A Comprehensive Transparency Regime For Warheads and Fissile Materials

Arms Control Today

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U.S.-Russian efforts to limit nuclear forces largely have ignored their most fearsome components—the nuclear warheads. Arms control agreements have instead focused on limiting the number of deployed delivery vehicles and their launchers: ballistic missiles and their associated silos, mobile launchers or submarines; and long range bombers. START II limits the number of warheads that can be mounted on delivery vehicles, but is silent on non-deployed warheads. Presidents George Bush and Boris Yeltsin announced in 1991 that certain tactical warheads would be withdrawn and dismantled, but these initiatives were not legally binding and neither side could confirm that the promised reductions actually took place.

Nor have arms control agreements included restrictions on stockpiles of fissile materials—plutonium and highly enriched uranium (HEU)—the essential ingredients of all nuclear weapons. Control and accounting for these materials is the foundation for verifying compliance with the nuclear Non Proliferation Treaty (NPT). Fissile materials are the most difficult part of a nuclear weapon to produce, and the size of stockpiles held by the nuclear-weapon states places an upper limit on the number of warheads they could manufacture.

The focus on delivery vehicles is understandable. They are much easier to count and far more difficult to hide than warheads or fissile materials. Delivery vehicles are also expensive, typically costing 10 times more to produce and maintain than the nuclear warheads they carry. In addition, the number and characteristics of a nation's delivery vehicles are more accurate measures of the operational potency of its nuclear arsenal than are the size of its warhead or fissile material stockpiles.

In the future, however, it will become increasingly important to complement limits on delivery vehicles with restrictions on warhead and fissile material stockpiles, for several reasons. First, limits on warheads and fissile materials would make arms reductions far more difficult and time-consuming to reverse. Large stockpiles of non-deployed warheads or fissile materials create the potential for rapid and large-scale "breakout" from treaty obligations. The United States plans to maintain over 5,000 strategic warheads (and nuclear components to build another 5,000 warheads) in storage after START II is fully implemented, in addition to the 3,500 deployed warheads permitted by the treaty.<sup>1</sup> This has generated concern in Russia that the United States could increase the size of its strategic force very rapidly by simply replacing warheads that had been removed from missiles and bombers under START II. Although the breakout potential of Russia would be considerably smaller than that of the United States after START II is fully implemented, the United States is concerned about the durability of Russian democracy and the possibility of a return to hostile relations. Both countries would benefit if agreed reductions in nuclear arsenals were made as irreversible as possible.

Verified limits on warheads and fissile materials would also lay an essential foundation for much deeper reductions in nuclear arsenals. At the high force levels permitted by START I and START II, the stability of the nuclear balance is relatively insensitive to the total number of warheads each side possesses, and the breakout problem is not acute. But as the number of deployed warheads moves from 3,500 to 1,000 or less, uncertainties about the total number of warheads—and the amount of fissile material available to make new warheads—would loom much larger. At that point, it will be
essential to have in place a system for limiting warhead and fissile material stockpiles. The time to begin building that system is now.

Second, unlike strategic weapons, most tactical warheads lack unique nuclear delivery vehicles or launchers. Verified limits on warheads are the only way to build confidence that existing commitments to reduce tactical nuclear weapons have been implemented. Additional restrictions on tactical warheads will become more important as the number of strategic warheads is reduced, because the distinction between "strategic" and "tactical" warheads is hazy. For example, U.S. B61 tactical bombs are nearly identical to the B61 strategic bomb, and the W80 warhead on the tactical sea launched cruise missile is nearly identical to the W80 warhead on the strategic air launched cruise missile. If strategic warheads are limited, their tactical counterparts should be limited as well.

Agreed limits on the number and deployment of tactical nuclear warheads would also be a useful confidence building measure in the wake of NATO expansion. The United States is concerned about the fate of Russia's huge stockpile of tactical warheads and about Russia's increased reliance on tactical nuclear weapons to offset the conventional forces of NATO and China. Russia is worried about the deployment of U.S. tactical warheads in an expanded NATO. Both sides would gain from greater transparency regarding tactical nuclear weapons.

Third, limits on warhead and fissile material stockpiles and associated transparency measures could help reduce risks of theft or unauthorized use. Transparency measures would build confidence that warheads and fissile materials are secure. If security is lacking, transparency measures would help identify shortcomings and facilitate U.S. Russian cooperation toward improving safeguards. Merely compiling the necessary data and preparing for inspections could deter or detect threats to the security of warheads and fissile materials. In the longer term, reductions and centralized, monitored storage would make stockpiles easier to safeguard.

The need to begin to build a transparency regime for warheads and fissile materials is recognized in the March 1997 joint statement of Presidents Bill Clinton and Yeltsin issued in Helsinki, which calls for a START III agreement that includes "measures relating to the transparency of strategic nuclear warhead 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." The presidents also agreed to "explore, as separate issues, possible measures relating to...tactical nuclear systems, to include appropriate confidence building and transparency measures," and to "consider the issues related to transparency in nuclear materials."

The Helsinki statement is, in some respects, a step backward from joint statements issued in 1994 and 1995, which directed experts on both sides to immediately begin negotiating cooperative measures to ensure the transparency and irreversibility of nuclear arms reductions, including exchanges of data on warhead and fissile material stockpiles. Russia effectively ended these negotiations in 1995 when it refused to complete an agreement for cooperation that would allow the parties to exchange sensitive information. The Russian government has never explained publicly why it broke off the talks. Perhaps the Helsinki agreement will breathe new life into this process.

The Helsinki statement could be interpreted in a very circumscribed way. For example, transparency measures might be restricted to certain strategic warheads, or to only those strategic warheads that are to be removed under a START III agreement. The significance of such half way measures would be limited, except as first steps toward a more comprehensive regime. Little would be gained by verifying the elimination of a few selected warheads if other warheads in the stockpile could take their place or if new warheads could be produced to replace them. The security benefits of transparency measures would be far greater if they applied to all warheads—tactical as well as strategic, reserve as well as deployed.

A comprehensive set of transparency measures for warheads and fissile materials will raise difficult technical and political challenges that could take years of hard work and negotiation to resolve. For this reason, it probably is best to divide the Helsinki agenda into two parallel tracks: one dealing with warhead and fissile material transparency, and a START III track that establishes a lower limit on deployed strategic warheads. By having START III operate within the technical framework of the existing START agreements, it should be possible to sign a START III accord while Clinton and Yeltsin...
are still in office.

At Helsinki, the presidents agreed to begin negotiations on START III immediately after START II enters into force. (This commitment was subsequently modified and will become effective when the Duma ratifies START II.) It appeared that this would happen in December 1998, but the U.S. attack against Iraq prompted the Russian Duma to postpone ratification yet again. The announcement in January 1999 by Secretary of Defense William Cohen that the United States would seek to renegotiate the ABM Treaty to allow the deployment of a national missile defense (NMD) casts further uncertainty over the future of START II. The Clinton administration understands the importance of preserving the U.S. Russian arms control process, however, and there is a good chance that the parties will begin negotiations on START III sometime this year. If and when this happens, the United States should be ready to describe and promote a vision for a comprehensive transparency regime.

Building a Transparency Regime

A comprehensive transparency regime would have several components, including initial and ongoing declarations; inspections to gain confidence in the accuracy and completeness of the declarations; and measures to confirm the dismantling of warheads and the disposition of warhead components.

Declarations.

The first element in a transparency regime would be an initial declaration of nuclear warhead and fissile material inventories, updated at agreed intervals. This is especially important because estimates by national intelligence agencies are highly inaccurate. For example, a CIA official testified in 1992 that Russia had 30,000 nuclear warheads, "plus or minus 5,000." Subsequent statements by Russian Minister of Atomic Energy Viktor Mikhailov that the Russian stockpile peaked at 45,000 warheads in 1986 cast doubt on the CIA estimate and emphasized further the difficulty of estimating warhead stockpiles by national intelligence alone. The value of agreed limits on stockpiles or agreements to dismantle a certain number of warheads would be diminished considerably if the initial inventory could not be established with greater accuracy.

In June 1995, the United States proposed a modest stockpile data exchange agreement, as called for by the U.S.-Russian joint statement just one month earlier. The proposed agreement called for exchanging data, on a confidential basis, on total current inventories of nuclear weapons and fissile materials, as well as the total number of nuclear weapons dismantled each year since 1980, and the type and amount of fissile material produced each year since 1970. Unfortunately, then Russian Assistant Minister of Atomic Energy Vladislav Balamutov reportedly rejected the proposal as "too comprehensive."

Although the June 1995 proposal represents a useful starting point, declarations ultimately would have to be considerably more comprehensive to achieve the goals set out above. The information to be exchanged should include the location, type and serial number of every nuclear device; the location and serial number of each fissile component recovered from a dismantled warhead; total inventories of plutonium and HEU; and a detailed inventory for each facility for bulk fissile materials. For stored warheads or warhead components, the location would be a particular storage facility; for deployed warheads, it would be the corresponding launcher. The serial number could serve as a unique identifier for each item, or special "tags" could be used for this purpose.

Unique identifiers or tags would have three key advantages. First, tags make it easier to certify the completeness of a declaration, because the discovery of an untagged warhead or canister would constitute an unambiguous violation. Second, it would not be necessary to inspect or count each and every controlled item to gain confidence in the accuracy of the declaration. Inspectors could authenticate the tags in a randomly selected sample of items, thereby reducing the inspection effort and its degree of intrusiveness. Third, tags would allow a chain of custody in which individual warheads could be tracked from deployment sites to storage bunkers to dismantlement facilities. Similarly, canisters containing warhead components could be tracked from dismantlement facilities to storage sites to facilities for the civil use or disposal of the material.
A tagging scheme could make use of existing surface features (at sufficiently high magnifications all surfaces have a unique “fingerprint”) or several different kinds of applied tags, such as bar coded labels or plastic holographic images overlaid by a tamper proof tape. Tags are used by the UN Special Commission (UNSCOM) in Iraq to log and track items which could be used both for civilian and military purposes, by the International Atomic Energy Agency (IAEA) to safeguard civilian nuclear materials, and by the U.S. military to track weapons. These tags require that inspectors have physical access to the tag, but it is possible to imagine tags that could be authenticated outside of a container or at a distance. The use of tags for verification, while not yet applied to warheads, is provided for in START I.

Although certain technical issues would have to be worked out, there should be no problem in instituting an effective tagging system for canisters containing warheads, warhead components or fissile materials.

To provide confidence that the declaration is accurate and complete, it also would be helpful to have information on the history of warhead and fissile material stockpiles and the facilities used to produce them. For warheads, one could begin by exchanging data on the aggregate number of warheads produced and dismantled each year, or, better still, the date of assembly or disassembly of each device. For fissile materials, the annual production and consumption of plutonium and HEU by facility would be useful. A detailed description of the warhead production complex would be valuable in this context, and would help in designing transparency measures to validate the declaration.

The Department of Energy (DOE) has taken an important step toward increased transparency by publishing a report that summarizes U.S. plutonium production and use from 1944 through 1994. The report provides a comprehensive accounting of plutonium inventories at each DOE facility, including the sum of the quantities of plutonium in the U.S. nuclear weapons stockpile and in pits at the Pantex warhead assembly/disassembly facility in Texas. It also provides a summary of the production of plutonium at DOE sites, small acquisitions of foreign plutonium and removals of plutonium from the stockpile. A similar report on the production and use of U.S. HEU is in preparation. As a first step toward a formal data exchange, the United States could fund, through the Cooperative Threat Reduction program or U.S.-Russian lab-to-lab programs, the generation of comparable reports by Russia.

It is important to begin exchanging such data as soon as possible. There is no need to wait until transparency measures are worked out completely. Early declarations would build confidence and would stimulate both governments to ensure that their accountancy systems are accurate and understandable. In the case of historical information, such as the rates of production of nuclear weapons or fissile materials many decades in the past, it is important to assemble this data today, while the personnel who were involved in these operations are still available to resolve any discrepancies or uncertainties that might arise.

**Inspections.**

The second element of a transparency regime would be inspections to confirm the accuracy and completeness of the declarations. There would be no need to count warheads deployed on strategic missiles, since these would be covered by the START agreements. Nearly all other warheads are in storage, so inspections would mostly involve visiting a particular storage facility and checking that the declared number of warheads is present—no more, no less. Alternatively, inspectors could randomly select a small number of warheads for inspection and verify that their serial numbers matched those listed in the declaration. If a random sample of 20 or 30 warheads turned up no undeclared or bogus warheads, then one could be highly confident that the declaration was accurate.

There are, however, two key problems in confirming the declarations. The first is knowing that an object which is declared to be a warhead of a certain type really is a warhead of that type. This could be dealt with by developing “fingerprints” or templates of warhead types, and using random sampling to confirm that a particular warhead is an authentic warhead of the declared type.
example, Russia could present one or more SS 18 ICBM warheads for fingerprinting, or warheads could be selected from a deployed missile by U.S. inspectors. A set of agreed characteristics could be measured: length and diameter; mass and center of gravity; the relative strength of neutron emissions or gamma-ray emissions at certain points; or heat output. A fingerprint of this type would be extremely difficult to spoof. To protect sensitive weapon design information, an automated system could be devised to give a simple "yes" or "no" answer to the question: "Is this an SS 18 warhead?" A similar system is being developed by U.S. and Russian laboratories to confirm the authenticity of plutonium pits placed in a U.S. funded storage facility now under construction near Chelyabinsk.

A second problem is demonstrating that the declaration is complete—in other words, that there are no hidden or undeclared stockpiles of warheads or fissile material. Challenge, or anytime anywhere, inspections are often mentioned as one way to detect undeclared stockpiles if they exist, but a well designed plan to hide warheads or materials would give few clues about where to look. A better approach is to exchange detailed historical information on the nuclear stockpiles as part of the initial declaration. These records could be examined for internal consistency and for consistency with the current stockpile declaration, and they could be compared to archived intelligence information.

In some cases, inspections might be able to confirm the completeness of the declaration. For example, measurements of isotope ratios in the permanent structural components of plutonium production reactors can verify, at least approximately, declarations of the total production of plutonium at that reactor. Knowing the amount of plutonium produced would, in turn, validate declarations about the production of warheads.

**Dismantling.**

Once a baseline warhead inventory is established, agreed reductions can be achieved by confirming that a certain number of warheads have been dismantled. This could be accomplished rather easily by demonstrating that the warhead had been removed from the stockpile and that the corresponding fissile components—in particular, the plutonium pit—had been placed in a monitored storage facility. For example, Russia could verify that a U.S. warhead had been removed from the storage area and delivered to the dismantling area at Pantex, and that some days later a pit had been placed in the storage area. The fingerprinting procedures described above could be used to show that the object to be dismantled was an authentic warhead of a given type. Intrinsic gamma-ray signatures might also be used to verify that the pit which is subsequently placed in storage was taken from a warhead of that type. It may even be possible to determine whether the pit was taken from a particular warhead (for example, by irradiating the warhead with a burst of neutrons and measuring the fission-product gamma-ray signature of the pit some days later). Again, sampling could be used to minimize the number of warheads or pits that are subjected to detailed examination. Components containing plutonium or uranium would be stored pending their ultimate disposition under mutual monitoring; other components could be destroyed or recycled, as agreed by the parties.

Another method would use perimeter-portal monitoring at the dismantling facility. The portal would be equipped with a system to verify the authenticity of warheads entering the facility and to detect fissile materials exiting the facility. A third method would track the warhead and its components through the dismantling process. Although this is often considered excessively intrusive, it may be possible to protect sensitive information. The monitoring party could, for example, track the warhead up to the disassembly cell, track the fissile components from the disassembly cell to the storage area, and verify that the disassembly cell contained no warheads or warhead components either before or after the disassembly procedure. Monitoring could be done by on site inspectors, or remotely using secure video links or radio beacons.

**Disposition.**

If reductions are to be truly irreversible, a comprehensive transparency regime must also provide confidence that components from dismantled warheads and other excess fissile materials would not
be available to rebuild nuclear arsenals. The goal should be to render these materials at least as unattractive for use in nuclear weapons as is fresh or spent civilian reactor fuel.<sup>11</sup>

In the case of HEU weapons components, transparency measures have already been negotiated to provide confidence that the low enriched uranium that the United States is purchasing from Russia for civilian reactor fuel is derived from dismantled warheads. Disposing of plutonium pits will be more difficult. The plutonium could be used to fabricate mixed oxide fuel elements for civilian reactors, but the resulting fuel would be more expensive than uranium fuel, and neither country has facilities to fabricate plutonium fuels. Alternatively, the plutonium could be mixed with vitrified high level radioactive wastes. In either case, IAEA type safeguards could provide assurance that no plutonium had been diverted.

**Manufacture.**

Finally, in addition to monitoring the elimination of warheads and the disposition of fissile materials, it would be important to have confidence that new warheads or fissile materials are not being produced. In the case of fissile materials, this could be done by applying IAEA type safeguards to plutonium-production reactors, reprocessing facilities and uranium-enrichment plants. Indeed, the United States favors such measures as part of a multilateral agreement to end the production of fissile material for weapons or outside of safeguards—the so called fissile material cutoff treaty proposal now before the UN Conference on Disarmament.

Gaining confidence that additional warheads are not being manufactured will be more difficult, since warhead maintenance and remanufacture will continue as long as nuclear weapons exist. Transparency measures on fissile materials provide assurance that a large number of additional warheads could not be produced without detection. Additional confidence could be obtained by requiring a strict balance between the number of warheads and pits entering and exiting a warhead maintenance or remanufacturing facility.

Some worry that the monitoring party would learn of vulnerabilities in the force by observing maintenance and remanufacturing activities. If, for example, Russia observed that all the U.S. Trident warheads were being rebuilt, it might conclude that that system had a major reliability problem. Even so, it is difficult to see how that knowledge would confer a significant and usable military advantage, since Russia would not know the actual potency of the warheads. The United States plans to maintain a mix of warheads in the stockpile, so that the failure of any one system would not cripple the deterrent capability of the overall force.

**Conclusions**

A comprehensive transparency regime for nuclear warheads and fissile materials would have a number of important advantages. A transparency regime would build confidence that agreed reductions in strategic and tactical nuclear forces are irreversible, lay the foundation for much deeper reductions in nuclear forces, and facilitate efforts to reduce the risks of theft or unauthorized use of nuclear warheads and fissile materials.

Although a comprehensive transparency regime will present numerous challenges, the task is manageable if both sides do the necessary technical work and negotiate in good faith. This work should begin immediately. We cannot afford to wait until negotiations begin, or until political agreement has been achieved, to work out the details of verifying declarations or the dismantling of warheads. Unlike past arms control agreements, which were discrete events, we should think of increased transparency as a continuous process, in which we constantly increase the exchange of more detailed information and find ways to corroborate that information. This process is an essential component of a long term program to reduce the size and salience of nuclear arsenals, as well as a vital element of the effort to improve U.S. Russian relations.

**NOTES**
1. The warheads held in reserve for possible redeployment include approximately 550 B61 and B81 strategic bombs; 1,450 W80 cruise missile warheads; 1,500 W62 and W78 Minuteman warheads; and 1,900 W78 Trident warheads. In addition, the United States plans to hold over 5,000 plutonium “pits” in reserve. Thomas B. Cochran, personal communication based on unclassified and declassified Department of Energy documents, 4 March 1999.


4. A specific tamper tape system used in Iraq and in the United States is the so called "CONFIRM" seal. This is a tape placed over a unique identifier. The tape is an adhesive, imbedded with microscopic beads of colored glass in several strata forming a specific design (such as the UN logo). The tape is see through and is read through reflected light.

5. Tags that can be read remotely are available commercially. See, for example, the Argus tag produced by Aquila Technologies, described at http://www.aquilagroup.com.

6. Annex 6 to the Inspection Protocol of START I, which describes procedures for associating unique identifiers with mobile missiles or their launch canisters, defines a unique identifier as "a non repeating alpha numeric production number, or a copy thereof, that has been applied by the inspected Party, using its own technology."


8. Assume that 10 percent of the warheads at a particular site have invalid tags. If the total number of warheads at the site is large (greater than 400), the probability that a random sample of 20 warheads would include at least one invalid warhead is 88 percent; for a sample of 30 warheads, the probability is 96 percent. The general formula is $P = 1 - (1 - F)^n$, where $F$ is the invalid fraction, $n$ is the number sampled, and $P$ is that probability that the sample contains at least one invalid warhead. The probability is greater if the total number of warheads is small; for example, if the site contains only 50 warheads, the probability that at least one of 20 would be invalid is 93 percent. The general formula in this case is $P = 1 - ([N - M]!(N - n)!) / ([N - M - n]! N!)$, where $N$ is the total number of warheads and $M = FN$ = the number of invalid warheads.

9. The Controlled Intrusiveness Verification Technology (CIVET) system developed at Brookhaven National Laboratory accomplishes this task with a high resolution gamma ray detector and a special purpose computer without permanent memory.

10. These options are reviewed in Department of Energy, Office of Arms Control and

[Back to text]


[Back to text]

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