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Working Paper

A Verification Regime for Warhead Control

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After a brief period of progress, the U.S.-Russian nuclear reduction process has reached a stalemate.[1] This situation causes us to rethink the following issues:

- What is the motivation for the two nuclear superpowers to conduct nuclear reductions?
- How can the focus of the nuclear arms reduction process be changed from verification of reduction of delivery vehicles to verification of reduction of warheads and nuclear materials?
- What is the objective for future nuclear reductions?
- What kind of verification regime will be required for future nuclear reductions?

What Is the Motivation for the Two Nuclear Superpowers to Conduct Nuclear Reductions?

In the Cold War, the two military-political alliances, NATO and the Warsaw Pact, were locked in a rigid confrontation which resulted in a colossal arms race and the accumulation of enormous nuclear arsenals that far exceeded any reasonable and sufficient levels. With the collapse of the former Soviet Union, and in light of the political upheavals and economic degradation it is experiencing, Russia has to change its nuclear policy from one of confrontation to nonconfrontation to serve its national interests after rethinking its role and place in the international system. This new nuclear policy is intended to be credible and non-provocative, and to defend Russian territory from nuclear attacks launched by any country or group either deliberately or accidentally.[2] This policy requires Russia to focus its limited resources on maintaining a nuclear qualitative parity rather than a numerical parity with the

United States. Russia's existing nuclear forces, which were inherited from the Soviet Union, are excessive in size and inadequate in structure to carry out this strategy. Russia has tried to reshape the structure and size of its nuclear forces through two approaches. One is to cooperate with the United States to reduce its nuclear forces, and to lessen its economic burden. The other is to increase the relative emphasis on nuclear forces to counterbalance the inferiority of its conventional force. Russia has not only abolished its "no first use" policy, but has also made a new decision to develop a new generation of small tactical nuclear weapons for defense against conventional attack.

On the American side, with the end of the Cold War, threats to its national security have shifted from possible nuclear wars to accidental or unauthorized launches of nuclear missiles and to risks of nuclear proliferation. In recent years, due to the ongoing economic and political upheavals in Russia, the "loose nukes" threat has become more serious.[3] The United States is seriously concerned about nuclear warheads and their essential ingredients—plutonium and highly enriched uranium (HEU)—falling into the hands of terrorists and nuclear black marketeers, and also about potential aggressive moves by the so-called rogue states should they acquire nuclear, biological, or chemical capabilities. As a result, it has tried to reduce nuclear threats by means of the further reduction of nuclear arsenals, de-alerting measures, and nonproliferation efforts. Meanwhile, it is planning, notwithstanding the reductions, to retain large arsenals (nearly ten thousand warheads) of nuclear weapons in a "permanent stockpile" under the "reduce and hedge" policy.[4]

Both the United States and Russia continue to rely on nuclear deterrence as the foundation of their security. At the same time, joint efforts toward arms control and disarmament would lessen the economic burden on both countries and lower the risk of an unauthorized or accidental use of nuclear weapons, and of their proliferation. Also, these joint efforts toward arms control and disarmament are necessary to keep some non-nuclear weapon states parties from withdrawing from the Non-Proliferation Treaty (NPT) and pursuing nuclear weapons themselves.

From the above discussion, one can see that, to comply with their NPT obligations, the long-term development of nuclear policy in the United States and Russia should be a gradual decline in the role and size of their nuclear weapons to their total elimination.

How Can the Focus of the Nuclear Arms Reduction Process Be Shifted from Verification of Reductions of Delivery Vehicles to Verification of Reductions of Warheads and Nuclear Materials?

During the past thirty years of the U.S.-Russia arms control and nuclear disarmament process, the focus of negotiations has been limiting the number and deployment of nuclear-warhead delivery systems. The focus has not been on eliminating nuclear warheads, nor on restricting the stockpiles of fissile materials. This was true for several reasons:[5]

- There was no "strategic imperative" to control warheads. Controlling launchers, while not perfect, was both easier and sufficient to contain the threat, especially while the number of deployed warheads numbered in the thousands.

- Verification or monitoring of any warhead elimination agreement would have required a degree of intrusiveness unimaginable in the Cold War climate.
- To be effective, any mandated warhead elimination regime would require restrictions on net new warhead production.

Today, the dramatic changes in the international security environment have made it both necessary and possible to seek a warhead elimination and fissile material control regime. The end of the Cold War promised a new era of cooperation, which, in many respects, is already under way. The United States and Russia have a good track record in politically sensitive areas, such as material protection, control, and accounting activities, Nunn-Lugar Cooperative Threat Reduction assistance, and expert interaction at the lab-to-lab level. Such approaches are at least tentative steps toward a regime for warhead elimination and fissile material control.

As to the "strategic imperative" for warhead elimination, the United States feels it more urgently than Russia does. On the American side, there are widespread concerns about the great uncertainty surrounding the size of the Russian nuclear weapons and fissile material stockpile and about the safety and security of Russian nuclear weapons and fissile materials. For instance, former senator and co-sponsor of the Nunn-Lugar legislation Sam Nunn has characterized the "loose nuke" problem as the single most dangerous threat to U.S. national security.[6] On the Russian side, however, there is no overriding interest in greater transparency for nuclear weapons and fissile material stocks. Russia apparently believes it will bear the larger burden in a transparency arrangement and gain little by comparison in return. This asymmetry of interests between the two sides is one of the most important reasons for the failure of the short-lived U.S.-Russian discussions on safeguards, transparency, and irreversibility (STI)—the closest the two sides have come to addressing warhead elimination and transparency of fissile material stocks.[7] This failure does not mean, however, the exclusion of the possibility of cooperation in warhead and fissile material control. Actually, Russia has its own incentives to cooperate with the United States in this field. Russian officials have expressed concerns that the United States could "upload" additional warheads onto missiles in a bid for strategic superiority. Eliminating excess warheads could help ease Russian concerns over this possibility. Therefore, in spite of Russia's reluctance, efforts toward warhead and fissile material control could be productive if the United States can manage to strengthen incentives for Russia to cooperate.

Once a political climate for cooperative warhead and fissile material control is in place, much openness would be achieved on nuclear-related activities. Although the subject matter is still sensitive—sensitive facilities are involved and sensitive information needs to be exchanged—it is quite possible for the United States and Russia to build a legal mechanism by which to exchange sensitive and classified information for the purpose of arms control and nonproliferation.[8] Verification technology for an agreement on a nuclear warhead and fissile material control regime will not be an insurmountable obstacle if some necessary classified data are legally allowed to be exchanged, because many of the verification techniques rely on technology that is now available or under development.[9]

The call for the negotiation of a "non-discriminatory, multilateral and international effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices" has become louder and louder.[10] The conclusion of this treaty would lay the groundwork for restrictions on net new warhead production and would greatly facilitate progress toward the elimination of nuclear warheads.

In sum, the "strategic imperative" for warhead elimination, the greater cooperation and openness in nuclear activities, and the prospect of concluding a cutoff treaty indicate that the time for nuclear elimination is approaching.

What Is the Objective for Future Nuclear Reduction?

As stated before, the current arms control and disarmament agreements have involved elimination of delivery vehicles, launchers, and associated equipment only and limits on the number of nuclear warheads each can carry. There is no requirement to eliminate any nuclear warheads. For instance, START I and START II limit the number of warheads that can be mounted on strategic delivery vehicles, but they do not oblige the United States or Russia to destroy the nuclear warheads covered by the treaties. Instead, they require that the treaty parties simply remove some warheads from the subject missiles. Although some of the warheads are being dismantled,[11] there has been no verification of warhead dismantling by any other countries. The rest of the removed warheads (the substantial majority) are stockpiled intact.[12] These intact warheads would enable the United States and Russia to rapidly "rebuild" their nuclear arsenals if political decisions were made to do so.

The current agreements also have no restrictions on the stockpiles of fissile material, the essential ingredient of all nuclear weapons. Fissile material is the most difficult part of a nuclear weapon to produce, and the size of the fissile material stockpiles held by the nuclear weapon states places an upper limit on the number of warheads they can manufacture. Large stockpiles of fissile material also create the potential for rapid and large-scale "breakout" from treaty obligations.

Are the United States and Russia seeking "in good faith" to reduce their nuclear weaponry? What is a genuine nuclear reduction regime?

A genuine nuclear reduction regime should include the irreversible destruction of nuclear warheads and transparency of nuclear stockpiles, including warhead and fissile material stocks. Three requirements must be met to satisfy this objective:

- Confirm that the declared dismantling is actually taking place.
- Have confidence that components from dismantled warheads and other excess fissile materials would not be available to rebuild nuclear warheads.
- Have confidence that those additional warheads beyond the agreed weapons or military fissile material levels are not being produced.

The objective and its indispensable requirements were officially put forward at the January 1994 summit between Presidents Clinton and Yeltsin at which they agreed on a goal of "ensuring the transparency and irreversibility of the process of reduction of nuclear weapons." Three years later, the objective was again emphasized by the two presidents at the March 1997 Helsinki Summit. In their joint statement, Presidents Clinton and Yeltsin called for a START III agreement that includes "measures related to the transparency of strategic nuclear warheads inventories and the destruction of strategic nuclear warheads . . . to promote the irreversibility of deep reductions including prevention of a rapid increase in the number of warheads." Also, the two presidents agreed that "the sides will consider the issues related to transparency in nuclear materials."

The two crucial words in these official statements are "transparency" and "irreversibility." They are defined in an American "non-paper" presented to the Russians as:[13]

- Transparency: The measures that build each side's confidence in its understanding of the size of the other's stockpiles of nuclear weapons and fissile materials, and the rate of reduction in these stockpiles.
- Irreversibility: The measures should build each side's confidence that the nuclear arms reductions being carried out are irreversible, and in particular that fissile materials declared in excess to military needs (including civilian weapon-usable materials) are not being used to build new nuclear weapons.

These definitions suggest a way to address the control of warheads in any future nuclear arms-control regime. The warheads would not simply be removed from delivery vehicles and put in storage; they would be dismantled in a manner that would render them unusable in weapons. The fissile materials from these warheads would be put in storage under international safeguards to prevent them from being recycled into weapon arsenals. Furthermore, the production both of additional warheads beyond the agreed levels and new weapon fissile materials would be prohibited to ensure the substantial shrinkage of nuclear weaponry and the stocks for making warheads.

What Kind of Verification Regime Will Be Required for Future Nuclear Reductions?

Achieving the irreversible destruction of nuclear warheads and transparency of nuclear warhead and fissile material stockpiles requires a comprehensive verification regime that would address the following issues:

- Declarations of nuclear stockpiles
- Dismantlement of nuclear warheads
- Transparency, safeguards, and disposition of fissile material stocks
- Prohibition on manufacture of additional warheads or new fissile materials for warheads

Declarations of nuclear stockpiles. The first element in a warhead verification regime would be an initial declaration of nuclear warhead inventories, to be updated at agreed intervals. This is especially important because estimates by national intelligence are highly inaccurate. For example, the United States made an estimate of Russia's nuclear stockpile with a level of uncertainty of a staggering five thousand warheads.[14] The purpose of this declaration is to establish the benchmark against which progress in warhead elimination required by the treaty would be measured, as well as to establish a database for tracking and monitoring the "treaty limited items" (TLI) in each of the party's arsenals.[15]

Several problems are commonly raised. What information should be exchanged? How should it be exchanged? And how can confidence be achieved that the declaration or data exchange is accurate and complete?

To facilitate deeper nuclear disarmament, one of the major obstacles that needs to be dealt with is the excess of secrecy that surrounds nuclear weapons, which traditionally has been the consequence of too much concern about vulnerability. One cannot, however, go too far in the opposite direction—declarations of too much detail. If so, increased vulnerability would be disclosed. For instance, exact knowledge of locations of nuclear explosives would increase the danger of preemption, sabotage, and so on. Therefore, negotiations on the items to be declared will require a balance between transparency and vulnerability. Optimistically, declarations for the deeper nuclear disarmament would include:[16]

- The type, status, and serial number of all nuclear explosive devices;
- The location, status, and description of facilities at which nuclear explosives had been designed, tested, assembled, stored, deployed, maintained, modified, repaired, and dismantled;
- The location, status, and description of facilities that produced key nuclear weapon components, such as high-explosive assemblies, detonators, neutron generators, and arming, fusing, and firing sets; and of facilities that produced or fabricated special warhead materials, such as plutonium, highly enriched uranium, tritium, enriched lithium deuteride, and beryllium;
- The history of each nuclear explosive device, including the dates of assembly, movement between various declared facilities, and its dismantling, destruction in an explosive test, or accidental loss; and
- The operating records of the warhead-related facilities listed above.

Data exchange in a regime for nuclear warheads should be a multi-stage process beginning as early as possible, because an early exchange of data would force governments to make decisions about compliance with reporting requirements well in advance of possible disarmament agreements.[17] Upon completion of the initial exchange of data, it would be necessary for each of the parties to establish a database relating to the treaty. Such a database should include all the information exchanged. Data updates at agreed-upon intervals could allow each of the parties the opportunity to fine-tune its data prior to entry into force. Final data updates for the initial database should be exchanged after entry into force of the treaty, but prior to the commencement of the baseline inspections.[18]

If the initial inventory could not be established with great accuracy and completeness, the value of agreements to dismantle a certain number of warheads would be diminished considerably. Inspections and history of the stockpiles can help to minimize the uncertainty of declarations.

During inspections, it would be necessary for inspectors to obtain two kinds of assurances. The first is to assure that objects declared to be warheads are authentic, not fake. A combination of radiation and other distinctive signatures, like the dimensions, weight, and heat output, might be used to "fingerprint" types of nuclear warheads.[19] The second is to make sure that undeclared objects do not contain warheads. If the objects are not too large, gamma ray and neutron detectors with certain limits on the resolution could confirm the absence of fissile materials. Large objects could contain enough shielding to prevent such detection in a reasonable amount of time, however, in which case the inspection party should be required to use other methods to demonstrate that the objects contain no warheads.

If all declared items were equipped with a unique identification, like a serial number or special "tag," verification of the declaration would be enhanced and simplified. Any discovery of an untagged warhead or canister would constitute an unambiguous violation; also, tags would allow random sampling to be used to verify declarations, thereby decreasing the monitoring effort, cost, and intrusiveness.

Data on the history of warhead stockpiles and the operation of warhead-related facilities cannot be verified directly, of course, but could be checked for internal consistency, and for consistency with archived intelligence data.[20] If, for example, U.S. satellites had detected the movement of nuclear warheads from a particular Russian facility on a particular date in the past, this could be checked against the records exchanged between the two countries. Indeed, such records should improve the value of archived data by confirming or contradicting past interpretations by intelligence agencies. The fact that countries would not know what intelligence information might be available would act as an incentive to provide complete and accurate data.

Dismantlement of warheads. Once a baseline warhead inventory is established, agreed reductions can be achieved by confirming that a certain number and/or type of warheads have been dismantled. This confirmation could be done in three steps: (1) authenticating that the warheads arriving at a warhead dismantling facility are of the type declared; (2) confirming that a declared dismantling has actually taken place in a dismantling facility; and (3) confirming that the components from dismantled warheads are placed in storage under the safeguards of the International Atomic Energy Agency (IAEA).

The first step—determining that an item to be dismantled is actually a nuclear warhead of a given type—may require the use of both chain-of-custody procedures from a delivery vehicle, deployment site, or weapon storage depot to the dismantlement facility and the use of warhead radiation signatures to determine the unique template of the warhead.[21]

The third step can be accomplished relatively easily. After dismantlement takes place (a warhead is considered to be fully dismantled when the high explosive is removed from the "pit"), its components ("pit" and canned subassembly) would be stored in individual containers. Inspectors could perform "fingerprint" measurements to confirm that the containers do contain the components from a warhead of the stated type. After such an inspection, the component containers would be tagged and sealed with "tamper-indicating seals," and delivered in chain of custody to storage depots where they would remain inspectable until they come under IAEA safeguards.[22]

The second step—confirming that a declared dismantling has actually taken place in a dismantling facility—has been the most sensitive issue for nuclear disarmament for two reasons: (1) the dismantling of nuclear warheads cannot be verified directly without revealing sensitive design information; and (2) assembly and stockpile maintenance activities usually take place in the same facility as dismantling occurs, like the Pantex plant and Y-12 plant in the United States[23] and Arzamas-16, Sverdlovsk-45, Zlatoust-36, and Penza-19 in Russia.[24]

To minimize both the disclosure of sensitive information and the impact on stockpile surveillance and maintenance activities at a dismantling facility, there may be some significant advantages in using a dedicated dismantlement facility. Russia has indicated that it would not encounter fundamental difficulties in concentrating the dismantling of eliminated warheads at one of its four warhead production and dismantling plants.[25] The United States is also considering the Device Assembly Facility (DAF) at the Nevada Test Site as a dedicated dismantlement facility.[26] To modify the DAF, however, an investment of up to hundreds of millions of dollars is required; also required are several years to develop the environmental, safety, and health assessments, the security evaluations, and the operational readiness reviews.[27] Furthermore, in order to preserve safety and security in disassembly, people have to be trained if the present dismantlement rates are to be increased and if new dismantlement sites are to be installed.

If a dedicated dismantlement facility were built, the verification of warhead dismantling could be achieved by establishing portal and perimeter continuous monitoring (PPCM) at the dismantling facility. At the inception of PPCM, the inspectors should have the right to sweep the whole facility one time to ensure that a stockpile of warheads and components does not exist inside the facility. During the long-term operation of the PPCM, all items, vehicles, and personnel entering and leaving the facility would have to be subject to search by the inspectors. Inspections at the portals would ensure that objects declared to be warheads or pits of a particular type are authentic, and that no warheads or pits entered or exited the facility without being detected and accounted for.

Given the investment and effort required to construct a dedicated dismantlement facility, an existing assembly/disassembly facility is still a good candidate. In this case, four options might be viable for the verification of warhead dismantling.[28]

Option 1: storage monitoring plus chain of custody to and from the gate of the dismantlement area. This option is designed to demonstrate that the warhead had been removed from the stockpile to the dismantlement area and that the corresponding fissile components—in particular, the plutonium pit—had been placed in a monitored storage facility. Since the option does not provide access to the dismantlement area, where actual dismantlement of warheads takes place, the intrusion would be minimal. The verification of warhead dismantlement, however, would be challenging. Two major technical obstacles are how to confirm that an object delivered to the dismantlement area was a TLI authentic warhead of a given type and how to confirm that the pit, which was subsequently placed in storage, was actually taken from a specific warhead. Perhaps radiation signature measurement and chain of custody would help to deal with these obstacles.

Option 2: storage monitoring plus chain of custody to and from the gate of a PPCM guarded, segregated dismantlement section within the dismantlement area. To establish PPCM around the entire dismantling area would be extremely intrusive and costly because it would require that all items entering and leaving the dismantlement area be subject to search. This would result in an unintentional loss of information regarding the enduring stockpile, because warheads returned for retrofitting or testing would be subject to inspection and potential radiation measurements. It might be possible, however, to establish PPCM around a portion of the dismantlement area dedicated to the monitored dismantlement. Although this would affect the current operations at this facility and would require a onetime investment in facility modification, the segregation of dismantling activities from the assembly and stockpile maintenance activities by using different perimeters and portals would greatly reduce the impact on the enduring stockpile. This option has been given a high priority in the United States.[29]

Option 3: storage monitoring plus chain of custody to and from the gates of cells and bays within the dismantlement area.[30] This option makes the fullest possible use of chain-of-custody techniques in place of PPCM. It would allow the inspectors to track a TLI warhead up to the disassembly cells and bays (a particular warhead might be transferred to and from several bays and cells during the course of dismantlement, as successive stages of dismantlement are performed) and track the fissile components from the cells to the storage area. Also, it would allow the inspectors to verify that the disassembly cells and bays contained no warheads or warhead components either before or after the disassembly procedure. In other words, except for the dismantling process occurring in the cells or bays, the inspectors should monitor the entire flow of the TLI warhead and its components within the dismantling area, to and from the cells and bays.

Option 4: storage monitoring plus chain of custody through the whole procedure of warhead dismantlement. This option would extend the chain of custody into the bays and cells. The inspectors would be allowed to observe visually or via remote monitors the dismantling process in the bays and cells. The loss of information through direct or remote observation could be controlled by limiting the quality of the view given to the inspectors through various means, such as controlling the resolution of optical devices, restricting the field of view, or careful masking.

Transparency, safeguards, and disposition of fissile material stocks. If reductions are to be truly irreversible, a deep-cut verification regime must also confirm that the components from dismantled warheads and other excess fissile materials would not be available to rebuild nuclear arsenals. This requires transparency, safeguards for the stocks of fissile materials, and disposition of excess HEU and plutonium—rendering them unusable or unattractive for use in nuclear weapons.

Transparency of the stocks of fissile materials should include the following declaration:[31]

- The mass, chemical and isotopic composition, status (in weapons or weapon components, storage, fresh or spent reactor fuel, or wastes), and location of all fissile materials;
- A description of all facilities that had been used to produce fissile materials;
- The production records and a material balance for each facility;
- An account of fissile materials otherwise acquired (e.g., from foreign countries);
- An account of all fissile materials removed from the inventory (consumed in weapon tests or nuclear reactors, dispersed in accidents, lost to waste or radioactive decay, or transferred to other countries).

The diversity in status of fissile materials would challenge the accuracy and completeness of the fissile material declaration because the error of measurement for different forms is quite different, potentially rendering some small portion of fissile stocks uncountable. Estimates of national inventories may contain uncertainties of a few percentage points. For example, the uncertainty of the total amount of plutonium produced or otherwise acquired by the United States is about 2.5 percent,[32] which corresponds to enough material to build about seven hundred nuclear explosives.[33] The large uncertainties in fissile material inventories could prove to be a giant obstacle to verifying nuclear disarmament.

To minimize the uncertainties in fissile material inventories requires not only precise measurements of the amount of fissile material in the various forms enumerated in the declaration, but a certain degree of confidence that there are no undeclared stocks of materials. This would be accomplished primarily by confirming declarations about the total amount of material that has been produced.

Both operating records and physical evidence could be used to verify the total amount of material that had been produced. One could check that operating records were consistent with declarations, and that the records were internally consistent. This is not impossible, but the records might be falsified or inaccurate and incomplete. In these cases, physical evidence could be helpful to dispel or support the suspicions. For example, in plutonium-production reactors, measurements of the concentrations of some long-lived radionuclides in permanent components of the reactor (e.g., calcium-41 and nickel-59 in graphite, and nickel-59 and nickel-63 in steel) may provide a fairly accurate (about 90 percent) estimate of the total amount of plutonium produced during the reactor's lifetime.[34] Although estimates derived in this way would be uncertain by perhaps 10 percent, they would be largely independent of record keeping by the host country, and might provide an independent check on the declaration.

Through the disarmament process, some of the military stocks of fissile materials become excessive.[35] For the sake of the irreversibility of nuclear disarmament, these excess materials should be placed under IAEA-type safeguards to prevent the reuse of retired weapon-grade material in new weapons and to prevent its diversion to the black market. The need to do so, however, must be balanced against the need to protect sensitive information about nuclear weapon design from international inspectors.[36] Two options for doing this are to convert the material to forms which do not reveal weapons information when accounted for by traditional IAEA safeguards measurement techniques or to develop new techniques to account for the material in component form without revealing sensitive information.[37] To strike this balance, the United States, Russia, and the IAEA are negotiating a "trilateral initiative"[38] to build a verification regime for the long-term, verified storage of fissile materials originated from weapons at Russia's Mayak facility[39] and one or more U.S. facilities.[40] Once materials are submitted, they would remain under IAEA verification until they are disposed of to meet the "spent fuel standard," a goal set by the United States and Russia for the disposition of excess fissile materials.[41]

HEU disposition could reach the spent fuel standard simply by blending it with LEU, depleted, or natural uranium to an intermediate level below 20 percent enrichment, or even below 10 percent so that it was no longer usable in weapons. Both the United States and Russia are blending down their excess HEU in this way.[42]

For plutonium disposition to reach the spent fuel standard, the United States and Russia have officially proposed their approaches.[43] Russia has expressed its preference to dispose of its excess plutonium by mixing plutonium oxide with uranium oxide and burning the resulting mixed-oxide (MOX) fuel in both light-water power reactors and breeder reactors. The United States has officially adopted a "dual-track" policy. On one track, it would burn much of the excess plutonium in MOX fuel in commercial power reactors. On the second track, it would seal cans of plutonium ceramic inside large canisters filled with vitrified high-level waste. On either track, the plutonium would be as difficult to recover for use in weapons as if it were in spent fuel.

Russia has identified several reactors capable of burning MOX fuel. Meanwhile, it is seeking American funds to build new generations of plutonium-burning reactors. A justification for building new reactors is to meet the expected disposition rate that is required by the agreed basic principle of plutonium disposition—"disposition of excess weapons plutonium should proceed in parallel [between the United States and Russia], with the goal of reducing to equal levels of military plutonium stockpiles."[44] However, building new reactors to dispose of plutonium is against the U.S. policy, which insists that both the United States and Russia should burn off the MOX fuels in existing reactors, not in dedicated future reactors for plutonium disposition.[45] Besides, Russia lacks a facility for converting plutonium into an oxide form and for fabricating MOX fuel. The ongoing discussions and negotiations with the United States on the construction of a plutonium conversion facility in Russia, and with France and Germany on providing a MOX fabrication facility to Russia, could assist Russia to dispose of its excess plutonium.

Notwithstanding intensive domestic political controversy about its plutonium disposition program,[46] in December 1998 the United States proposed to build both a pit conversion plant and a MOX fabrication plant at the Savannah River Site. Immobilization would also take place at Savannah River. Neither track is expected to be ready to begin operations before the middle of the next decade.

Prohibition on manufacture. Finally, in addition to monitoring the dismantlement of warheads and the disposition of fissile materials, it would be important to have confidence that new military fissile materials or additional warheads beyond the agreed levels are not being produced.

In the case of cessation of the production of fissile materials for explosive purposes, a cutoff convention, to be negotiated at the UN Conference on Disarmament, would provide a high level of assurance that all nuclear weapon production facilities have been either dismantled or converted to peaceful use, and that any fissile material produced was under safeguards that would bar its use in weapons. The extent of verification required by a cutoff convention will be determined largely by its scope, which is not yet resolved. The main options are a wide scope agreement which would apply to all nuclear facilities involved in fissile material production, processing, or use, as well as existing stocks of fissile material and future production, or an agreement concentrating on the sensitive fissile material production facilities, such as enrichment and reprocessing plants and the product from these plants.[47] No matter what the scope codified in the cutoff convention, confidence should be built that no clandestine, undeclared enrichment and reprocessing activities occur. This would require monitoring for environmental signatures[48] indicating possible undeclared activities, and application of remote surveillance techniques and expanded access for IAEA inspectors to a suspected site[49] to enable the IAEA to investigate possible undeclared enrichment or reprocessing activities.

In order to maintain the treaty levels of warheads, both Russia and the United States would continue to maintain and remanufacture warheads, and Russia would be compelled to produce more warheads than the United States because of the presumed approximately 1.5–2 times shorter service life of the Russian warheads than American warheads.[50] Under these conditions, an ideal regime for gaining confidence that additional warheads beyond the agreed levels were not being manufactured would be to monitor warhead maintenance and remanufacture facilities and to strictly balance the number of warheads and pits entering and exiting. However, some worry that the monitoring party would learn of the vulnerabilities in the force by observing maintenance and remanufacture activities. If this option were not adopted, a compromise measure could be the exchange of data on the total number of warheads produced during a specified time period. Transparency measures on fissile material would provide assurance that a large number of additional warheads could not be produced without detection. Transparency measures on warhead stockpiles, including warheads deployed and in reserve, newly produced and dismantled, would be helpful to enhance the assurance that additional warheads beyond the agreed levels were not being manufactured.

The United States and Russia, possessors of the largest and most sophisticated nuclear arsenals, bear a special responsibility in nuclear arms control and disarmament. Their joint efforts would help to reduce and eliminate the danger of nuclear war and help to increase prospects for international peace and security. They would also accelerate progress toward the ultimate goal of nuclear disarmament: the complete prohibition and thorough destruction of nuclear weapons.

Notes

[1] George Bunn, *The Nonproliferation Regime under Siege* (Stanford: Center for International Security and Cooperation, September 1999). Anatoli Diakov and Eugene Miasnikov, "Breaking the Deadlock: Confidence-Building Measures Could Accelerate the Nuclear Weapons Reduction Process" (Moscow Institute of Physics and Technology: Center for Arms Control, Energy and Environmental Studies, April 1999).

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[3] Matthew Bunn, "Loose Nukes Fears: Anecdotes of the Current Crisis," unpublished memorandum (5 December 1998); published in abbreviated form as Matthew Bunn, "Some Horror Stories since July," *Boston Globe* (29 December 1998). Matthew Bunn, "The Next Wave: Urgently Needed Next Steps to Control Warheads and Fissile materials," in Joseph Cirincione, ed., *Repairing the Regime* (New York: Routledge, for the Carnegie Endowment for International Peace, forthcoming in 2000).

[4] Private communication with Wolfgang K. H. Panofsky on September 13, 1999, at CISAC. Panofsky is director emeritus of the Stanford Linear Accelerator Center and chairman of the National Academy of Sciences Committee on International Security and Arms Control.

[5] Robert Gromoll, "A Nuclear Warhead Control and Elimination Regime: Problems and Prospects," Proceedings of the 38th Annual Meeting of the Institute of Nuclear Material Management, July 20–24, 1997, Phoenix, Arizona.

[6] Ibid.

[7] The STI initiative arose out of the January 1994 Joint Summit Statement, in which Presidents Clinton and Yeltsin agreed to establish a joint working group to consider steps to ensure the transparency and irreversibility of the process of reduction of nuclear weapons, and collapsed in October 1995, with Russia putting off repeated U.S. requests for renewed discussions.

[8] In 1994, the U.S. Congress acknowledged the difficulty imposed on further transparency and arms-control agreements by the need to discuss classified, and in particular restricted,

data information. As a result, Congress amended the Atomic Energy Act of 1954 to allow the reciprocal sharing with a treaty partner, under an Agreement for Cooperation, of restricted data information for the purpose of arms control and nonproliferation.

[9] Steve Fetter, *Verifying Nuclear Disarmament*. Fetter is an associate professor in the School of Public Affairs, University of Maryland, College Park. This paper was produced for the Henry L. Stimson Center's Project on Eliminating Weapons of Mass Destruction. Occasional paper, No. 29, October 1996.

[10] In December 1993 the UN General Assembly adopted resolution 48/75L calling for the negotiation of a "non-discriminatory, multilateral and international effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices."

[11] Take the United States as an example. W-85 warheads attributed to the Pershing II under the INF treaty have been dismantled; W-56 warheads attributed to the Minuteman II under the START I treaty are scheduled for dismantlement in the current Long Planning Assessment.

[12] Take the United States as an example. Warheads that are removed by way of unloading from Minuteman III (W-62, W-78) and Trident missiles (W-76, W-88), and also from the Peacekeeper missile (W87), are in storage.

[13] In December 1994, the United States presented the Russians with a non-paper defining the objectives of the STI initiative and outlining the key elements of the U.S. STI approach. See "Transparency and Verification Options: An Initial Analysis of Approaches for Monitoring Warhead Dismantlement," prepared by the Department of Energy Office of Arms Control and Nonproliferation, May 19, 1997, p. 21.

[14] In May 1992, for example, the CIA's Lawrence Gershwin stated that Russia had 30,000 warheads and that "the uncertainty [of this estimate] is plus or minus 5,000." (Testimony before the House Appropriations Committee, "DOD Appropriations for 1993, Part 5," May 6, 1992.) More recently, General Habiger stated that "the gross number of tactical nuclear weapons that are in Russia today. . . [is] from 17,000 to 22,000 nuclear weapons." (Hearings before the Committee on Armed Services, United States Senate, 105th Congress, Second Session on S.2057. Part 7, Strategic Forces, U.S. GPO, Washington, D.C., 1998, p. 492.)

[15] Michael E. Dosier, "Devising an Effective Arms Control Regime for Tracking, Monitoring, and Verifying the Elimination of Nuclear Warheads," thesis submitted to the Faculty of the Joint Military Intelligence College, 22 August 1997, p. 76.

[16] See Steve Fetter, *Verifying Nuclear Disarmament*.

[17] Harald Mueller, "Transparency in Nuclear Arms: Toward a Nuclear Weapons Register," *Arms Control Today* 24, no. 8 (October 1994).

[18] Dosier, "Devising an Effective Arms Control Regime," pp. 80–84.

[19] Thomas B. Cochran and Steve Fetter, "Verifying the Authenticity of Nuclear Warheads without Revealing Sensitive Design Information," paper presented at the Third International Workshop on Verified Storage and Destruction of Nuclear Warheads, Kiev, December 16–20, 1991.

[20] See Steve Fetter, *Verifying Nuclear Disarmament*.

[21] "Transparency and Verification Options: An Initial Analysis of Approaches for Monitoring Warhead Dismantlement," prepared by the Department of Energy Office of Arms Con-

trol and Nonproliferation, May 19, 1997, p. 73.

[22] See Dosier, "Devising an Effective Arms Control Regime," p. 105.

[23] In the United States, the dismantlement of intact warheads and storage of plutonium pits take place at the Pantex plant, Amarillo, Texas; management and disassembly of HEU secondaries, which are removed from the warheads at Pantex, as well as HEU-only gun-type warheads, take place at the Y-12 plant in Oak Ridge, Tennessee.

[24] Arzamas-16, Sverdlovsk-45, Zlatoust-36, and Penza-19 are Russia's four "series production" (assembly-disassembly) facilities. Minatom deputy minister Lev Ryabev at the 7th Carnegie Endowment Nonproliferation Conference (January 11–13, 1999, Washington, D.C.) revealed that warhead dismantlement work will cease at Arzamas-16 and Penza-19 by 2003. In addition, management and storage of HEU and plutonium components take place in Chelyabinsk-65 and Tomsk-7.

[25] See Diakov and Miasnikov, "Breaking the Deadlock."

[26] See "Transparency and Verification Options," p. 3.

[27] "An Analysis of Potential Measures for Monitoring U.S. Nuclear Warhead Dismantlement," Volume 1: Unclassified Executive Summary of the Wilson Report, SNL, December 1993.

[28] See "Transparency and Verification Options."

[29] Personal email communication from Wolfgang K. H. Panofsky, September 13, 1999: ". . . I believe that the problem of having both assembly and disassembly taking place at the same facility can be solved. The solution would be separated enclosures within a given plant where assembly and disassembly takes place and restricting the PPCM to the disassembly areas only. I believe that this would be quite feasible at the U.S. facility. . . ."

[30] In general, operations involving conventional high explosives, such as the removal of the high explosive from the pit, occur in the cells; other mechanical assembly and disassembly operations occur in the bays.

[31] See Steve Fetter, *Verifying Nuclear Disarmament*.

[32] *Plutonium: The First 50 Years* (Washington, D.C.: U.S. Department of Energy, February 1996). The best estimate of the total amount of plutonium produced or otherwise acquired by the United States (111.4 tons) is 2.8 tons higher than the measured amount of plutonium in current stockpiles (99.5 tons) plus the estimated amount removed from the inventory in tests, wastes, reactors, decay, accidents, and transfers (9.1 tons).

[33] Assumes four kilograms of plutonium for each fissile explosive.

[34] Steve Fetter, "Nuclear Archaeology: Verifying Declarations of Fissile-Material Production," *Science and Global Security* 3, no. 3–4 (1992).

[35] The United States has declared 226 tons of fissile material, including 174 tons of HEU (of various enrichments) and 52 tons of plutonium, to be excess; Russia has declared that "up to" 500 tons of HEU and "up to" 50 tons of plutonium have "become available through the disarmament process."

[36] Kevin O'Neill, "Efforts to Manage and Irreversibly Reduce Existing Stocks of Fissile Material in the Nuclear Weapon States," paper presented to the Fissile Material Information Workshop, January 25–26, 1999, Geneva, Switzerland.

[37] Anatoli S. Diakov, "Disposition of Weapon-grade Plutonium in Russia: Evaluation of Dif-

ferent Options." Presented at the NATO Advanced Research Workshop on Disarmament and Destruction of Chemical, Nuclear and Conventional Weapons, May 19–21, 1996, Bonn, Germany.

[38] In September 1996, the United States, Russia, and the IAEA launched a "trilateral initiative," seeking to "define the verification measures that could be applied at Russia's Mayak fissile material storage facility . . . and at one or more U.S. facilities" where excess "weapon-original fissile materials" will be stored.

[39] The Mayak facility is designed to house approximately 12,500 dismantled nuclear warheads and 50,000 containers of fissile material. For more information, see "Mayak Fissile Material Storage Facility" at http://cns.miis.edu/research/summit/mayak.htm.

[40] The negotiation of the trilateral initiative has not been concluded because of Russia's insistence on reciprocal access for Russian inspectors to a Mayak-like facility at Savannah River (South Carolina) and/or the Pantex plant.

[41] The "spent fuel standard" requires that any disposition options should "result in a form which the uranium would be as difficult to recover for weapons use as ordinary commercial low enriched uranium; and the plutonium would be as difficult to recover for weapon use as the larger and growing quantity of plutonium in commercial spent fuel." See *The Report of the Canberra Commission on the Elimination of Nuclear Weapons*, Annex A, 1996, at http://www.dfat.gov.au/cc/cc_report_annexa.html.

[42] Under a twenty-year purchase agreement, Russia is blending down 500 tons of weapon-grade HEU to LEU and selling the LEU to the United States as raw material to fabricate reactor fuels. By the end of 1998, approximately 50 tons of weapon-grade uranium had been blended down and transferred to the United States. Where the United States is concerned, by the end of 1998 13 tons of HEU had been downblended at the Portsmouth Gaseous Diffusion Plant. Of this quantity, 3.5 tons were blended down under IAEA verification.

[43] David Albright, Lauren Barbour, Corey Gay, and Todd Lowery, "Ending the Production of Fissile Material for Nuclear Weapons: Background Information and Key Questions—Sections II and III," prepared for the Fissile Material Information Workshop, January 25–26, 1999, Geneva, Switzerland.

[44] In 1995, the United States declared 52.6 metric tons of plutonium excess. Of them 38.2 metric tons are weapon-grade, 13.2 fuel-grade, and 1.2 reactor-grade. Russia has not made a specific declaration that particular quantities of material are excessive to its military needs. Unclassified estimates indicate that in order to match the stockpile the United States currently plans to retain, Russia would need to declare over 100 tons of weapons plutonium excess, as well as 30 tons of civilian material. For more detail, see the DOE document "Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives," January 1997.

[45] Private communications with George Bunn and Wolfgang K. H. Panofsky. Bunn is professor and dean emeritus of the University of Wisconsin School of Law and former counsel and ambassador to the U.S. Arms Control and Disarmament Agency. He is a member-in-residence of the Center for International Security and Cooperation, Stanford University.

[46] The United States officially halted its civil plutonium recycling program in the late 1970s. On September 27, 1993, President Clinton announced that "the United States does not encourage the civil use of plutonium and, accordingly, does not itself engage in plutonium reprocessing for either nuclear power or nuclear explosive purposes."

[47] See *The Report of the Canberra Commission on the Elimination of Nuclear Weapons*, Annex A.

[48] Environmental signatures, i.e. environmental sampling, is a new element of the IAEA's 93+2 program, which is aimed at enhancing the legal and technical capability of the IAEA safeguards system with respect to its ability to detect undeclared nuclear activities.

[49] Expanded access for IAEA inspectors is another new element of the 93+2 program.

[50] See Diakov and Miasnikov, "Breaking the Deadlock."

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