By Andreas Persbo
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Verifying Nuclear Disarmament:
An Inspector's Agenda

In the past year, support for moving toward eventual nuclear disarmament has gathered force. In early 2007, an op-ed by four influential U.S. policy shapers, two Republicans and two Democrats, called on the nuclear-weapon states to "turn the goal of a world without nuclear weapons into a joint enterprise."[1]

Reaching this goal will require overcoming many political, diplomatic, and technical obstacles. In a June 2007 keynote address to the Carnegie International Nonproliferation Conference, former British Foreign Minister Margaret Beckett embraced the goal of eliminating nuclear weapons and sought to help with this task by offering her country as a "disarmament laboratory."[2] What this meant was clarified in a February 2008 speech by British Defense Minister Des Browne when he invited representatives of weapons laboratories from four other nuclear-weapon states (China, France, Russia, and the United States) to participate in a technical conference in the United Kingdom on disarmament verification.[3] The challenge, Browne argued, "is in developing technologies which strike the right balance between protecting security and proliferation considerations and, at the same time, providing sufficient international access and verification." The proposed conference could contribute toward the development of these technologies and at the same time help build deeper technical relationships between the recognized nuclear-weapon states, hopefully generating additional confidence in the disarmament process.

In his speech, Browne confirmed his country's willingness to take the lead on disarmament research and also made reference to relevant joint British-Norwegian research cooperation. In March 2007, about 20 representatives from various institutes in Norway and the United Kingdom met in London to explore how in the future they might bring their respective expertise to bear on the challenge of verifying nuclear disarmament and agreed to explore a series of technical questions through sustained and cooperative research. Subsequently, technical experts from Norway and the United Kingdom, as well as nongovernmental researchers from the Verification Research, Training and Information Centre, met repeatedly to discuss verification requirements in nuclear disarmament. This article, which draws on some of these discussions, will focus on some of the key challenges related to verification, in particular, international inspections at nuclear dismantlement facilities. Moreover, it will mark out the course for future research and cooperation in disarmament verification.

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Defining Verification and the Role of Inspections

Verification can be understood as the "process of gathering and analyzing information to make a judgement about parties' compliance or non-compliance with an agreement."[4] However, it is difficult to say what verification will practically entail outside the context of a given treaty.[5]

One thing is relatively certain: the difficulties of verifying nuclear disarmament will correspond with the complexity of the disarmament commitment. For example, verifying that a state has complied with an obligation to dismantle one nuclear warhead will be relatively straightforward. Even in that case, several important questions would need to be answered: How can the inspector be sure that she is looking at a nuclear warhead and not a dummy? If the inspector cannot observe the dismantlement process, how will he be sure that disassembled parts come from the warhead and not some hidden stash of electronics components? How can the inspector be sure that the host state has accounted for all nuclear material if she cannot measure and weigh the "physics package" (the fissile material part of the warhead)?

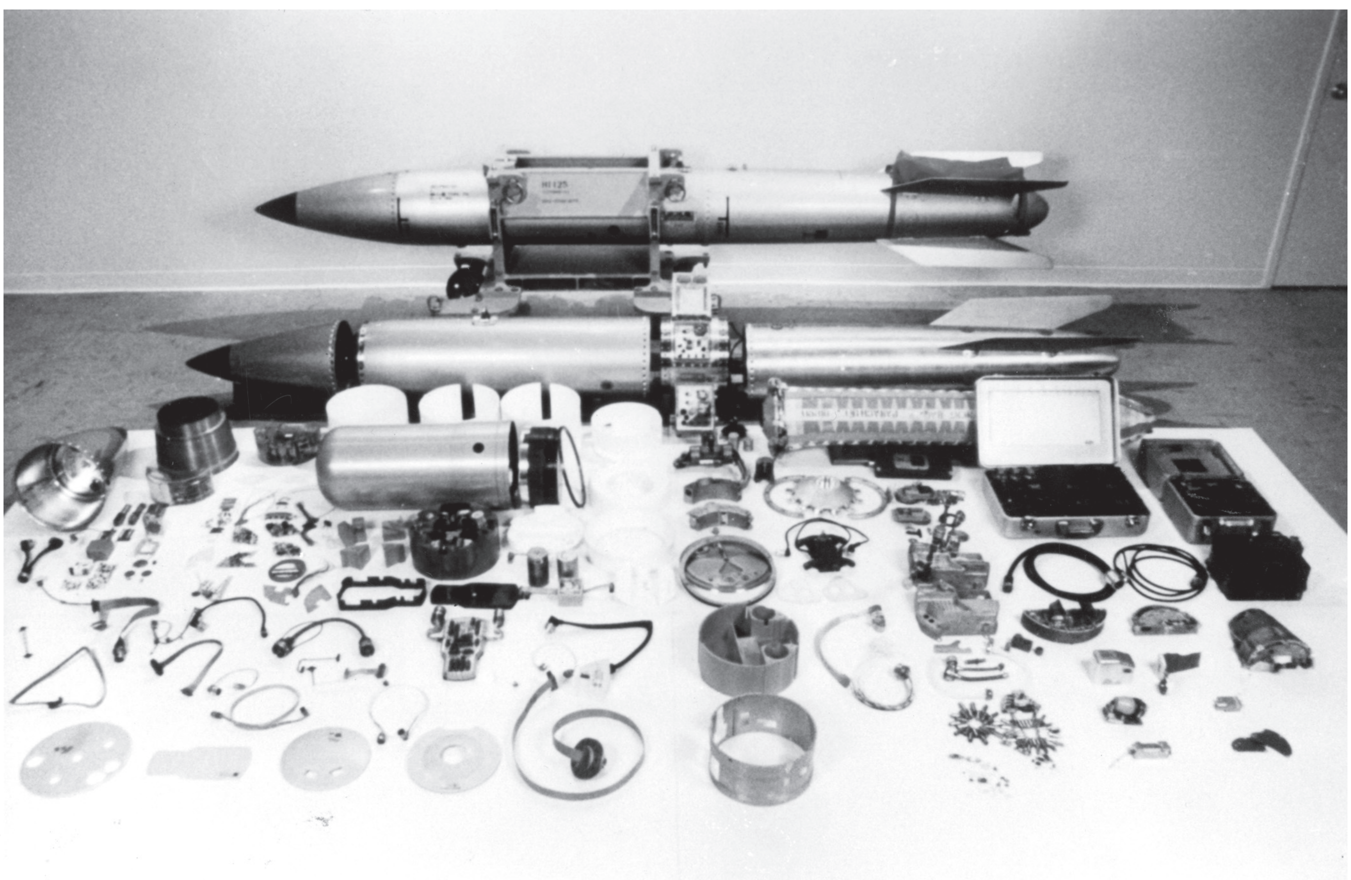
Verifying complete disarmament is likely to be far more difficult and will involve addressing an even larger and more complex set of questions: How can the inspector be certain that the state has declared all its nuclear warheads? How can the inspector be assured that there is no further undeclared production of nuclear warheads?

One factor that facilitates effective and efficient verification is the careful selection of items, activities, and facilities that must be monitored and those that need not be. If the goal is to verify the dismantlement of an agreed number of warheads, the inspector may not need access to the entire nuclear weapons complex, but only to certain sites, activities, and personnel. Under such a scenario, inspectors will no doubt prefer to pick and choose which sites to visit, although nuclear-weapon states may be unlikely to grant this privilege. By contrast, a comprehensive verification scheme is likely to require nuclear-weapon states to grant access to all relevant facilities, a large selection of relevant personnel, and a wide range of documentation.

Inspection designers need to develop standards for declarations of treaty-limited items along with lists of items, activities, and personnel available for inspection and interrogation. Ideally, the right to pick and choose some of these items, activities, and personnel should be firmly established.

In neither case, however, is it likely that an inspection process will "establish" or "confirm" that a warhead has been dismantled or that all warheads have been declared. In any verification scheme, it may be possible to identify and point out a fake weapon with relatively high certainty. Nonetheless, unless one can open up and check a weapon against a clear guide, there may be no way to prove that one's assessment is correct. Opening up the weapon would mean giving away critical design information. Obviously, that much transparency can never be given, making the quest for absolute confirmation a fool's errand. Therefore, some degree of uncertainty must be acceptable in verification.

Traditional International Atomic Energy Agency (IAEA) safeguards, inspections, and measurements are likely to be powerful tools for nuclear disarmament verification because they would allow inspectors to monitor dismantlement processes up close. Moreover, interaction



Department of Energy

A disassembled B61 nuclear gravity bomb is displayed by the Department of Energy in this undated photo.

between the inspecting and the inspected party is likely to induce trust and cooperation, enabling more credible and efficient verification in the long run. Inspection designers need to define the purpose of verification, including the role of inspections, in any verification scheme.

Verification Challenges: Warhead Design and Fissile Materials

Those wishing to design a nuclear warhead dismantlement verification regime possess some advantages. First, nuclear weapons exist in small quantities compared to, for instance, small arms and light weapons. There are consequently fewer items to declare, monitor, and verify. Fissile material is also relatively scarce compared to treaty-limited items in other regimes, such as conflict diamonds. Fissile material is also inorganic, which means that quantities remain roughly the same once declared. Unfortunately, these few advantages are readily outweighed by the numerous safety, legal, and national challenges facing the verification designer.

The legal problem is one of interpretation. A nuclear-weapon state cannot, according to Article I of the 1968 nuclear Nonproliferation Treaty, "assist, encourage or induce" a non-nuclear-weapon state to manufacture a nuclear weapon or other nuclear explosive device. If non-nuclear-weapon state inspectors are to play a role in the verification regime, negotiators would have to tackle several difficult questions. For example, is a nuclear-weapon state assisting another state if it unintentionally leaks weapons-relevant information, or does the assistance have to be intentional? What kind of leak would break international law? Would information on non-nuclear components constitute a breach?

Under the strictest of interpretations, the risks of involving international inspectors would probably be too great. With some legal flexibility, non-nuclear-weapon state inspections could be permitted if conducted with the utmost care. On the other hand, if inspectors are nuclear-weapon-state nationals, the designers of a verification regime have more legal flexibility. Here, however, national security considerations would play a major role. After all, the nuclear-weapon states would be hesitant about sharing their capabilities with states other than their closest allies.

As seen from the host state, inspector access to its nuclear weapons and facilities poses serious risks of passing on classified information: Could some inspectors be there under false guise to gather intelligence on behalf of another state? If so, what could they learn? Would an inspector from another nuclear-weapon state learn more, or look for other things, than inspectors from other countries?

Department of Energy

In March 1992, non-nuclear components of disassembled warheads are sorted in recycling bins at the Pantex plant in Amarillo, Texas.

What would an inspector from a state seeking to acquire nuclear weapons want to find out? For instance, is it isotopic ratios and similar information, or is it the layout of the weapon? Is it more important to protect the internal composition of advanced weaponry than that of an early-generation weapon, or should all weapons be equally protected irrespective of generation?

The host state may ask itself some of these questions when considering acceptable levels of intrusiveness. As a default position, it is therefore likely to provide only a minimum level of transparency just to be safe. Yet, this position may backfire. Seen from the inspector's point of view, a delay or deferral in access, for example, may be seen as a way to circumvent inspections in cases where compliance is an issue. Inspectors may think that the host is squirreling away a treaty-limited item. Consequently, inspection designers need to develop procedures and methods for resolving compliance issues involving national security-related facilities and information. These procedures are likely to differ from state to state.

Yet another challenge relates to the safety of the inspectors and the facility staff. Inspectors need to know how to behave around conventional explosives, as well as nuclear material. They must be made aware that certain restrictions are in place to prevent an accident rather than to curtail access. The large quantity of conventional explosives involved even in latest-generation nuclear devices puts restrictions on what equipment the inspectors can bring in, as well as what clothes they should be allowed to wear. This information should be available to the inspector upfront so as to avoid any misinterpretations or suspicions.

Verification Challenges: Protecting the Dismantlement Facility

Verification activities in established assembly/disassembly sites, such as AWE Burghfield in the United Kingdom or Pantex in Amarillo, Texas, are likely to be challenging.

The host will wish to protect as much sensitive information as possible, while the inspectors will wish to find out the truth. Naturally, any instruments or equipment that can give away device-based information relating to the mass, configuration, or isotopics of the physics package are sensitive. Other information that will need to be protected is the exact facility layout linked to various processes, schedules for input and output, and the location and function of security systems. Moreover, inspectors will be in close contact with ordinary facility operations, which may be unrelated to

The Trilateral Initiative: A Model For The Future?

Those seeking to design a system for verifying the dismantlement of nuclear weapons do not have to start from a blank slate. They can benefit a great deal from building on the experience of the Trilateral Initiative. This was a six-year (1996-2002) effort to develop a verification system under which Russia and the United States could submit classified forms of weapons-origin fissile material to International Atomic Energy Agency (IAEA) verification and monitoring in a irreversible manner and for an indefinite period of time.

Russia and the United States needed a new system because the IAEA's normal safeguards system, designed to prevent peaceful nuclear materials and facilities from being used for military purposes, is not set up to cope with nuclear materials still tied to weapons programs or with inspections at locations that have or had such programs. The initiative sought to broaden the items that could be brought under IAEA monitoring to include any classified items containing plutonium or highly enriched uranium, including nuclear warheads, warhead components, pits, or secondaries. The initiative also sought to ensure that these would be permanently safeguarded, unlike material submitted to IAEA monitoring under existing voluntary agreements. In 1993, for example, the United States had submitted 10 metric tons of highly enriched uranium and two metric tons of plutonium to voluntary IAEA safeguards, but this material could have been withdrawn at will.

Moreover, the methods and the overall framework had to be designed to protect classified information and to ensure that both countries met their obligations under Article I of the nuclear Nonproliferation Treaty (NPT). Under that article, nuclear-weapon states-parties to the NPT are prohibited from assisting, encouraging, or inducing any non-nuclear-weapon state to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices, and this obligation logically extends to the IAEA or any other multilateral entity. Therefore, the IAEA recognized that its access would be restricted so as to prevent nuclear secrets from leaking out.

Some of the early decisions reached under the initiative related to defining the nature and scope of verification so that it could be politically acceptable and provide sufficient confidence that disarmament was actually taking place. One decision involved the nature of the disarmament-related nuclear material that the countries would seek to verify. Four verification levels were considered:

Level 1: limit the initiative to accepting only unclassified materials, which would have removed those materials from reuse;

Level 2: accept classified forms of fissile material without attempting to establish that the forms actually represent nuclear warheads or components thereof;

Level 3: verify the fact that the items presented are in fact nuclear warheads or specified components thereof, including specific model identifications; or

Level 4: start with the dismantlement of weapon systems or subsequent stages so that the monitoring could attest to the removal of warheads from delivery systems.

For practical purposes, the parties decided that the initiative should aim for Level 2, which posed significant challenges but was considered to be achievable. Level 1 would not have required a new framework. Going to Level 3 would have presented far greater security concerns and challenges related to authenticating warhead templates that could be used by the IAEA. Level 4 would have been a simple extension of Level 3.[1]

Participants also decided on a metric of effective verification, "the 1 percent solution." The working group proceeded on the basis that a breakout involving on the order of 1 percent of the monitored inventory at any time could portend a strategic change. Although never formally adopted, the 1 percent figure served as the de facto reference for determining sample-plan sizes for verification and reverification.

Participants examined various technical means of verification, looking first at whether a technology might be found that would allow unrestricted measurements but would not be capable of extracting any classified information from the objects being measured. Not finding any suitable methods, the working group agreed to base IAEA verification measurements on references to unclassified attributes, using sensitive measurements operating behind "information barriers."[2] Although attribute verification would provide far less information than the IAEA obtains under routine plutonium safeguards, it was deemed to be sufficient to be formally accepted as the basis for the IAEA verifying the classified materials involved in the initiative.

Attribute verification involves comparing an object to a set of reference characteristics. For example, the presence of a militarily significant quantity of weapons-grade plutonium would be assessed by measures that first determined the presence of plutonium, then assessed that the isotopic composition of the plutonium was such that it was weapons-grade material rather than reactor-grade,[3] and finally calculated that the mass of plutonium fell above an agreed minimum defined in relation to each facility.

Several measurement methods were identified that could satisfy this requirement. In the end, the working group settled on high-resolution gamma ray spectroscopy to establish the presence of weapons-grade plutonium and the combined use of neutron multiplicity counting and high-resolution gamma ray spectroscopy to measure the plutonium mass.

The scheme for monitoring and verifying this material as it was converted to eventual peaceful use in nuclear fuel was straightforward: sealed containers would be transported to facilities where the material would be converted and shorn of classified isotopics and chemical properties. IAEA monitoring would begin with the arrival of the classified material at the entry point to the conversion facility. A perimeter monitoring system would assure that only monitored containers, plus other nonweapons materials needed in the peaceful fuel, would be allowed in. All fissile material containers exiting the conversion facility would be measured using normal IAEA safeguards methods, and then seals would be applied to the containers for storage or transport to processing facilities where they would be converted to fuel for nuclear reactors. Managed access would be allowed into the conversion facility annually to ensure that no warhead components accumulated and that no undeclared penetrations occurred that could have resulted in undeclared additions or removals of fissile material. IAEA inspectors could witness containers entering the measuring system, identify tag measurements, confirm seal data, and observe the attribute measurement results on a pass-fail basis.

Working group participants judged that if such a scheme were to be practical, the conversion facilities would have to be constructed following mutually agreed architectural plans. No discussions took place on specific agreements, however.

The initiative developed slowly because of some highly arcane technical differences between Russia and the United States and because the 2000 conclusion of a separate bilateral Plutonium Management and Disposition Agreement between Russia and the United States drained some of the necessary political impetus and attention.[4]

Nonetheless, by November 2001, Russia and the United States were on the brink of agreeing to a model verification agreement. Unfortunately, the new Bush and Putin administrations brought the initiative to a halt. When President George W. Bush took office, his administration announced that it did not support a 13-point Article VI agenda from the 2000 NPT Review Conference that included support for the initiative. The Putin administration was also not as supportive as its predecessor. By the time of the 2002 IAEA General Conference, the two sides had agreed that the initiative should be brought to a close, concluding that it had been a success and that it was now up to the states to enter into individual implementation agreements with the IAEA.

Accomplishments

In many ways, Washington and Moscow were correct. From a legal perspective, the Trilateral Initiative was ready at that point to be carried out, although some implementation details still required further negotiation. As the final report of the Joint Working Group to the Trilateral Initiative Principals put it in 2002:

Over the course of six years, the Joint Working Group addressed the technical, legal and financial issues associated with implementing IAEA verification of weapon-origin and other fissile material released from defence programmes and can now recommend the successful completion of the original task. The enabling technologies developed under the Initiative could be employed by the IAEA on any form of plutonium in nuclear facilities, without revealing nuclear weapons information. The Working Group found no technical problem that would prevent the IAEA from undertaking a verification mission in relation to such fissile materials released from defense programmes, and believes that many of the technical approaches could have broader applicability to other forms of fissile materials encountered in conjunction with nuclear arms reductions.

In addition, verification arrangements essentially were agreed on for initial implementation at the Fissile Material Storage Facility at Mayak in Russia and at the K-Area Material Storage (KAMS) Facility at the Savannah River site in the United States. In placing the KAMS Facility under voluntary-offer safeguards, the United States stated its intention to alter these safeguards once an agreement pursuant to the initiative entered into effect.

Could the Trilateral Initiative Be Reactivated?

States looking at verifying nuclear disarmament might consider reactivating the Trilateral Initiative. In particular, two options might be pursued:

1. The initiative could be reactivated as a three-way study effort to continue work aimed at fleshing out a verification system in relation to nuclear disarmament. With no obligations to commit, that would be the low-risk option, more likely to gain support but running the risk of being a perpetual experiment.

2. Alternatively, Russia, the United States, or both acting together could negotiate agreements in a few months that could allow them to begin to submit weapons-origin fissile material to IAEA verification. Although the preparatory work carried out was extensive, significant practical issues remain. Phasing in the agreements over time could allow progress to be made while gaining confidence in the security measures implemented. Under such an arrangement, Russia or the United States would retain the right to determine which fissile materials to submit, when to submit them, and the conditions necessary. Through such provisions, Russia, the United States, and any other state possessing nuclear weapons that would enter into such an arrangement could gain the assurances needed to protect their security interests. The agreements could have a specified duration to provide an out if the parties could not reach agreement.

Concluding the first verification agreement based on the Trilateral Agreement would energize the international community, bolster support for the NPT, and provide the foundation for engaging other states possessing nuclear weapons. Such a step could be carried out in time for the 2010 NPT Review Conference. —*THOMAS E. SHEA*

ENDNOTES

1. Thomas E. Shea, "Potential Roles for the IAEA in a Nuclear Weapons Dismantlement and Fissile Materials Transparency Regime," in *Transparency in Nuclear Warheads and Materials: The Political and Technical Dimensions*, ed. Nicholas Zarimpas (Oxford: SIPRI, Oxford University Press, 2003), pp. 229-249.

2. An information barrier would permit unrestricted measurements on a secure basis. The results would be compared to unclassified parameters in a way that questions could be answered in a pass-fail manner. For example, the measured ratios of the key isotopes would be compared to a limit. If less than the limit, the answer would be "pass," and conversely, if greater than the limit, then "fail."

3. The isotopic ratio chosen was such that there was at least 10 times as much plutonium-239 as plutonium-240, which is true for plutonium used in nuclear weapons in Russia and the United States.

4. The Plutonium Management and Disposition Agreement (PMDA) focused on the implementation of the steps for verification as one objective, but disposition was its primary focus. It called for reusing 34 metric tons of excess weapons plutonium in each country in mixed-oxide fuel for nuclear reactors. Although the IAEA was an equal partner in the Trilateral Initiative, in the PMDA, a different team of U.S. officials carried out the bilateral negotiations, and the IAEA was informed of the PMDA for the first time when the negotiations were essentially concluded. Nor did the PMDA include provisions for taking classified forms of fissile material into monitored operations. To be sure, the PMDA provides for the possibility of IAEA verification and calls for "early consultations" with the IAEA to work out the verification arrangements, but those consultations have yet to be held.

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the verification objective. In addition to being a potential security risk, the inspectors' presence will interrupt site operations. Facility staff may feel that the presence of international inspectors is threatening, and the facility operator may want to safeguard the anonymity of his or her staff. There is a very real risk that the host's sensitivities will override the inspector's demands for transparency, effectively undermining the verification regime.

Many if not all of these concerns may be remedied by choosing built-for-purpose disarmament facilities and training programs. The advantage of constructing a new facility built with international inspections in mind is that it would be possible to share the facility floor plan with the inspectorate as soon as it leaves the drawing board. Inspectors could then be invited to conduct design-information verification as the facility is constructed. During these visits, the inspectors check the building against the floor plan to make sure that there are no hidden trapdoors, extra piping, or other undeclared construction. Ideally, all the nuclear-weapon states would build identical dismantlement facilities in order to facilitate inspections. Each facility could be placed within a larger construction protected by whatever physical protection measures the host state deemed necessary. This way, one would facilitate inspections while accommodating national security concerns. Facility operators could be specially trained to accommodate inspectors while protecting information at the facility.

Inspection designers should compare the costs and benefits of building new, identical built-for-purpose dismantlement facilities with using old, existing facilities with their inherent challenges.

A Proposal for a Future Research Agenda

Getting to zero nuclear arms will take a long time. It will be a frustrating process fraught with difficulties and dangers, but, as Browne stated, this is "a challenge we can overcome."[6] Norwegian Minister of Foreign Affairs Jonas Gahr Støre made clear recently that achieving the vision of a world free of nuclear weapons requires at least five things: political leadership at the highest levels, commitment followed up by action, nondiscrimination, transparency, and cooperation.

Støre held that "[n]on-nuclear-weapon states should cooperate with nuclear-weapon states to develop the technology needed for verifying disarmament. Nuclear-weapon states should seize the opportunity presented by reductions in nuclear weapon numbers to demonstrate this technology."[7] At a technical level, this cooperation in nuclear disarmament verification research should focus on at least the following:

> One thing is relatively certain: **the difficulties of verifying nuclear disarmament will correspond with the complexity of the disarmament commitment.**

1. Developing a generic model of the entire dismantlement process. This model should include all relevant verification objectives and technologies and identify suitable verification procedures for each dismantlement action.

2. Developing a declaration standard. This standard should allow the inspected party to list all sites, documentation, and personnel relevant to the verification process. It should include a section describing sites, documents, or personnel not eligible for inspection and for what reasons. It should include an attached description of special safety precautions the inspectorate must take when visiting the facilities.

3. Identifying key inspection points and associated measurement technologies and techniques, including information barriers and other restrictions. The IAEA Trilateral Initiative made significant headway in this work (see page 17). The British and Norwegian research institutes are developing an information barrier system and procedures that will be credible and mutually acceptable to all parties under future disarmament treaties.

4. Developing procedures and methods that will help states-parties and the inspectorate resolve compliance concerns involving national security-related facilities and information.

5. Calculating the costs of building new, identical built-for-purpose dismantlement facilities and comparing these with the costs of using existing facilities with their inherent challenges.

A joint commitment by nuclear-weapon and non-nuclear-weapon states will make verified reductions and, eventually, elimination of all nuclear weapons a reality. Joint cooperation between laboratories, where possible, will further this goal. It is time to seize the opportunity and get to work. **ACT**

ENDNOTES

1. George P. Shultz et al., "A World Free of Nuclear Weapons," *The Wall Street Journal*, January 4, 2007, p. A15.

2. Margaret Beckett, "A World Free of Nuclear Weapons?" Keynote address at the Carnegie International Nonproliferation Conference, Washington, DC, June 25, 2007.

3. Des Browne, "Laying the Foundations for Multilateral Disarmament," Speech before the Conference on Disarmament, Geneva, February 5, 2008.

4. United Nations Institute for Disarmament Research and the Verification Research, Training and Information Centre (VERTIC), *Coming to Terms With Security: A Handbook on Verification and Compliance* (London: VERTIC, 2003), p. 1.

5. Allan Krass, *Verification: How Much Is Enough* (Stockholm: SIPRI/Lexington Books, 1985), p. 2.

6. Browne, "Laying the Foundations for Multilateral Disarmament."

7. Jonas Gahr Støre, Statement at the Conference on Disarmament, Geneva, March 4, 2008.