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Global Nuclear Materials Management: Building the Framework

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The Global Nuclear Materials Management concept[1] of system of national and international programs to address the safety, security and legitimate use of civilian, excess defense, and defense materials has gained increasing attention and acceptance over the last year. Senior officials and scientists in the United States and key international organizations have acknowledged the urgent need to transparently ensure this responsible management of nuclear materials worldwide, from cradle to grave. They have recognized that to meet this need, all states possessing nuclear materials, whatever their policy towards nuclear power and nuclear weapons may be, must help build and subscribe to a system of effective, durable, and consistent minimum standards for nuclear materials management[2].

The framework for this system, including verification and transparency activities, can be built on a combination of domestic, bilateral, multilateral, and international regimes. There has been significant progress towards building such a framework in the past year through initiatives in the United States, between the United States and Russia, and within the international community. For example, Integrated Safeguards will be a step forward for international assurance that civil nuclear materials are not being diverted for weapons purposes, and to detect any such clandestine activity, if it exists. Cooperative nuclear transparency projects, such as one initiated in the past year among Asian nuclear states, promise to openly provide assurance that power plants are operating safely. In the area of defense nuclear materials management, the United States Department of Energy initiated a comprehensive domestic Nuclear Materials Stewardship Initiative, and, in addition, opened the world's first deep geologic repository for transuranic wastes at the Waste Isolation Pilot Plant. Progress has continued in the Material Protection, Control, and Accounting programs in Russia's nuclear weapons complex. In the area of excess defense materials, the United States Department of Energy issued a record of decision for excess materials disposition in January 2000. Further progress has been made between the United States and Russia for an agreement on excess plutonium disposition, and between the United States, Russia, and the International Atomic Energy Agency for a verification regime to ensure that nuclear materials are irreversibly removed from defense programs.

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[1] See, "A Uniform Framework of Global Nuclear Materials Management", Dupree et al, presented at ESARDA 1999 Annual Conference.

[2] See, for example, "Managing the Global Nuclear Materials Threat – Policy Recommendations", Report of the Center for Strategic and International Studies, Washington DC, January 2000.

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Much remains to be done. The European community, through a broadened vision within EURATOM, can play a key role in building this global framework. In particular, we believe that ESARDA can make significant contributions by leading efforts in the European technical community to identify new verification and transparency technologies and processes to monitor not only the safety, but also the security, and legitimate use (i.e., use as declared) of nuclear materials of all classes. This paper reviews some of the progress in the last year towards building a global nuclear materials management framework, and recommends areas of emphasis for continued development within the community worldwide.

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Introduction

Global Nuclear Materials Management (GNMM) is a concept that envisions a dynamic and transparent framework to assure that all nuclear materials in the world – whether in civilian or military programs - are being used legitimately, safely, and securely[i]. The concept of such a system built on national and international programs has gained increasing attention and acceptance over the last year. Senior officials and scientists in the United States and key international organizations have acknowledged the urgent need to transparently ensure this responsible management of nuclear materials worldwide, from cradle to grave. They have recognized that to meet this need, all states possessing nuclear materials, whatever their policy towards nuclear power and nuclear weapons may be, must help build and subscribe to a system of effective, durable, and consistent minimum standards for nuclear materials management[ii].

The conceptual GNMM framework includes verification and transparency activities in a synergistic system of domestic, bilateral, multilateral, and international regimes. Many building blocks already exist – such as the international IAEA safeguards regime and individual state security systems – but these lack consistency and comprehensiveness in a global context. The GNMM vision is of a comprehensive system built upon these existing components. It includes technical requirements and implementation procedures, and the rationale for those requirements and procedures, for all phases of nuclear activities -- including potentially sensitive areas such as those involved in weapons production and excess material disposition. There has been significant progress towards building such a framework in the past year through initiatives in the United States, between the United States and Russia, and within the international community. This paper reviews some of the progress in the last year towards building a GNMM framework, and recommends areas for continued development within the community worldwide.

Role of Transparency

In the GNMM context, the goal of transparency is to provide continuously evolving insights into what the rationale behind the GNMM framework. These insights contribute to national and international confidence in the measures employed for implementation, increase openness where appropriate, and promote trust for working cooperatively between different states towards common security, safety, and nonproliferation goals.

Transparency measures are shaped in response to both world events and technical advancements. To understand what is needed to address present and future needs, both in terms of building a GNMM framework and the transparency measures necessary for confidence in that framework, it is useful to examine the historical events and responses that have shaped the present attitudes and regimes for use of nuclear options – both for defense and civilian power purposes – and the management of nuclear materials.

Prior to 1940, the world was in a period of open discovery and science, where the primary questions facing the nuclear community and world leaders was how to gain a better understanding of the science of nuclear physics how this new science could best be exploited for the benefit of mankind. This changed abruptly with the onset of World War II, which precipitated a period of secrecy, as world powers engaged in a race between opposing forces to develop the atomic bomb. This period ended with the first atomic explosions – first by the United States in 1945, followed closely by the Soviet Union in 1949.

In the period following World War II, there was a collective commitment of the international community to manage the peaceful uses of nuclear power under the United Nations framework and which was promoted by the United States with the Atoms for Peace program in 1954 and by the establishment of the International Atomic Energy Agency (IAEA) in 1957 During this era, the rationale was to limit access to materials for adverse purposes while promoting beneficial uses of the nuclear option. Transparency in the civilian use of the nuclear option was defined by the protocols established between the IAEA and member states to assure legitimate use of declared facilities and materials. At the same time, however, proliferation of missiles and bombers in both the United States and the Soviet Union, was based on defense rationale of mutual assured destruction. This period culminated in the Cuban Missile Crisis in 1962. The major nuclear powers responded with more surveillance and recognition of the need for more transparency in communications of strategic intent, while Latin America responded with the Treaty of Tlateloco to create a Nuclear Weapons-Free Zone.

The Cuban Missile Crisis also convinced the Soviet Union to never again be in a position to back down, and escalated vertical proliferation of missiles and multiple re-entry vehicles (MRV's). At the same time, the United States and the Soviet Union began to engage in a series of strategic arms control treaties, beginning with the Limited Test Ban Treaty (LTBT) in 1963, through the Strategic Arms Limitation Treaties (SALT I and II), the Intermediate Range Nuclear Forces (INF) Treaty of 1987, and continuing today with the Strategic Arms Reduction Talks (START). These treaties were possible because of the perception by both the U.S. and Russia that they served mutual security interests. Transparency was the means by which the intent of each sate was made evident so as to have an understanding of and confidence in this shared interest. The desire for transparency provided the rationale not only for the scope of the arms control treaties, but the implementation and verification procedures.

The international community responded with successively more rigorous and transparent measures to prevent horizontal proliferation and reverse the vertical proliferation; with the cornerstone being the landmark Nonproliferation Treaty of 1968. A key aspect to promoting the peaceful uses of nuclear energy under both the NPT and the IAEA regime was the development of nuclear export control regimes in the seventies, and the transparency measures developed between parties to these regimes. Even so, the world witnessed the nuclear explosion by India in the seventies. During the seventies, the world also witnessed several accidents in the civilian nuclear power industry, raising public concerns about the safety of nuclear power plants and the need for more transparency in their operations.

Proliferation has continued in the eighties and nineties, simultaneous with continued success in building and strengthening the nonproliferation regime. With the fall of the Berlin Wall in 1989, a new problem arose for the world's nuclear community, as they realized the urgency with which they must respond to the degraded security of nuclear materials in the weapons complex of the former Soviet Union. Increasing transparency in this instance, to provide the required protection, accountancy, and control measures to ensure the safety, security, and legitimate use of this material.

Today's Challenge: GNMM

Where is the world community today, as we enter the new millennium, in terms of balancing the risk-benefit equation for the management of nuclear materials, power, and arsenals? World inventories of plutonium and highly enriched uranium (HEU) have increased significantly in both the civilian and military cycles, with only a fraction falling under IAEA safeguards (See Figure 1).

Three countries not party to the NPT - India, Pakistan, and Israel – have demonstrated nuclear capabilities, while many others are widely recognized as being capable of developing nuclear weapons in short timeframes. In the Western world, civilian nuclear power capacity and associated infrastructures have at best remained static, if not decreased, while rising significantly in the Eastern Hemisphere. Nuclear arsenals are decreasing, and weapons are being dismantled, creating a need for new transparency measures and implementation regimes for management of these excess defense materials. The reduced nuclear arsenals of the U.S. and Russia will eventually drive a re-evaluation of the strategic balance of power between the other three declared nuclear powers, and corresponding transparency measures for the nuclear arsenals.

We maintain that this is a unique period of the nuclear era when the world collectively recognizes the need for synergistically balancing the risks with the beneficial uses in the three aspects of the nuclear equation: materials, power, and weapons.

The development of a global nuclear materials management framework is more essential now than ever to provide comprehensive, dynamic, and transparently effective means for uniform levels of assurance of the safety, security, and legitimate use of nuclear materials. The management of these nuclear materials can be considered along three pathways, including how the materials move between these three pathways. These three pathways are defense, excess, and civilian.

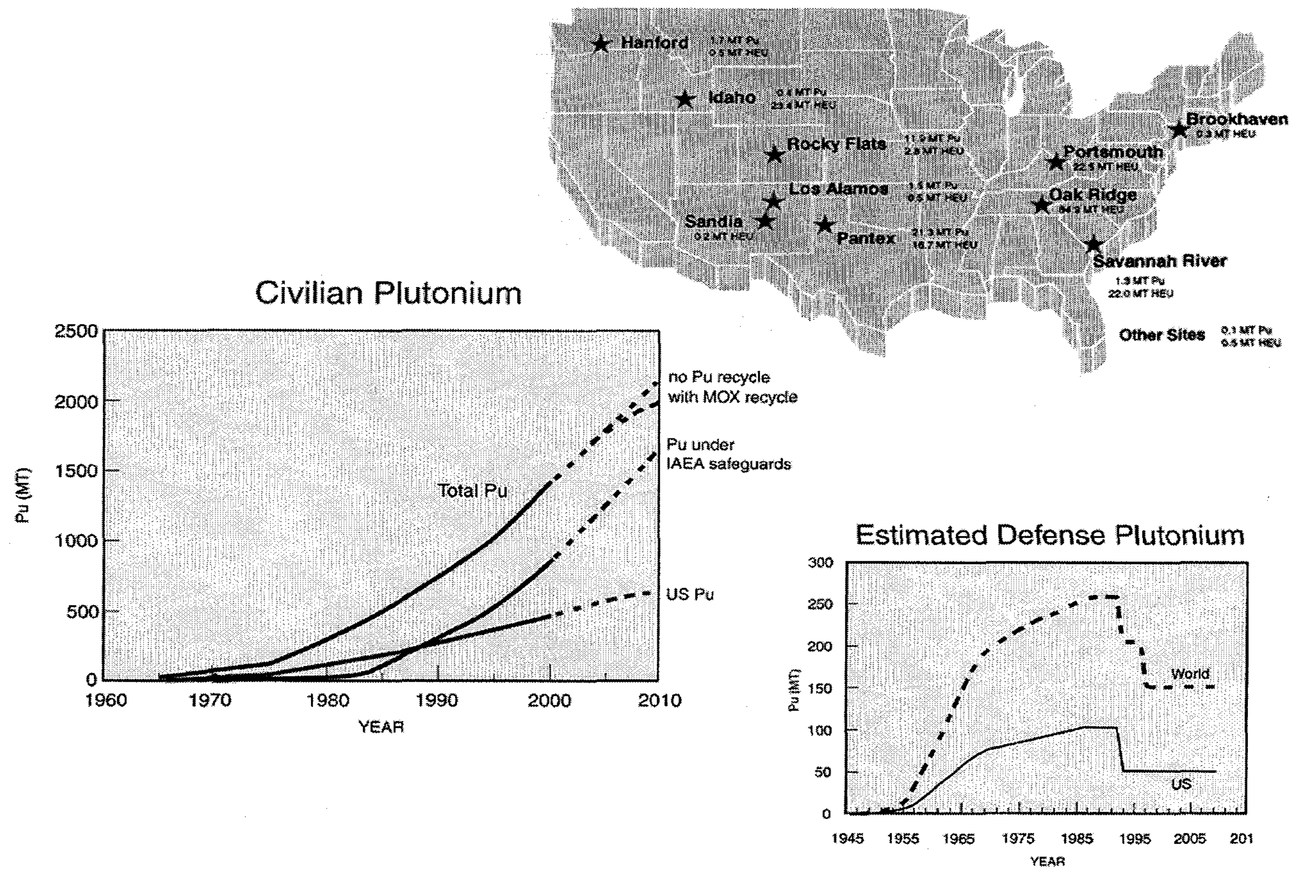

Figure 1. World plutonium inventories

Each pathway has unique characteristics and requirements that must be considered in populating the GNMM framework, with particularly sensitive requirements for transparency being set by the disarmament process and the resulting movement of materials from defense pathway to the excess material pathway for final disposition.

The GNMM Framework: Building Blocks

The building blocks for GNMM include formal verification activities associated with international treaties and regimes, cooperative measures between regional parties, and domestic measures undertaken by individual states. There has been significant progress this past year in each of these areas.

Domestic States' Measures: Activities in the United States

The GNMM concept has gained increasing attention and acceptance in the United States. For example, in 1999, the GNMM project of the Center for Strategic and International Studies (CSIS) in Washington D.C. brought together key government decision-makers, nuclear material managers, and academics to make high-level policy recommendations for GNMM. Of the four task forces in the CSIS project, the transparency task force dealt with the following issues of particular relevance:

- What is transparency?
- Can transparency ensure that nuclear materials are safely, securely and legitimately used throughout the world?
- Where and how can transparency be enhanced to support the worldwide management of all nuclear materials; what is the relation to other regimes and agreements?

The four CSIS task forces presented their policy recommendations in a colloquium in July 1999 and a subsequent report[iii], with the following recommendations from the task force on transparency[iv]:

Modest Actions

1. Enhance the ongoing transparency activities between the U.S. and Russia, and share the U.S.-Russia relationship into a model for others to emulate. Components include the use of the "lab-to-lab" model for transparency activities, data exchanges on aggregate stockpiles of nuclear warheads and fissile materials, joint transparency experiments at non-sensitive facilities, and the promotion of bilateral transparency norms and standards for the safety and security of excess and defense nuclear materials.
2. Complete the U.S-Russia-IAEA TriLateral Agreement.
3. Increase support for expanding IAEA transparency efforts, especially in strengthening safeguards, integrated safeguards, and safety and physical protection areas.

Significant Actions

1. Implement U.S. – Russia safety norms.
2. Negotiate and conclude data exchanges among the five nuclear powers.
3. Establish transparency norms among the nuclear weapon states.
4. Put all excess materials in the five nuclear weapons states under arrangements similar to the TriLateral Initiative
5. Improve international safety, security, and transparency in the back end of the nuclear fuel cycle of all states.

The CSIS task force envisioned that components under these recommended actions would include the following:

- The negotiation of safety, security and transparency norms for defense materials among the five nuclear weapon states, and the implementation of those norms, and
- The negotiation of international safety, security and transparency standards in the civilian nuclear fuel cycle for all states, and the implementation of those standards.

The CSIS policy recommendations highlighted the significant challenges faced in the U.S. and Russia in the post-Cold War transition, as both downsize their defense complex and engage in arms reduction and in disposition of excess materials. The U.S. Congress responded quickly to the CSIS policy recommendations with a mandate to the U.S. Department of Energy (DOE) to provide an integrated nuclear materials management plan for U.S. domestic programs and facilities.

To satisfy the Congressional mandate, the DOE established the Nuclear Materials Stewardship Initiative, reporting directly to Undersecretary Moniz. The goal of the DOE's Nuclear Material Stewardship Initiative is to provide integrated, corporate structure for achieving mission objectives[v] through effective and integrated cradle-to-grave management of fissile materials and other nuclear materials in a way that

- Provides for cost savings and budgetary efficiencies
- Provides continued risk reduction
- Advances integrated management of nuclear materials
- Results in improved effectiveness
- Promotes non-proliferation and arms control.

The development of DOE's Integrated Nuclear Material Management Plan (INNMP) has involved over one hundred contractors and government officials during the past fiscal year in reviewing DOE programs involving the management of nuclear materials, identifying opportunities for integration, and making recommendations for future planning. The plan, which is undergoing review and concurrence within the DOE, and which will be issued to the U.S. Congress this summer, addresses cross-cutting program issues for nuclear materials management, such as disposition of excess materials, facilities planning and operations for plutonium, uranium and orphan materials management[vi], and cost recovery.

In the process of producing the INNMP, DOE working groups recognized the need to develop methods of assessing proliferation risks to support planning and decision-making. A primary consideration in assessing the relative risk of proliferation in different fuel cycle options, is the consideration of the effectiveness of available safeguards and other measures to reduce those risks. Sandia National Laboratories is involved in a multi-laboratory effort, in partnership with private industry, to develop such a proliferation risk-informed method that may be used by the DOE and other government organizations to provide insights into the synergistic trade-offs between fuel cycle options among many programmatic areas.

The theoretical concept for the proliferation risk-informed approach being developed by Sandia builds on probabilistic risk assessment methods for nuclear safety and waste management programs, and incorporates methods developed for vulnerability assessments for safeguard and security, as well as human factors analysis. There is a close relationship between this theoretical concept to provide an assessment of proliferation risk and that being developed to support the IAEA in assessing the effectiveness of approaches for Integrated Safeguards under INFCIRC/ 540 and 153.

Sandia's conceptual proliferation risk model addresses the risks of material acquisition, weapon development, motivation, and opportunity in both nuclear and non-nuclear weapon states, and the consequences of the proliferation activity. The intent is to develop a theoretical basis for a uniform level of risk acceptance while enabling differentiation between options that account not only for objective measures of proliferation risk, but also subjective and situational, and the available means for preventing consequences from those risks. The effectiveness of safeguards is a fundamental component in the formulation of means available for preventing consequences, as well as estimation of the risk for material acquisition and opportunity. Some of the immediate potential applications for this method are regarding DOE decisions for domestic programs in advanced reactor technology, proliferation resistant fuel cycles, waste treatment and disposal methods, and facility management.

Cooperative Measures

Unofficial, cooperative measures can contribute significantly to the GNMM framework to develop common approaches to problems involving two or more states that are particularly difficult to resolve formally with multiple international parties. For example, potential solutions to the particular challenges that exist for nuclear weapon states to provide transparency in managing materials for defense needs have been investigated jointly by the U.S. and Russia since 1997 through the storage monitoring collaboration between Sandia National Laboratories and Arzamus-16. The system that has been jointly developed uses remote monitoring to observe storage containers at real storage sites for real weapons-useable materials, and the processes for sharing that monitoring data. This cooperation may form the basis for expanded cooperation between all nuclear weapon states for transparency as the means to ensure that their stocks of weapons useable materials are adequately protected and accounted for, without compromising security concerns.

In addition to cooperation measures for assuring the safety and security of weapons useable materials from defense programs, there has been increasing emphasis in the past few years for international cooperation in assuring that nonproliferation and international security objectives are met at the back end of the civilian fuel cycle. Last year, DOE Secretary Bill Richardson hosted an international conference on geologic repositories, with a panel devoted specifically to the issue of transparency and the need for international cooperation. This panel recommended that the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, which opened in 1999 as the world's first geologic repository for nuclear wastes, be used as a transparency testbed for engaging in international collaborations. Several activities have been initiated to this end using remote monitoring of underground sensors at WIPP that gather operational data, and monitoring of transportation shipments, with the ultimate goal of making the information accessible on the worldwide web, in accordance with security concerns.

The U.S. is also a key participant in the Northeast Asia Transparency Experiment. This activity, sponsored by the Center for Security and Cooperation in the Asia Pacific, has the goal of establishing regional confidence in the safe operation of nuclear power plants in Asia. The project has established a web page that provides data from radiation monitoring stations of nuclear providers in Japan, Taiwan, Korea, and China. The information is collected and displayed on a website maintained by DOE's Cooperative Monitoring Center in Albuquerque, New Mexico. This experiment provides a precedent for how to use the worldwide web as a building block in the GNMM framework –

engaging a multilateral community in a cooperative transparency regime – with many potential applications beyond Asia.

International Treaties and Agreements

Significant progress has been made in building the GNMM framework based on the work between the U.S. and Russia under formal governmental agreements already in existence, as well as in negotiating new treaties and agreements. Important milestones have been achieved in DOE's Material Protection, Control, and Accounting Program to secure nuclear materials in Russia, and in other Cooperative Threat Reduction programs, such as the HEU purchase agreement, to reduce the world inventories of stocks of weapons useable materials. Programs between European countries, Russia, and former Soviet Union States have made similar progress, but much remains to be done as more materials and sites of unsecured nuclear materials in Russia are revealed.

Of particular note is the progress made in negotiating both the legal terms and technical procedures for the TriLateral Initiative between the U.S., Russia, and the IAEA. The U.S., Russia, and the IAEA first undertook this initiative in September 1996 to consider the legal, financial and technical issues associated with IAEA verification of fissile material declared excess for defense purposes. IAEA verification under this initiative will promote international confidence that fissile material submitted by either of the two states to such verification remains irrevocably removed from nuclear weapons programs[vii].

Whether classified component will be subjected to the new verification regime has not been decided. However, special technical provisions are being developed that will allow the States to submit dismantled nuclear weapon components or other classified forms of fissile material to verification, with assurance that IAEA inspectors would not gain access to information relating to the design or manufacture of such weapons. A new model agreement is being developed as the legal instrument for this regime. The Russians plan to implement the new regime at the Mayak Fissile Material Storage Facility beginning around the year 2003. The US plans to begin implementation at the K-Area Fissile Material Storage (KAMS) Facility beginning later this year.

The first US material to be offered under the TriLateral Initiative will be unclassified stabilized plutonium oxide and metals from Rocky Flats Environmental Test Site. Initially, since a legal instrument for verification does not exist, this material will be placed under IAEA safeguards consistent with the US voluntary offer. When a legal instrument for verification is reached, then it is envisioned that this material would be transferred to the verification regime, which is anticipated to be less intrusive than safeguards. When the verification would terminate is being negotiated in the legal instrument.

The GNMM Framework: Managing the Future

The concept of a global framework to transparently ensure the safety, security, and legitimate use of nuclear materials is timely for the international community to embrace. We are at a unique period in history where there is widespread recognition of the need to support responsible stewardship of nuclear weapons, even as the arms reduction process continues in accordance with obligations under the NPT; horizontal proliferation is now viewed globally as a threat to be controlled and reversed; management of the legacy defense materials from the Cold War has become an international security concern; the management of materials in the back end of the fuel cycle requires international solutions; and the responsible development of nuclear power and management of the civilian fuel cycle is being increasingly viewed as a vital component to provide necessary energy for future generations without unacceptable degradation to the environment.

Much has been done, yet much remains to be done. The European community, through a broadened vision within EURATOM, can play a key role in building this global framework. In particular, ESARDA can make important contributions by leading efforts in the European technical community to identify new verification and transparency technologies and processes to monitor the safety, security, and legitimate use of nuclear materials of all classes. The forum sponsored by ESARDA to discuss approaches advocated by individual states, the IAEA, and EURATOM for Integrated Safeguards is an example of such a leadership role. This role may be broadened for application to other components necessary to build a GNMM framework, including norms and standards for domestic states' measures, cooperative regional measures, as well as international treaties and agreements as discussed in the examples presented herein.

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[i] See, "A Uniform Framework of Global Nuclear Materials Management", Dupree et al, presented at ESARDA 1999 Annual Conference.

[ii] See, for example, "Managing the Global Nuclear Materials Threat – Policy Recommendations", Report of the Center for Strategic and International Studies, Washington, DC, January 2000.

[iii] Ibid.

[iv] Dr. Roger Hagengruber, Sr. Vice President, chaired the CSIS task force for transparency for Nonproliferation and National Security at Sandia National Laboratories. Members included representatives from U.S. government, weapons laboratories, Congress, Non-governmental Organizations, and international government representatives.

[v] DOE major missions are basic research and science, energy, nuclear weapons programs, naval reactors, nonproliferation and national security (which includes arms control), and environmental management.

[vi] Examples of DOE orphan materials are some DOE research reactor fuels, Americium and curium in waste solutions and U-233.

[vii] The removal of weapon-origin fissile material from the US and Russian defense programs is in furtherance of the disarmament obligations of the two States under Article VI of the Treaty on the Nonproliferation of Nuclear Weapons (NPT). Verification would be applied to material declared excess by both countries.