11. Potential roles for the IAEA in a warhead dismantlement and fissile materials transparency regime

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I. Introduction

The elimination of nuclear weapons is likely to be a long process involving limitations on both the weapons and the ability to expand existing arsenals. The nuclear weapon states (NWS) may undertake unilateral arms reductions or engage in bilateral reductions similar to those pursued by Russia and the United States. While further unilateral reductions can be anticipated, arms reductions involving other combinations of the five NWS and the three de facto NWS might become necessary. Successive arms limitations undertaken by one or more of the NWS may encourage the others to follow suit, but this will depend on the level of transparency that is implemented. Transparency measures could be undertaken on a voluntary basis or as part of an agreed framework involving the parties to a negotiated arms control arrangement. Expanding arms control beyond bilateral to multilateral arms reduction arrangements may bring additional benefits in the form of transparency, although perhaps at the expense of additional complications in the negotiation and implementation processes. As new arms reductions are contemplated, transparency measures can accelerate the process of nuclear disarmament by two means. Allowing the public and the media to observe and confirm the steps taken by a state will help to lock in the progress made and put pressure on other NWS to do the same. Transparency measures engender confidence that a NWS is actually pursuing reductions in accordance with its stated intentions and, by observing these steps, other NWS will see that threats have been reduced and be encouraged to reduce their nuclear weapon holdings.

Transparency measures reveal the extent to which actions taken by a state are consistent with its declared intentions. The more complete and timely the measures, the more assurance is provided. If the transparency measures involve an independent organization, then, at a certain point, they become sufficiently formal so as to constitute a form of verification, providing proof that a state's commitments are being honoured.

Assigning transparency activities, including verification, to an independent entity could serve several purposes. First, an independent body would be

* The views expressed in this chapter are those of the author and do not necessarily reflect views of the International Atomic Energy Agency.

unbiased and could therefore be more acceptable than mutual reciprocal verification to all the parties to a multilateral arms reduction agreement. This would become increasingly important as the number of parties to an agreement grew, especially when there was distrust among the NWS. Second, an independent entity would be insulated from the periodic tensions that might arise between the parties to an arms reduction agreement. Third, an independent body could represent the international community, and verification could be seen in the context of meeting obligations under existing and new treaty arrangements, such as those under Article VI of the 1968 Treaty on the Non-proliferation of Nuclear Weapons (Non-Proliferation Treaty, NPT). Having an independent entity carry out such transparency activities, including verification, would serve to encourage all the NWS to adopt similar arrangements and collectively strengthen international commitments to nuclear disarmament and non-proliferation.

Transparency in nuclear disarmament is likely to involve activities that are similar or even identical to the International Atomic Energy Agency (IAEA) safeguards measures undertaken for non-proliferation purposes. The non-nuclear weapon states (NNWS) parties to the NPT, which are subject to comprehensive IAEA safeguards agreements, are growing increasingly concerned at the lack of concrete steps by the NWS towards nuclear disarmament. Involving the IAEA in nuclear disarmament would both strengthen the obligations to be fulfilled by the NWS and reduce the gap between the commitments of the five NPT-recognized NWS and those already assumed by the NNWS. Engaging the IAEA to assist with transparency and verification measures seems appropriate and logical as successive steps are taken towards nuclear disarmament. Establishing another body for this purpose could undermine the IAEA safeguards system and would introduce duplicate safeguards responsibilities. The IAEA has the distinct advantage of being an existing, functioning body with a high reputation in the family of international organizations.

IAEA safeguards place controls on the possession, production, storage, use, import and export of nuclear materials, with the goal of preventing the further proliferation of nuclear weapons. All safeguards applications are carried out under agreements between the IAEA and a state and are legally binding on both the state, in terms of its commitments, and the IAEA, in terms of its verification obligations. A system of transparency in nuclear warheads, fissile material and facilities under the responsibility of the IAEA would be most appropriate if it was formally constituted on the basis of legally binding commitments. At this early stage in the process of universal nuclear disarmament, any transparency system involving the IAEA should allow for credible and independent verification of the participating states' commitments to support and encourage progressive nuclear arms reductions.

II. Rising expectations

Controls on fissile materials are certain to be an essential element of international nuclear disarmament. A number of important developments suggest that the IAEA could play a key role in this regard.

1. In 1993 the United Nations General Assembly adopted a resolution which recommended the negotiation of a 'non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices' and requested the IAEA 'to provide assistance for examination of verification arrangements for such a treaty as required'.[1] Little progress has been made since then and, despite recommendations by the UN General Assembly,[2] the Conference on Disarmament has not started negotiations on a treaty.

2. In 1994 the USA for the first time submitted unclassified forms of excess defence fissile materials to IAEA safeguards under its Voluntary Offer Safeguards Agreement as a means of making them unavailable for further military use.[3] All payment of verification costs for such materials was provided by the USA through extra-budgetary contributions. The number of locations and the amounts of excess defence materials submitted by the USA to IAEA safeguards have continued to increase since then.

3. In 1995 the NPT Review and Extension Conference agreed that 'Nuclear fissile material transferred from military use to peaceful nuclear activities should, as soon as practicable, be placed under Agency safeguards in the framework of the voluntary safeguards agreements in place with the nuclear-weapon States. Safeguards should be universally applied once the complete elimination of nuclear weapons has been achieved'.[4]

4. In 1996 Russian President Boris Yeltsin made reference to a role for the IAEA in a statement to the Moscow Summit on Nuclear Safety and Security.

> All nuclear materials resulting from conversion should be used in the civil nuclear area. And, as it is known, this will require no less than 20 to 30 years.
>
> Hence, we stand for the construction of secure storage facilities for nuclear material.
>
> We have completed the design work and are constructing now a similar storage facility at the site of the 'Mayak' industrial complex with US participation.
>
> This storage facility will accommodate about 40 percent of the Russian weapons-grade plutonium. We are planning to place this facility under the IAEA safeguards.

[1] United Nations General Assembly Resolution 48/75, Dec. 1993, URL <http://www.un.org/documents/ga/res/48/a48r075.htm>.

[2] E.g., the General Assembly renewed this call in Resolution 56/24J, which was adopted without a vote on 29 Nov. 2001.

[3] IAEA, The Text of the Agreement of 18 Nov. 1977 Between the United States of America and the Agency for the Application of Safeguards in the United States of America, INFCIRC/288, Dec. 1981, URL <http://www.iaea.org/worldatom/Documents/Infcircs/Others/infcirc288.shtml>.

[4] NPT/CONF.1995/32(Part 1): 1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, Final Document, Principles and Objectives for Nuclear Non-Proliferation and Disarmament, p. 11, §13m, 1995, URL <http://www.un.org/Depts/ddar/nptconf/2142.htm>.

I believe that this experience should be extended to other countries.[5]

5. In 1996, in response to Russian and US offers, the Trilateral Initiative was launched to investigate the technical, legal and financial issues associated with IAEA verification of weapon-origin and other fissile material released from defence programmes in Russia and the USA (see section VII). In the system under consideration states may submit to IAEA verification classified forms of fissile material, including nuclear weapon components, under new agreements established pursuant to the Trilateral Initiative. The hope is that the legal framework developed under this initiative will serve as a basis for other NWS to accept similar arrangements in the future. In 2000, in the Final Document of the NPT Review Conference, the parties called for the completion and implementation of the Trilateral Initiative.[6]

6. In 2000, Russia and the USA signed the Agreement concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes and Related Cooperation (the Plutonium Management and Disposition Agreement, PMDA).[7] Under the PMDA, both parties are required to begin consultations with the IAEA at an early date and to conclude appropriate agreements with the IAEA to allow it to implement verification activities not later than: (*a*) when disposition plutonium or disposition plutonium mixed with blend stock is placed into the post-processing storage location of a conversion or conversion/blending facility; or (*b*) when disposition plutonium is received at a fuel fabrication or immobilization facility, whichever occurs first. The PMDA makes a further provision that, if agreed in writing by the parties, the exercise of each party's rights with regard to monitoring and inspection may be suspended in whole or in part by the application of equivalent IAEA verification measures. The parties shall, to the extent practicable, avoid duplication of effort in monitoring and inspection activities implemented under the PMDA and appropriate agreements with the IAEA.

7. In 2002 the summit meeting of the Group of Eight (G8) issued a statement in which the members pledged aid for non-proliferation efforts.

[5] Statement by Boris Yeltsin, President of Russia, to the Moscow Summit on Nuclear Safety and Security, 19–20 Apr. 1996, p. 35.

[6] Final Document of the 2000 Review Conference of the parties to the Treaty on the Non-Proliferation of Nuclear Weapons, NPT/CONF.2000/28, 24 May 2000, Article VI, para. 15.8, available at URL <http://www.iaea.org/worldatom/Press/Events/Npt/npt-2000.shtml>.

[7] See URL <http://www.ransac.org/new-web-site/related/agree/bilat/pudisp-agree.html>. The PMDA, which had not formally entered into force as of Dec. 2002, has been under review by the Bush Administration. The review was concluded in Dec. 2001, and in a White House fact sheet of 27 Dec. 2001 the findings were positive. As noted there, 'The Administration remains committed to the agreement with Russia to dispose of excess plutonium'. US Department of State, 'Fact Sheet: Nonproliferation, threat reduction assistance to Russia', Washington, DC, 27 Dec. 2001, URL <http://usinfo.state.gov/topical/pol/arms/stories/01122701.htm>.

The attacks of September 11 demonstrated that terrorists are prepared to use any means to cause terror and inflict appalling casualties on innocent people. We commit ourselves to prevent terrorists, or those that harbour them, from acquiring or developing nuclear, chemical, radiological and biological weapons; missiles; and related materials, equipment and technology. We call on all countries to join us in adopting the set of non-proliferation principles we have announced today.

In a major initiative to implement those principles, we have also decided today to launch a new G8 Global Partnership against the Spread of Weapons and Materials of Mass Destruction. Under this initiative, we will support specific cooperation projects, initially in Russia, to address non-proliferation, disarmament, counter-terrorism and nuclear safety issues. Among our priority concerns are the destruction of chemical weapons, the dismantlement of decommissioned nuclear submarines, the disposition of fissile materials and the employment of former weapons scientists. We will commit to raise up to $20 billion to support such projects over the next ten years. A range of financing options, including the option of bilateral debt for program exchanges, will be available to countries that contribute to this Global Partnership.[8]

8. In 2000 and 2001, a bill was introduced in the US Senate which would guarantee loans to Russia in return for bringing weapon-usable plutonium additional to the amounts covered under the PMDA and weapon-usable highly enriched uranium (HEU) under IAEA controls.[9]

These steps and declarations collectively suggest that international fissile material controls will shortly begin to be implemented to facilitate the eventual elimination of nuclear arsenals. No state is as yet bound by any specific commitment, but a transparency scheme for nuclear stockpiles and warhead dismantlement may emerge as one of the first steps. It could serve in part as a means to lock in progressive nuclear arms reductions, to inhibit re-armament and to create the climate of trust needed for the acceleration of the elimination of nuclear arms.

The role or roles eventually assigned to the IAEA within the broader scheme of nuclear disarmament measures will require a consensus within the international community. That consensus would evolve over time and the scope of activities would be determined partly on the basis of what the NWS will allow and partly on what the international community is willing to finance. The early assignment of a role for the IAEA in this process would establish a foundation for a more complete and coherent spectrum of future international controls.

[8] 'The G8 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction', Statement by the Group of Eight Leaders, Kananaskis, Canada, 27 June 2002, URL <http://www.state.gov/e/eb/rls/othr/11514.htm>.

[9] Russian Fissile Materials Disposition Loan Guarantee Act of 2001, S.1277, US Senate, 31 July 2001, available on the US Senate Internet site at URL <http://www.senate.gov>.

III. Fissile material controls and nuclear disarmament

All nuclear warheads have fission energy elements that rely on the use of fissile materials,[10] which have only two practical uses—in nuclear weapons or as fuel materials in nuclear reactors. Controls on the production, storage, use and export of fissile materials are accordingly the principal focus of international efforts to stem the proliferation of nuclear weapons and, specifically, of IAEA safeguards. The IAEA safeguards system has matured to a high level of effectiveness and efficiency, and further steps are under way to strengthen its capabilities, particularly in the detection of clandestine military nuclear programmes.[11]

While the circumstances may differ in fundamental ways from the application of IAEA safeguards, a coherent system of fissile material controls could make it impossible for NWS to re-use existing fissile material or to make new material for the production of nuclear weapons. As progress is made towards the elimination of nuclear weapons, such a system could be expanded to include: (*a*) verification of weapon-origin and other fissile material released from military use by states; (*b*) verification of a ban on the production of fissile material for use in nuclear weapons or other nuclear explosive devices, including verification of declared production facilities and the detection of clandestine programmes; and (*c*) estimation of the amounts of fissile material produced by the NWS (the amounts expended, exported and remaining) and a reconciliation of these estimates.[12]

These are the traditional means by which controls on fissile materials can contribute to the elimination of nuclear weapons. They will probably all come into play, especially as deep cuts in the nuclear arsenals of all NWS are contemplated.

Depending on how such a system is designed and implemented, appropriate controls might also provide a potential means to monitor the dismantlement of nuclear warheads and the removal of fissile materials from the production of such warheads, thereby giving the IAEA a more direct role in the verification of nuclear arms reductions.

Completing the physical dismantlement of tens of thousands of warheads and disposing of the tonnes of recovered fissile materials is likely to be a very long process. The amount of fissile material in military use or available for such use is very large and diverse, and it will take decades to make the material unsuit-

[10] For the purposes of this chapter, fissile material means plutonium containing 90% or more of the isotope Pu-239 and uranium containing 90% or more of the isotope U-235. Other materials appear to be suitable for weapon use, in particular Np-237. However, heat, spontaneous fission neutrons and intense gamma-ray emissions would limit the usefulness for weapons of materials such as U-233, Am-241 or Cu-242.

[11] Goldschmidt, P., 'The IAEA safeguards system moves into the 21st century', Supplement to the *IAEA Bulletin*, vol. 41, no. 4 (Dec. 1999), pp. 1–20.

[12] Establishing accurate estimates of past production and use will pose daunting challenges, because the measurement and accounting practices applied were neither complete nor rigorously applied and the people involved are retiring.

able for further use in nuclear weapons. Progress towards nuclear disarmament will require a stable international security environment. A 'Warhead Dismantlement and Fissile Materials Transparency Regime' incorporating IAEA fissile material controls could be an important contribution to such progress.

IV. The statutory basis for the involvement of the IAEA

Any role for the IAEA would require the approval of its policy-making organs, the Board of Governors and the General Conference. The authority for the IAEA to undertake a role could be based on two provisions of the IAEA Statute.[13] Article III.A.5 authorizes the Agency:

> To establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under its supervision or control are not used in such a way as to further any military purpose; and to apply safeguards, at the request of the parties, to any bilateral or multilateral arrangement, or at the request of a State, to any of that State's activities in the field of atomic energy.

Article III.B provides that:

> In carrying out its functions, the Agency shall:
> 1. Conduct its activities in accordance with the purposes and principles of the United Nations to promote peace and international co-operation, and in conformity with policies of the United Nations furthering the establishment of safeguarded worldwide disarmament and in conformity with any international agreements entered into pursuant to such policies.

V. The legal framework for a role for the IAEA

Following the process established for IAEA safeguards, a role for the IAEA in a future nuclear stockpile and warhead dismantlement transparency regime should be based on essentially identical bilateral legal agreements between the IAEA and states. Each such agreement would require the approval of the IAEA Board of Governors and the state, according to its constitutional practices. There are three basic requirements for such agreements.

1. The agreements should provide that the undertakings by states are irrevocable.
2. The agreements should provide that verification by the IAEA would be obligatory and that the measures employed would permit the IAEA to derive credible and independent findings.
3. The results of the verification should be conveyed to the international community in a manner designed to achieve the intended transparency.

[13] IAEA, Statute of the International Atomic Energy Agency (as amended up to 28 Dec. 1989), URL <http://www.iaea.org/worldatom/Documents/statute.html>.

The IAEA already has safeguards agreements in force with all the NWS.[14] Extending them might, in principle, meet the requirements for the IAEA to play a useful role in a future nuclear stockpile and warhead dismantlement transparency regime. However, for the reasons given in the sections below, such a route does not appear to be appropriate.

VI. The dismantlement process and progressive monitoring alternatives for the IAEA

If the IAEA is to play a role in a transparency regime for fissile materials, warheads and facilities, the regime should represent a balance between providing the most useful service possible and respecting security concerns regarding information on the design of nuclear warheads or the configuration of national arsenals. It may have to reflect pragmatic considerations associated with the high costs and long process that will be required to reconfigure, process and alter the characteristics of fissile material from dismantled nuclear warheads. The IAEA could begin with steps that are meaningful now, with the notion that, as progress is made towards the final elimination of nuclear weapons, its role might be expanded to support the final stages and to facilitate the convergence of all verification systems associated with fissile material.

Figure 11.1 illustrates the steps involved in the dismantlement of nuclear warheads and the disposition of the fissile materials removed from them. The operations at the start of the process involve weapons and weapon components. Extensive security measures are applied to protect the items themselves and the sensitive information pertaining to the warheads. International involvement for the purpose of monitoring that warhead dismantlement is actually taking place could begin at the very start of the process, using the verification procedures described below. Figure 11.1 also shows four alternative points at which monitoring might begin, in order of their relevance to nuclear disarmament.

Option 1: the baseline

In line with the IAEA's core capabilities and the extensive experience gained under its safeguards programme, the foundation for a role for the Agency in a transparency regime should be a system of controls on the fissile materials

[14] IAEA safeguards agreements are incorporated in IAEA Information Circulars, most of which are available on the IAEA Internet site at URL <http://www.iaea.org>. For the nuclear weapon states parties to the NPT, the safeguards agreements are based on INFCIRC/153, June 1972. The specific documents are: France—INFCIRC/290, Dec. 1981; China—INFCIRC/369, Oct. 1989; Russian Federation (Union of Soviet Socialist Republics)—INFCIRC/327, July 1985; United Kingdom—INFCIRC/263, Oct. 1978; and United States—INFCIRC/288, Dec. 1981. Safeguards agreements with India, Israel and Pakistan are based on INFCIRC/66/Rev.2, Sep. 1968. Agreements in force for India are contained in: INFCIRC/154, Sep. 1971; INFCIRC/211; Nov. 1974; INFCIRC/260, July 1978; INFCIRC/360, Jan. 1989; INFCIRC/374, Jan. 1990; and INFCIRC/433, May 1994. The agreement with Israel is contained in INFCIRC/249, Sep. 1977. Agreements with Pakistan are contained in INFCIRC/135, Nov. 1969; INFCIRC/239, June 1976; INFCIRC/248, July 1977; INFCIRC/393, Oct. 1990; and INFCIRC/418, Mar. 1993.

removed from dismantled warheads, after the fissile materials have been processed so that no classified properties remain.

The objective for monitoring the unclassified materials would be to ensure that they are not returned to nuclear weapon use. This measure of assurance, together with a treaty banning the production of fissile material for use in nuclear weapons or other nuclear explosive devices, would limit the ability of states to produce additional nuclear weapons. As successive arms reductions are implemented, the ceilings on the arsenals would be lowered correspondingly if the fissile materials were subject to IAEA verification.

Once the classified properties of the fissile materials have been removed through conversion and blending, the resulting plutonium, HEU and low-enriched uranium (LEU) are essentially identical to those encountered in civil nuclear power programmes. The IAEA and the states involved have extensive experience in safeguarding those materials; hence little remains except to extend the applications to the unclassified forms of material.

Three important issues are associated with such a role—the nature of the verification agreements, the verification timing and intensity, and the point at which verification should terminate.

1. The safeguards agreements in force in the five NWS parties to the NPT, referred to as Voluntary Offer Safeguards Agreements, follow the form of the comprehensive safeguards agreements applied in the NNWS.[15] These agreements were intended to allow the NWS to assist the IAEA in developing safeguards arrangements for similar facilities in the NNWS, providing test beds to establish safeguards approaches, conduct training exercises, and gain experience, particularly in complex facilities. To some extent, the aim was also to provide a means of mitigating the economic burden of IAEA inspections, which would affect competition involving similar facilities in both NWS and NNWS. While in principle it would be possible to modify the Voluntary Offer Safeguards Agreements for the purpose of verifying unclassified materials from dismantled nuclear warheads, these agreements were intended for non-proliferation purposes and are not suitable for a role in nuclear disarmament. They are voluntary in nature, and they allow the state to decide whether it will withdraw facilities and nuclear materials from inspection. It is not clear whether the international community would be willing to finance these inspections under safeguards agreements. Modifications to the Voluntary Offer Safeguards Agreements might address these concerns, but that would still leave open the question of how to engage those states which possess nuclear weapons but are not parties to the NPT. All of this must be seen in relation to the need to apply a uniform standard.

[15] IAEA, The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons (NPT Model Safeguards Agreement), IAEA document INFCIRC/153 (Corrected), June 1972, available at URL <http://www.iaea.org/worldatom/Documents/Infcircs/Others/inf153.shtml>.

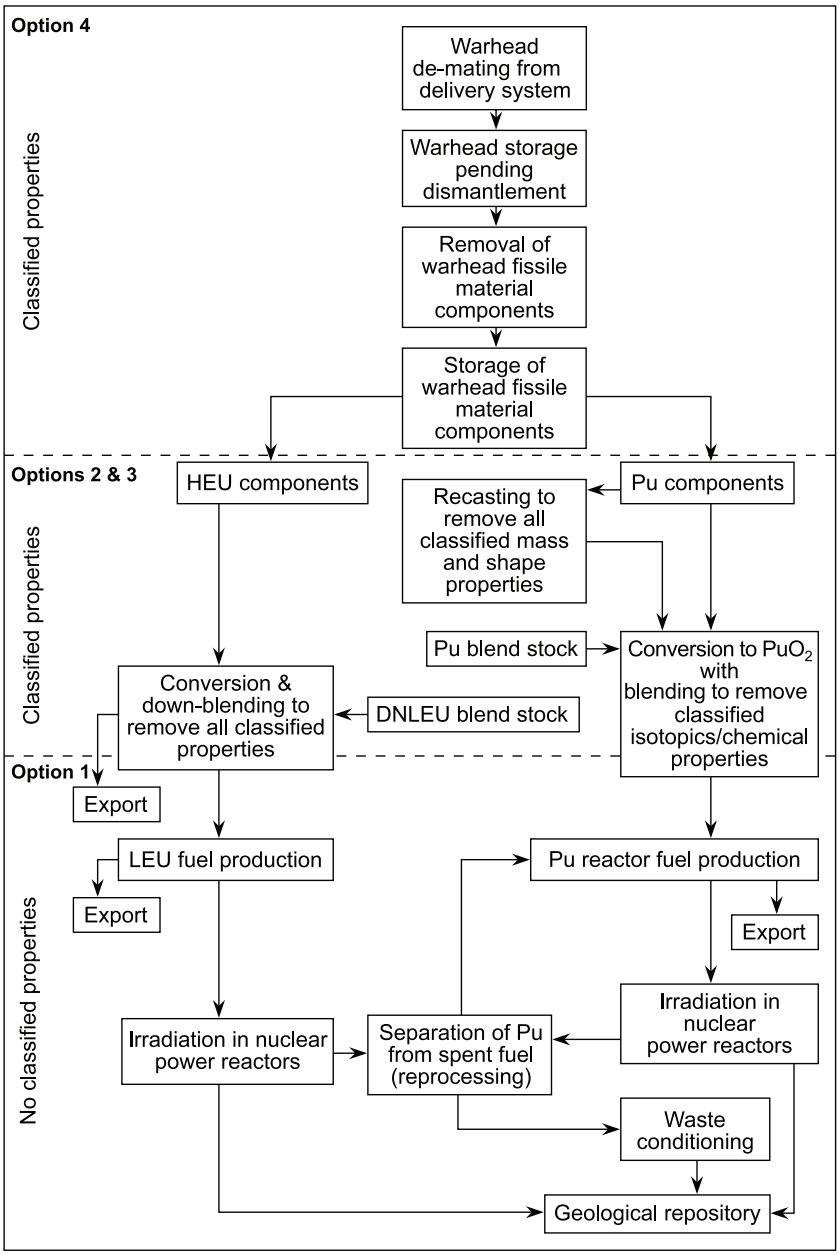

Figure 11.1. Warhead dismantlement and disposition of recovered fissile materials, shown with alternative monitoring starting points

DNLEU = depleted, natural, low-enriched uranium; HEU = highly enriched uranium; LEU = low-enriched uranium; Pu = plutonium; PuO_2 = plutonium dioxide.

Source: IAEA, *IAEA Safeguards Glossary*, 2001 edn, International Nuclear Verification Series no. 3 (IAEA: Vienna, 2002).

2. The technical criteria used for planning and evaluating IAEA safeguards are designed to meet the non-proliferation mission of the IAEA. They provide for the timely detection of the attempt of a state to acquire its first nuclear weapon, before it could reasonably be expected to succeed. If these non-proliferation criteria were to be applied in relation to the transparency of nuclear weapon dismantlement, in some cases it would not be physically possible to meet the requirements. For the foreseeable future, the costs for verification at such intense levels would far exceed any arms control benefit to be derived through the application of such criteria.

As progress towards the elimination of nuclear weapons is made, it will become necessary for all verification arrangements and requirements to converge so that all states are subject to a single, non-discriminatory framework.

3. In the Final Document issued at the NPT Review Conference in May 2000, the NPT parties agreed that the principle of irreversibility should apply to nuclear disarmament as well as to nuclear and other related arms control and reduction measures.[16] In comprehensive IAEA safeguards agreements, there is a provision that 'safeguards shall terminate on nuclear material subject to safeguards upon determination by the Agency that it has been consumed, or has been diluted in such a way that it is no longer usable for any nuclear activity relevant from the point of view of safeguards, or has become practicably irrecoverable'.[17] In an absolute sense, the safeguards interpretation could also define the end point for verification of fissile material in relation to disarmament. Should this same definition apply? Should it apply at the outset or should the verification requirements converge as the elimination of nuclear weapons approaches?

There is little benefit for arms control in spending significant resources on fissile materials following plutonium irradiation or down-blending of HEU. This view is reflected in the bilateral PMDA, the provisions of which will apply until pure plutonium is irradiated to specified levels or impure plutonium is immobilized for geological storage. Concentrating on the upstream activities associated with disposition would focus the effort on the most significant material forms in relation to nuclear disarmament and would reduce the costs of verification accordingly. For HEU, the requirements to follow down-blended uranium could be correspondingly expensive and not bring a great deal to the practical matter of verifying disarmament, until the elimination of existing nuclear arsenals approaches and convergence becomes essential.

However, applying the safeguards definition of the principle of irreversibility from the outset would have the advantage of establishing the verification framework in a manner that would anticipate the convergence foreseen as nuclear arms are eventually eliminated. It would also serve to erode the special status of the NWS under the NPT and could strengthen the commitments of NNWS.

[16] Final Document (note 6), Article VI, para. 15.5.
[17] INFCIRC/153 (note 14), para. 11.

Adopting these provisions at the outset could increase the willingness of the international community to pay for the required verification activities and could facilitate future NPT review conference deliberations.

A pragmatic means to proceed could involve establishing the principles of the agreements as early as possible. The technical criteria employed for planning and evaluation purposes would be modified over time. The inspection burden on the downstream materials would not be the same as that in NNWS until progress towards the elimination of nuclear weapons had advanced and a treaty banning the production of fissile material had entered into force.

Option 2: introducing classified forms of fissile material into the monitoring system

Moving the starting point of the verification of the dismantlement process forward would allow the monitoring system to be applied at a much earlier stage and forge a stronger linkage between the source of the materials and their ultimate disposition. It would also cost more and be more invasive than Option 1. Including classified forms of fissile material raises three security-related issues.

1. Appropriate measures must be taken to prevent the disclosure of classified information related to the design or manufacturing of nuclear warheads. All states possessing nuclear warheads would ensure that any verification arrangements are carefully examined to prevent intentional, inadvertent or unauthorized disclosures of such classified information. NWS parties to the NPT are obligated under Article I to take such precautions. Each step will involve considerations by the classification and security officials of the NWS. The requirements they apply and the decisions and related conditions are unlikely to be the same in each state.

2. In the course of carrying out their respective monitoring activities, IAEA inspectors will routinely receive information normally considered to be of a sensitive nature (e.g., on features of facility design and operational practices at facilities where weapon-related activities are carried out, on physical inventories and on aspects of the physical protection measures that are applied). Managing these activities, while allowing the IAEA inspectors to carry out their inspections in such a manner as to be able to derive credible, independent conclusions, will require both close attention to procedures and equipment and close supervision of inspectors within sensitive facilities.

3. The IAEA would have to assure the states that its inspectors would not be able to acquire unauthorized information. Nothing would diminish support for international verification of sensitive activities more quickly than an attempt by an IAEA staff member to misuse the opportunities and access provided in the course of his or her duties.

The provisions of the legally binding verification agreements would have to reflect both the rights and the restrictions of the state and the IAEA in relation to these security considerations.

Again, modifying the Voluntary Offer Safeguards Agreements to facilitate special conditions could undermine the implementation of safeguards in NNWS. The modifications would have to allow the states to withhold classified information from their declarations and would have to limit the inspection activities and equipment to prevent access to classified information. The problem is that such modifications could establish a further distinction between the NWS parties to the NPT and NNWS, and could serve to undermine the collective integrity of the IAEA non-proliferation safeguards system. Taking into account these considerations and the fact that not all NWS are parties to the NPT, a new verification agreement becomes increasingly attractive.

The new verification agreements being developed under the 1996 IAEA–Russian–US Trilateral Initiative envisage that weapon-origin and other fissile materials released from defence requirements in Russia and the USA, in classified or unclassified forms, could be submitted to IAEA verification. It would be up to each state to decide when, where and in what form its material would be submitted but, once submitted, the commitment would be irrevocable. Verification under the new agreements would ensure that the materials remain accounted for and are not used thereafter for any military purpose. The verification methods under development are believed to be suitable for any situation in which classified forms of fissile material are presented.

Under the Trilateral Initiative, it is foreseen that the two participating states may submit classified forms of fissile material to IAEA verification, including nuclear warhead components. When either state determines that its fissile material retains nuclear weapon information, the declaration accompanying a submission to IAEA verification would state whether the material mass (and virtually all other physical parameters) or the isotopic or chemical composition is classified. Corresponding to classified forms of plutonium and HEU, unclassified reference values are specified for the minimum ratio of plutonium-240 to plutonium-239 and the minimum percentage of uranium-235 enrichment. Minimum mass values are also specified, although these values may be facility-specific.

Three attributes are to be verified for classified forms of plutonium under the Trilateral Initiative: whether plutonium is present within the container; whether the ratio of plutonium-240 to plutonium-239 is 0.1 or less; and whether the amount of plutonium present in a container exceeds the specified minimum mass value. If a container passes these tests, it will be accepted for verification. If not, since the classification restrictions prevent further investigations into why the tests might not have been passed, the container will be rejected and removed from the facility.

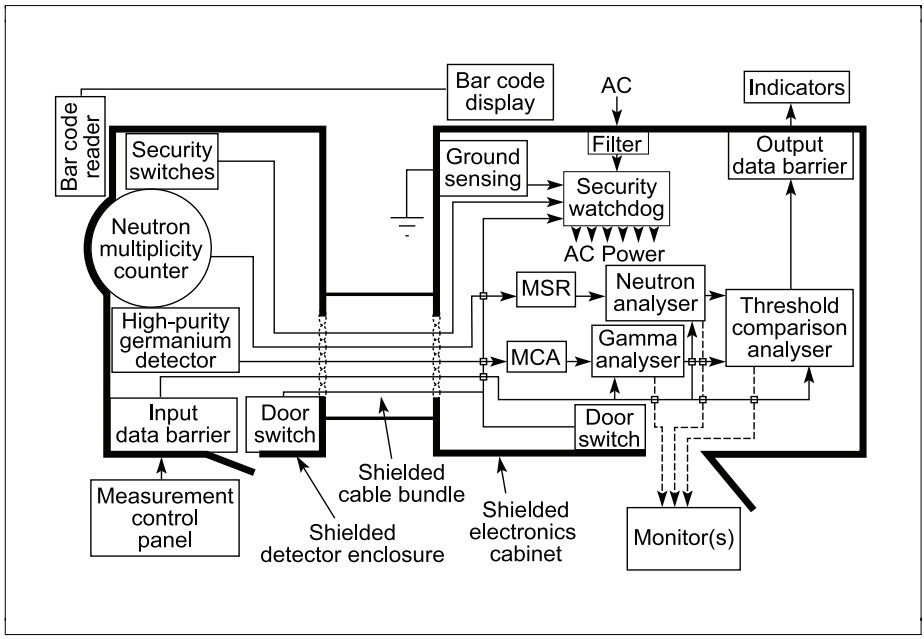

Figure 11.2. Attribute verification system for classified forms of plutonium, including 'information barriers'

AC = alternating current; MCA = Multi-Channel Analyser; MSR = Multiplicity Shift Register.

Sources: The system shown in the figure and the specific hardware solutions have been developed under the Trilateral Initiative. It is referred to as an 'enabling technology'. Variations of the same technology are being introduced in other bilateral fissile material agreements between Russia and the USA. See, e.g., Whiteson, R. *et al*. 'A prototype inspection system with information barrier for the Trilateral Initiative, *Proceedings of the 40th Annual Meeting of the Institute for Nuclear Materials Management (1999)* (on CD), available from the Institute of Nuclear Materials Management, email address inmm@inmm.org.

There have been attempts to determine whether there are any quantitative measurements that could be made without providing information that would allow classified properties to be deduced. No such measurements have been found. The approach that was decided upon, and is now being developed, employs robust non-destructive assay measurement methods typical of those used in IAEA safeguards, but with the instruments operating within an 'information barrier' security framework. Figure 11.2 illustrates this concept.

A significant amount of work remains in order to gain certification by the Russian and the US security authorities and to ensure that the authentication provisions applied will allow the IAEA to derive credible and independent conclusions.

For plutonium, the attribute verification measurement system will comprise a high-resolution gamma-ray spectrometer[18] integrated with a neutron multiplicity assay system.[19]

The detector systems are essentially identical to those used for IAEA safeguards purposes, but access to the signals is prohibited when classified forms of fissile material are present. The general technical requirements and associated functional specifications for such systems have been agreed. A prototype system was developed and demonstrated, and full-scale systems are currently being produced in Russia and the USA under the direction of a Trilateral Initiative experts group.

Once classified forms of fissile material are submitted for verification, since the commitment is irrevocable, they will eventually be removed from storage for disposition as shown in figure 11.1. From the perspective of protecting the classified information, the conversion operation is the most sensitive. Under the Trilateral Initiative, special provisions are made in the model agreement for such conversion operations. The verification arrangements would allow the IAEA to be confident that all inputs satisfy the attribute tests identified and that the declared conversion operations actually occur. Furthermore, it would be assured that the converted forms, no longer characterized by any classification restrictions, are measured quantitatively and are subsequently shipped to a fuel fabrication facility or exported. Verification would continue in both cases, either under the new agreement (assuming the material remains within the state or is shipped to another state possessing nuclear weapons) or under a comprehensive IAEA safeguards agreement if the material is exported to a NNWS.

The verification arrangements for such conversion facilities would entail a perimeter control system around each facility, with attribute verification of inputs and quantitative verification of outputs. Moreover, periodic managed-access design verification visits within the facility would ensure that no possibilities had been created for classified materials to be removed without verification.

Under the Trilateral Initiative, technical criteria are being established to serve as the basis for determining the requirements for various forms of material and operations. Requirements for the timing of successive inspections and the intensity of verification are being designed to reflect the disarmament nature of the undertaking, and the fact that there are no follow-up possibilities to resolve measurement anomalies for classified forms. Unattended monitoring systems

[18] High-resolution gamma-ray spectrometers incorporate high-purity germanium semiconductor detectors. Individual gamma rays strike the detector and the response is proportional to the energy of the incident gamma ray. A spectrum accumulated over time shows a distinctive form which is dependent upon the isotopic composition of the plutonium present.

[19] The even-numbered isotopes of plutonium spontaneously fission according to defined half-life values. A neutron multiplicity assay system measures the rate at which two and three neutrons are detected within a very limited time, corresponding to the emission characteristics of spontaneous fission. Measuring both two- and threefold coincidence allows for corrections to be made for neutrons emitted through induced fission reactions within a sample and, for non-fission events, reactions on low atomic number nuclides.

are featured in most applications as a means of providing measurements on all items passing a control point, while limiting inspector presence and minimizing inspection costs.

Option 3: providing added assurance that the fissile material actually originates from dismantled nuclear weapons

Under Option 2, the IAEA would not be able to establish that the materials submitted for verification actually came from dismantled nuclear warheads or that items declared to be nuclear warhead components were in fact warhead components. It would be possible through additional measurements on items submitted for verification to gain further confidence concerning such declarations. Two avenues might be explored.

First, additional attributes characteristic of nuclear warhead components might be verified by extending the analysis of data acquired with the help of high-resolution gamma-ray spectrometry and neutron multiplicity measurements. Three additional attributes have been considered for plutonium components: (*a*) the presence of americium, indicating that the plutonium has not been processed for some years and thus is not newly created; (*b*) the absence of oxygen, which indicates that the plutonium is in metallic form; and (*c*) the presence of other materials associated with plutonium weapon components, including low atomic number elements, such as beryllium.

The second possibility involves the creation of a radiation template for each model of a nuclear warhead component. Since nuclear warheads are manufactured to meet very high tolerance standards, a combined fingerprint made using spatially sensitive measurements should be sufficiently unique for items to be discriminated. Having such a capability would allow the verification to be extrapolated to the characteristics of the items submitted, to determine the number of components of a given model. Whether or not such information is too sensitive for the NWS is an issue that would require careful consideration and have to be balanced against the anticipated stimulus to further arms reductions.

All of these possibilities would require considerable development and testing. Each would raise additional issues concerning the protection of classified information, and each would entail additional costs and the possibility of false measurement results.

Radiation templates would require a reliable means of calibration that would not in itself reveal classified information. If successful, such templates could offer additional information regarding the character of the dismantled warheads, and that information could allow inferences to be drawn regarding the remaining capabilities of a state. This type of information might become increasingly important as deep cuts in existing arsenals become a reality.

Option 4: monitoring dismantlement

A fourth option presupposes that IAEA inspectors are allowed to witness the de-mating of warheads from missiles and that they could carry out attribute verification tests of each warhead and apply appropriate IAEA seals to the warhead. They would be able to record identifying information, including the type of missile, its identification number, and the types of warheads and their serial numbers. IAEA inspectors would be able to verify both the storage of such warheads pending dismantlement and the dismantling operations by means of a perimeter control arrangement such as that described in Option 2.

Moving the starting point of the monitoring system to the starting point for dismantlement would allow the IAEA to establish the source of all components and to ensure that the removed fissile materials were kept under verification throughout the disposition activities. The IAEA verification would be directly coupled to the arms reduction process through this means and the information provided would confirm the state's declarations regarding which weapons were in fact destroyed.

As in Options 2 and 3, the additional monitoring activities would raise implementation costs and cause additional security concerns.

VII. The Trilateral Initiative

Option 2 provides practical means to begin bringing surplus military fissile materials under international control. It is a step which Russia and the USA support and which allows progress to be made without ruling out more extensive measures at a later date. It does, however, raise concerns regarding the protection of classified information, which would be much more complex under Options 3 or 4. Option 2 provides a framework for ensuring that fissile material submitted to IAEA verification cannot be used except in peaceful applications. Moreover, as long as any classified properties are removed through conversion and blending, it offers a means to determine quantitatively just how much fissile material has been removed from defence programmes. However, this is not all that is needed; a treaty banning fissile material for use in nuclear weapons or other nuclear explosive devices and the other steps identified in section II must also be implemented.

The Trilateral Initiative places the IAEA in the middle of what would otherwise be a bilateral arrangement between Russia and the USA. Both states have indicated their continued support and commitment to the Trilateral Initiative, but neither has yet made any formal obligation. Even binding themselves to restrictions on the future use of the excess fissile material is a difficult decision that has to be weighed against the benefits of additional transparency in general and of showing distinct progress in relation to Article VI of the NPT in particular. Going beyond the commitments under Article VI, to submitting fissile material with classified characteristics to controls, brings the additional benefit

of early and significant transparency but also brings the concomitant concerns regarding the protection of weapon secrets.

Progress towards the completion and implementation of the Trilateral Initiative requires the continued interest and support of the parties. Since its inception, the administrations of both states have changed and the importance of the Trilateral Initiative has varied accordingly. Before the PMDA was concluded, the conditions of that bilateral agreement served as a means for deferring considerations related to downstream activities. Now, it is essential to come to a common understanding in a single verification framework. Another factor affecting the successful outcome of the Trilateral Initiative is the issue of symmetry: Russia has opted to convert its pits into solid plutonium balls and, while the mass of plutonium and its shape will no longer be classified, other properties will remain classified. Meanwhile, the USA will store pits, converting them only as feed for a mixed oxide (MOX) fuel fabrication facility when the facility becomes operational. Whether the two states can accept each other's terms of participation or not is an issue that has been important and may remain so.

Starting with two states is complicated in itself. Russia and the USA have different inventories, capabilities and intentions. Obtaining the extensive financial support needed to carry out the plutonium disposition activities called for in the PMDA may determine whether it is possible to obtain commitments to a full-scope undertaking. In the absence of sufficient funding for plutonium disposition, agreements limited to storage may have to suffice for now.

Even if all the issues up to this point can be resolved, acceptance by the IAEA Board of Governors and the General Conference is not assured. Some may question the statutory right of the IAEA to engage in verification related to disarmament. Others will question why they should contribute finances to solve a problem that the NWS have created. A parallel consideration will certainly be argued: just as all states benefit from non-proliferation and agree to pay the costs of IAEA safeguards, all states would also benefit from progress towards nuclear disarmament and should therefore support disarmament verification through arrangements similar to those applied for safeguards.

Adding more states will become desirable—and later important and then essential—if the Trilateral Initiative is to lead to a general arms control measure. The other three NPT-recognized NWS may or may not be interested in joining such a regime. They may be disinclined at present to move towards anything approaching a limitation on their respective stocks. They may also be reluctant because this is a 'trilateral' initiative, from which they were excluded in the formative period.

Going beyond the NPT-recognized NWS to the three de facto NWS raises the fundamental question of a framework in which the states in both groups could meet for discussion. A transparency system for fissile materials, warheads and facilities may provide a means to bring about such a framework. Without one, it is unrealistic to think that the Trilateral Initiative model could be extended to all the NWS. Progress towards the universality of a control system for fissile

material made surplus through nuclear arms reductions will require leadership, capital and motivating arguments. All the NWS will have to support such a step, and the rest of the international community will need to see, in the creation of any nuclear disarmament transparency regime, the possibility of a world in which international security will be enhanced.

VIII. Further considerations

A role for the IAEA in the context of a dismantlement transparency regime would require a new legal framework and a reliable funding source to cover the costs of staff and equipment. A new legal framework is needed because the existing Voluntary Offer Safeguards Agreements in the five NPT-recognized NWS are voluntary and were not designed for disarmament. For classified forms of fissile material, they would require information that could not be provided by the state and Agency inspection activities that could not be allowed because they would divulge sensitive nuclear weapon design information. In the de facto NWS, the IAEA safeguards agreements in force serve limited objectives and are not at all appropriate for a disarmament verification system. A new legal framework would provide a common basis for verifying excess fissile material in all the states possessing nuclear weapons..

Costs associated with the Agency's role in the context of dismantlement transparency should be borne by all IAEA member states, according to an appropriate formula. The willingness of states to pay for such an activity will depend on the value that they see in bringing about progress towards the elimination of nuclear weapons. There are various mechanisms available for providing funds according to a mandatory assessment scheme and it will be up to the IAEA Board of Governors to adopt what it believes to be the most appropriate arrangement.

In this role for the IAEA, consideration will have to be given to the relationship between the activities under a transparency regime for fissile material, warheads and facilities and the existing operations of the IAEA, especially those of the Department of Safeguards. There will be a need to ensure that the staff and equipment required for this role do not in any way undermine the effectiveness of the IAEA safeguards programme.

IAEA safeguards are applied in all NWS, albeit on a limited-scope basis. It will be necessary to ensure that there are no cases in which both safeguards and the new arrangements are applied to the same material. There should also be no cases in which safeguards and the new arrangements are applied to different materials within the same facility.

When a treaty banning the production of fissile material enters into force, or even in the period when the technical specifications of its verification system are being defined, it will be necessary to harmonize the requirements for similar materials with verification arrangements for the facilities that are affected.

Addressing harmonization with safeguards and implementation of the treaty will require careful consideration since the links are fairly extensive.[20]

IX. Conclusions

Although substantial progress has been made towards reducing the armaments maintained by the two principal adversaries of the 20th century, the decisions regarding what and where to cut remain exclusively within the Russian–US bilateral arena. There are no treaties in place involving international verification specifically in relation to nuclear disarmament and no framework exists which could provide a means for involving any other NWS. Whichever verification starting point is chosen, future developments will ultimately determine the role of the IAEA.

At present, many questions remain to be resolved. What confidence-building measures would be useful and, in a general sense, how might the IAEA contribute to the broader agenda? How should an international control regime begin, what should be controlled and how 'strict and effective' do the controls need to be—especially at the beginning? How can future growth be encouraged and incorporated? What type of legal framework would best meet the objectives of such an international control regime? Should the IAEA be assigned such responsibilities or should a new organization be created for this purpose? How should activities assigned to the IAEA be financed? How might such a role affect the IAEA non-proliferation safeguards programme? What impact would a fissile material production cut-off treaty have on such a regime?

The starting point for IAEA verification in relation to a nuclear stockpile and warhead dismantlement will seek to balance interests that may be in conflict.

1. The international community may wish to obtain as much transparency as possible, as early as possible.
2. Unless carefully controlled, international verification might undermine the ability of a NWS to protect its security. Thus, each state will have to examine all the details of verification before allowing inspectors into sensitive facilities or even to sites where sensitive activities are carried out.
3. Neither states nor any verification body would wish to see international verification further the weapon ambitions of other states or sub-national groups. Hence, information that could be made available for verification and the verification measures themselves may be limited by the need to prevent the disclosure of nuclear weapon design or manufacturing secrets.

The Trilateral Initiative represents a significant, concrete step forward. Although it is being pursued on a voluntary basis, all three participants have an interest in seeing it lead to a successful outcome. Assuming that the responsibil-

[20] Shea, T., 'Reconciling IAEA safeguards requirements in a treaty banning the production of fissile material for use in nuclear weapons or other nuclear explosive devices', *Disarmament Forum* (no. 2), 1999, pp. 57–71, URL <http://www.unidir.org/pdf/articles/pdf-art245.pdf>.

ities identified under the PMDA merge with the verification of plutonium storage, it will probably take 25 years or more to complete the disposition of the 68 tonnes of plutonium covered in the PMDA. During that time, much could happen—a treaty banning fissile material production, or perhaps even an arms reduction agreement that engages all NWS, could be concluded. Implementation of the Trilateral Initiative would be a good first step, and the other NWS could sign similar verification agreements on the disposal of their surplus fissile material stocks as they engage in the process of nuclear disarmament.

The case for bringing the verification starting point forward in the dismantlement process will depend on resolution of the technical issues in a way that dispels concerns about the protection of confidential information. Beyond that, there is the larger issue of the extent to which the monitoring of warhead dismantlement will itself contribute to removing some of the uncertainties that will inevitably arise as the number of weapons declines as well as the extent to which enhanced transparency will stimulate progressive reductions, thereby accelerating the ultimate elimination of nuclear weapons. All things considered, the Trilateral Initiative is an important, pragmatic starting point.