to S&S and non-proliferation (resistance to theft and diversion, resistance to material retrieval and reuse, fostering international progress and cooperation). In addition, the integration of S&S and ISG elements will be addressed to determine the degree to which those alternatives which minimize the operational life-cycle costs, radiation exposure, and nuclear safety concerns while still satisfying domestic and international policy requirements. Integration not only among S&S systems, but also with non-security functions is necessary to help minimize costs, minimize operational impacts and to enhance operational surety

APPROACH

Based on a history of over 25 years of experience in S&S and ISG, subject-matter experts from SNL, LANL and LLNL, will evaluate the FMDP alternatives end-to-end. The expertise will be applied to identify unique issues, risks and discriminators as well as evaluating the documented approaches that nuclear facilities have for handling Category I and II quantities of plutonium/HEU and other nuclear materials. The detail and accuracy of the information resulting from this task will be consistent with the limited level of detail available from the facility designs.

ACTIVITIES

The following activities will be performed in support of the FMDP which focus on providing input to the PEIS and ROD.

1. Develop an integrated S&S and ISG plan defining how representatives from the four technology areas, physical protection, containment & surveillance, domestic materials control and accounting, and international materials accountancy, will allocate responsibilities, interface with the alternatives, and coordinate their inputs to the PEIS/ROD.

2. Obtain data on the forms of material for each facility and the operations, evaluate the material flow diagrams with respect to S&S and provide support to the decision analysis process for selecting alternatives by providing information relative to the S&S and ISG technology areas. This includes development of metrics and providing information to evaluate objective and subjective criteria, helping to define guidelines for National Academy of Sciences (NAS) standards on spent fuel and stored weapons and resolving conflicts between S&S requirements, ISG requirements and operational needs.

3. Characterize the proliferation and security risk, identify S&S requirements, define the threat and targets for each alternative, and identify and evaluate significant vulnerabilities and risks. A security risk matrix will be developed for each alternative. This will provide guidance to the alternative teams on S&S and ISG issues, assist with inter-facility integration where such integration can improve S&S and ISG, reduce operational/ES&H impacts, and identify facility S&S risks. Nuclear measurement requirements, integrated material monitoring and control, continuous attribute monitoring, operational surety, S&S with respect to automation and robotics, intra-site movement of SNM and dual use of technologies for both domestic and international monitoring will also be evaluated.

4. Provide support to the PEIS process by preparing an S&S section for each alternative report and responding to questions that arise relative to S&S and ISG.

5. Identify areas for new technology applications and/or possible R&D activities to address S&S requirements and reduce technical risk in support of the various alternatives.

SPECIFIC S&S/NP AREAS AND ISSUES

Assumptions. Listed below are a few of the assumptions for the FMDP concerning S&S and NP.

1. Any material already under IAEA safeguards will remain under IAEA safeguards.

2. Any fissile material not declared excess to stockpile and the strategic reserve will be exempt from IAEA safeguards.

3. Any unclassified material which has been declared excess and is available for disposition may be offered by DOE to the IAEA for IAEA safeguards and will remain under these safeguards.

4. Excess classified materials will not be offered for IAEA safeguards until classified/restricted information has been protected by the appropriate DOE operations.

5. All appropriate domestic and international S&S guidelines, regulations and circulars will apply to FMDP facilities and operations.

Requirements.

For domestic safeguards, both the Department of Energy (DOE) and Nuclear Regulatory Commission (NRC) guidelines may apply depending on the facility. If the facility is to be NRC licensed then NRC guidelines will apply. Some facilities, particularly those which might have classified material, may remain under DOE control (e.g. pit disassembly and conversion) and then DOE orders will apply. It has already been mentioned that any unclassified excess fissile materials will be under IAEA safeguards and these safeguards will apply to all FMDP facilities as appropriate.

Threat.

A generic statement of the threats which should be considered for the FMDP was developed. This threat statement addresses the situations, agents and motivations associated with the threat and is consistent with the guidance developed by the DOE and NRC.

The primary threats considered are:
- Theft or diversion
- Sabotage (radiological, toxicological and industrial).
- Unauthorized access

The security agents may be either insiders or outsiders, domestic or foreign and may include: terrorists, organized criminals, psychotics, activists, computer hackers or government sponsored agents from either weapon or non-weapon states.

In defining the screening criteria, the terms theft, diversion, retrieval and resue are used. They can be defined as:
- theft - unauthorized removal of material by a group of outsiders from a host nation weapons complex,
- diversion - unauthorized removal of material by a member of the host nations own weapons complex or unauthorized removal of material by the host nation itself in violation of the international regime before final disposition has taken place,
- retrieval - unauthorized access by the host nation in violation of the international regime after final disposition or unauthorized access by outside groups after final disposition, and
- conversion - the converting of retrieved material back into weapons form either by the host nation or other outside groups.

Material Flow and Target Identification.

From the material flow diagrams the unit process operations will be analyzed for each FMDP alternative with respect to S&S and NP. In addition to the actual process operations, the inputs, outputs, and wastes will be identified. Attributes such as material form, time/duration, personnel access, material control & accountability, physical environment, and quantities of material will be identified for each unit process operation. Based on these attributes, the attractiveness of the material and targets for the possible various threats will be identified.

Discussion of Standards.

The terms *spent fuel standard* (SFS) and *stored weapons standard* (SWS) were used by the National Academy of Science (NAS) in their 1994 report to discuss security needs for the disposition of weapons plutonium[1]. The intent of these standards was to suggest that the security for excess plutonium be comparable with that given to nuclear weapons and that

the disposition activities would seek to meet a 'spent fuel standard' which would make it comparable to the spent fuel existing in commercial reactors. The SFS and SWS were not clearly defined because they did not include "inaccessibility" or the characteristics which made material inaccessible. For the FMDP, the S&S team has tried to clarify these terms using proliferation resistance. We defined proliferation resistance as being a function of material form (e.g. radiological, physical, chemical properties), physical environment (e.g. ease of access, transporation, process, storage) and safeguards and security (e.g. domestic and international safeguards). The SWS applies to FMDP fissile material and can be thought of as graded protection of material based upon its quantity and attractiveness for use as a nuclear device. Material meeting the SFS is a subset of the SWS where certain characteristics have been met which make it less attractive and/or accessable.

S&S Risk Matrix.

Using the material form and the characteristics of the process, the relative proliferation risk can be determined. Although the proliferation risk for any given alternative will decrease as the fissile material becomes less attractive and approaches the "spent fuel standard", for some individual processes within an alternative the attractiveness of the material may actually increase. An example of this is the conversion and stabilization activities where residues and other such material may be converted into relatively pure plutonium oxide.

S&S risk is a combination of the consequences of a security event and the likelihood of such an occurrence. The consequences and the likelihood may be divided into several factors that in combination result in a high, medium, or low rating which can then be compared on a relative matrix. The risk matrix will combine the threat, material attractiveness and form, physical environment and specific S&S areas to provide a relative risk comparison for the various FMDP alternatives.

S&S/NP Criteria and Metrics.

There are three screening requirements in the Fissile Materials Disposition Program (FMDP) that relate directly to nonproliferation issues. These three criteria are *Resistance to Theft, Diversion, or Retrieval by Unauthorized Parties; Resistance to Diversion, Retrieval, Extraction, and Reuse by Host Nation;* and *Fosters Progress and Cooperation with Russia and Other Countries*. Although related because of concern for proliferation of nuclear weapons potential, these three criteria are distinct.

The areas of responsibility for the first two criteria can be separated naturally into national and international. The responsibility of the host nation government is to prevent unauthorized access to its material either by groups within its own weapons complex such as disgruntled workers or by other national or international terrorist groups, criminal organizations, etc. The responsibility of the international group is to prevent the host country from diverting or retrieving material that has been declared surplus. This gives a very clear delineation of the threats associated with each criterion. The third criteria is an indication of the degree to which other countries can apply the same alternatives.

Below is a brief discussion of these criteria and some examples of measures being considered for criteria 1,2 and 3. They may not necessarily be used in the final methodology, but are representative of the level of detail being considered.

Criterion 1 - *Resistance to Theft, Diversion, or Retrieval by Unauthorized Parties*

This criterion evaluates the system resistance to theft by an outsider, diversion by an insider, retrieval after final disposition by outside groups, and conversion of retrieved material by outside groups. Protection of the material and information from these parties is a domestic responsibility, not an international one. The performance measures being considered for this are in terms of:

Material Form - attractiveness based on physical, chemical, or nuclear (isotopic and radiological) makeup of the nuclear material during processing, transportation, or storage. The risk of theft or weapon use is reduced if material is only available in small quantities, is in a physical and chemical form or matrix that makes recovery difficult, or is isotopically unattractive.

Environmental Conditions - the logistics, physical location, and the state during processing, transportation, or storage affect the opportunities for theft. The more complex the logistics (such as transfers and storage locations), the more opportunities there are for theft. The more inaccessible the physical location, the fewer the opportunities for theft.

Safeguards and Security Assurance - the effectiveness of S&S protection depends on the form of the material,the physical protection characteristics of the processes and facilities involved in the storage and disposition activities and the material measurement systems being applied.

Criterion 2 - *Resistance to Diversion, Retrieval, Extraction, and Reuse by Host Nation*

This criterion evaluates the system resistance to diversion of material before final disposition by the weapon state itself, retrieval of material after final disposition by the weapon state itself, and conversion of the material back into useable form by the weapons state. The only existing world-wide inspection regime that exists to address this threat is the International Atomic Energy Agency. The performance measures which would demonstrate effectiveness in this area are in terms of:

- *Difficulty of Diversion, Retrieval, Extraction, and Reuse* - the difficulty (in cost and time) of retrieval of surplus Pu and its reuse in weapons. This establishes the timeliness criteria and the level of safeguards required.

- *Assurance of Detection of Retrieval & Extraction* - the difficulty of detection of diversion of a significant quantity of material. This depends on the following factors:
  - Ability to measure material which includes processing that is underway, accuracy of applicable NDA techniques, the presence of waste streams, and classification issues which may prohibit measurement, and whether item accountancy instead of bulk accountancy methods can be applied.
  - Containment and surveillance systems
  - Timeliness of detection

Criterion 3 - *Fosters Progress and Cooperation With Russia and Other Countries*

In view of the current political and economic instability in Russia, it is important that long term storage and disposition activities in the US provide a model for or otherwise promote timely implementation of secure monitoring regimes and ultimate disposition of nuclear materials in Russia and other countries. While the threat and domestic/international aspects do not directly apply, the systems used to achieve high resistance for criteria 1 and 2 must be transferable to Russia and other countries, support international treaties and bilateral agreements, and demonstrate weapons stockpile reductions. The performance measures which demonstrate effectiveness in this area are in terms of:

- *Likelihood of Russian Reciprocity or Equivalence* - the economic feasibility of the alternative given the lack of capital, the surplus of skilled labor, and the need for civil reactor nuclear fuel in Russia.

- *Compliance with Treaties or Agreements* - consideration of the implications of various international treaties or agreements that may directly or indirectly be impacted by alternatives.

- *Transparency* - availability of procedures and technologies for observing weapons fissile material processing and material accounting systems.

In addition to these three criteria, areas related to S&S and NP will also influence other FMDP criteria such as cost, environmental, safety and health, schedule, and public and institutional acceptance.

S&S and NP Issues.

There are many issues that have and will come up during the process of determining the best alternatives for disposing of our excess fissile material. Listed below are just a few examples:

- *FMDP alternatives issues* - During the analysis of the various FMDP alternatives a number of S&S issues have been identified which are important to a particular alternative. For the storage alternative classified material may be present and the material will remain in a very highly attractive form. For the reactor alternatives the feed material quality, waste streams and the time dependence of the irradiated spent fuel all influence S&S considerations. For the deep borehole alternative the requirement for continuous monitoring and long-term protection requirements are important. Finally, for the immobilization alternative nuclear measurements on "glass logs" which are either spiked with Cs137 or not spiked and the concentration of the plutonium in the "glass logs" are important issues which must be resolved.

- *Regulatory guidelines* - Facilities could be operated and/or regulated by the DOE, NRC or by some foreign government and they could be government owned or private facilities. In addition, all FMDP facilities handling unclassified excess fissile material will be subject to IAEA guidelines. The specific regulatory guidelines for each facility must be clearly delineated and material accountability ensured for an entire alternative.

- *Continuous accountability* - Throughout each FMDP alternative the accountability of the fissile material must be maintained. This will be a challenging task in view of the many changes in material form, large quantities of material and the

many different and separate facilities involved. As proliferation risk is reduced the level of safeguards required, particularly for long-term final disposition activities, and possible termination of safeguards must be determined.

- *Classified fissile material* - At the front-end of the FMDP alternatives classified fissile material may be part of initial feed material (e.g. pits, other nuclear material). Accountability and protection of classified information on this material during the disassembly and processing operations and as it moves to the next alternate step must be maintained.

- *Domestic and International safeguards* - Meeting the requirements of domestic agencies (e.g. DOE, NRC) and the IAEA with the minimal cost and operational impact will be a challenge. The commitment to place material under IAEA safeguards poses new precedents for the U.S.

SUMMARY

The safeguards and security activities are an important cross-cutting task that must be addressed for all of the FMDP alternatives. The 1994 National Academy of Science study on plutonium disposition stated that, "The primary goal in choosing options for the management and disposition of excess weapons fissile materials should be to minimize the risks to national and international security." The S&S approach certainly supports this goal and provides for the evaluation of proliferation resistance at all stages of the disposition processes and for all of the varying safeguards environments. There are many areas and issues to be considered in providing the necessary S&S support to the FMDP.

REFERENCES

1. Committee on International Security and Arms Control, National Academy of Sciences, "Management and Disposition of Excess Weapons Plutonium", 1994.

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