Transparency and Predictability Measures for U.S. and Russian Strategic Arms Reductions

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On May 24, 2002, President George W. Bush and President Vladimir Putin signed the Moscow Treaty on Strategic Offensive Reductions. Under this new treaty, the United States and Russia will reduce their strategic nuclear warheads to a level of 1,700-2,200 by December 31, 2012, a reduction of nearly two-thirds below current levels.[1] In addition to the desire for reducing nuclear forces, the United States and Russia have consistently declared their intention to seek other mutual security objectives. These include improving the stability of nuclear forces, increasing mutual transparency and predictability regarding weapons stockpiles and nuclear infrastructures, improving the safety and security of nuclear weapons and materials, and preventing their proliferation.

The commitment to bilateral cooperation on this broader nuclear security agenda was also reaffirmed at the Moscow summit. The two presidents signed a "Joint Declaration on the New Strategic Relationship," pledging continued cooperation on reducing excess arsenals and securing weapons, materials, and expertise. The declaration includes a decision by the two states to establish a ministerial-level Consultative Group for Strategic Security to strengthen mutual confidence, expand transparency, share information and plans, and discuss strategic issues of mutual interest.[2]

The manner in which the Moscow Treaty is implemented may be a test case for how successful the two sides will be in transforming the nature and substance of their nuclear security relationship. The treaty does not contain any provision for verification nor inspection. However, it does create a Bilateral Implementation Commission that presumably will resolve compliance issues. The role of this commission and the mechanisms it uses to establish confidence in treaty compliance will likely receive scrutiny by legislatures in both the United States and Russia as they debate ratification of the treaty. In fact, Senator Joseph Biden, Chairman of the U.S. Senate Foreign Relations Committee, has already affirmed that transparency measures taken to build mutual confidence in treaty implementation will be vital to its success and to allowing future progress on other bilateral security issues such as non-strategic nuclear weapons.[3]

One problem that could arise under the treaty is continuing uncertainty on both sides regarding the actual size and disposition of deployed and reserve nuclear forces. This uncertainty still influences strategic planning and force structure decisions on both sides. The influence of this factor may increase as Russia responds to U.S. missile defense deployments. Suspicions regarding compliance, or doubts about the operational significance of the cuts, could motivate various factions within both countries to challenge the wisdom of further reductions, making their implementation uncertain. If such developments were to transpire, the treaty would not foster the strategic cooperation, transparency, and adoption of non-confrontational nuclear postures sought by both sides. Rather, it could become a source of strategic tension.

It is also important that the rest of the world have confidence in U.S.-Russian nuclear arms reductions. Key U.S. allies strongly value the stability and predictability provided by the monitored, reciprocal reductions required by formal arms control. Tangible evidence of reductions will be necessary if the United States and Russia hope to get credit via the new treaty for progress toward fulfilling Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the obligations contained in the 2000 NPT Review Conference Final Document. Finally, methods used by the former adversaries to convince one another that their actual nuclear capabilities have been significantly reduced and are no longer configured in a threatening manner could provide a valuable precedent for other states to follow.

The Moscow Treaty and the Joint Declaration on the New Strategic Relationship also represent an important opportunity for deeper U.S.-Russian engagement on nuclear security issues. Because no verification regime is defined, the two sides could use the Bilateral Implementation Commission and the Consultative Group for Strategic Security as mechanisms to propose and implement a range of cooperative activities designed to increase transparency and improve nuclear security. While the need for both sides to know the precise disposition of their nuclear forces may have decreased, it has not been eliminated altogether.

For example, U.S. interest in the security of all Russian nuclear warheads (strategic and non-strategic) and fissile materials has increased sharply. In addition, Russia's large stockpile of non-strategic weapons and its vast warhead production complex are of concern to the United States and, to some extent, have become a justification for the U.S. plans to maintain a very large stockpile of warheads that are not operationally deployed. In turn, the projected large size of the U.S. stockpile of stored warheads is of significant strategic concern to Russia. Addressing these enduring mutual uncertainties regarding weapons production infrastructures, stored warheads, non-strategic nuclear forces, and fissile material stockpiles are perhaps now more critical to building a fundamentally new and improved U.S.-Russian strategic relationship than accounting only for deployed strategic warheads. The consultative mechanisms established under the Moscow Treaty could be used creatively to address these broader issues.

This article provides a detailed proposal for the phased implementation of transparency and monitoring measures that could support the new treaty. It highlights the advantages of this approach for continuing the positive transformation of the U.S.-Russian nuclear posture. The primary objective of these measures is to provide mutual confidence that nuclear arms reductions are taking place as declared. These measures may also provide building blocks for establishing more comprehensive transparency and predictability in the U.S.-Russian nuclear posture and create a solid foundation for bilateral cooperation in furthering an improved strategic relationship.

POSSIBLE SCOPE OF STRATEGIC REDUCTIONS

The United States and Russia have each committed to reduce strategic forces to 1,700-2,200 warheads by the end of 2012. Each country maintains flexibility in how it achieves the prescribed force levels and actual approaches would likely depend on many factors, including perception of future threats, the overall state of the U.S.-Russian strategic relationship, and national economic capabilities. The following sections detail the possible strategic nuclear weapons reductions within each country.

United States

The U.S. strategic nuclear forces are currently maintained at a level of approximately 5,600 warheads attributable to the following delivery systems (see Table 1): 50 MX Peacekeeper and 500 Minuteman III intercontinental ballistic missiles (ICBMs); 18 Trident nuclear-

Table 1: U.S. Strategic Nuclear Weapons[8]

powered ballistic missile submarines (SSBNs), each carrying 24 submarine-launched ballistic missiles (SLBMs); and 76 B-52 and 21 B-2 strategic bombers. The U.S. nuclear force reduction plans were outlined in the Nuclear Posture Review (NPR), which was unveiled by the U.S. Department of Defense in early 2002. According to this document, strategic reductions will consist of two phases. The first phase of reductions to approximately 3,800 deployed warheads is to be completed by 2007 and would include inactivation of all MX ICBMs, and reduction of the SSBN force from 18 to 14 submarines, all of them equipped with D-5 SLBMs. Further reductions to 1,700-2,200 would occur by 2012, most of them by downloading of strategic missiles and bombers (reducing the number of warheads carried by each missile or bomber). The NPR also eliminated any future nuclear role for the B-1B bombers.

Inactivation of the MX missiles is expected to begin in late 2002. The W87 warheads to be removed from these missiles eventually would replace W62 warheads that are currently deployed on Minuteman III missiles. The W62 warheads, the oldest in the U.S. stockpile, will reach the end of their service life around 2009 and will likely be eliminated. The replacement of W62 with W87 warheads will begin around 2006, when Minuteman III missiles will be retrofitted to accommodate W87 warheads.[4]

The weapon-system deactivation process for the four Ohio-class SSBNs would begin in 2003. All of them are to be armed with conventional sea-launched cruise missiles or used in other non-nuclear roles.[5]

Phase 2 reductions would be implemented by the downloading of all Trident SLBMs to possibly six (and eventually five) warheads, and Minuteman III ICBMs to one warhead. A significant fraction of these removed warheads would be placed into the responsive force (active warheads not operationally deployed) that together with the operationally deployed warheads would constitute the strategic active stockpile.[6] Weapons in the responsive force would be available for uploading on bombers, SLBMs, and ICBMs in a period ranging from weeks to a year or more. Warheads associated with strategic submarines and bombers in overhaul and spare warheads would be a part of the responsive force and would not be counted as operationally deployed.[7] In addition, the United States would maintain a strategic inactive stockpile that would contain warheads to be consumed in surveillance testing and warheads maintained for the purpose of replacing catastrophic failures of similar warheads.

The size and composition of the responsive force and inactive stockpile are yet to be determined. It is possible that some ballistic missile warheads (W76s and W78s) and air-delivered weapons would be gradually removed from the stockpile and eliminated. Without such eliminations, the strategic responsive force and the inactive stockpile could together include as many as 5,400 warheads.

Russia

As of early 2002, the Russian operational strategic stockpile consisted of approximately 5,600 warheads, deployed on land- and submarine-launched ballistic missiles and heavy bombers (see Table 2). Russia's reductions under the 2002 Moscow Treaty are expected to follow the path of natural attrition of these strategic weapon systems due to aging.

By 2007, the deployed Russian strategic stockpile is projected to decline to 1,500-2,100 warheads owing to the retirement of all SS-24 ICBMs and SS-N-20 SLBMs (the latter based on Typhoon-class SSBNs), as well as massive retirement of SS-18 and SS-25 ICBMs, SS-N-18 SLBMs on older Delta III submarines, and Tu-95 and Tu-160 strategic bombers. These retirements would be caused by the obsolescence of major components of missile systems (such as rocket motors) and launcher platforms (submarines). The rest of the SS-18s (possibly with the exception of a few) and SS-25 ICBMs, SS-N-18/Delta III SLBMs, and all but 20 strategic bombers are projected to be retired by 2012. The number of deployed warheads would at that time decline to approximately 900-1,200. The estimates of the 2007 and 2012 strategic warhead levels assume that Russia would retain the six-warhead configuration for its remaining SS-19 ICBMs and would maintain some of its ten-warhead SS-18 ICBMs.

In reality, the pace of Russian reductions and future force composition will depend on many factors. The service life of some weapons systems could be extended by improved maintenance and reduced operational tempo. Production of new missiles, submarines, and bombers could somewhat compensate for the retirement of older systems. Russia also could augment the remaining force by equipping SS-27 Topol-M ICBMs with three warheads each, which would allow it to maintain up to

Table 2: Russian Strategic Nuclear Weapons[10]

continued on page 6

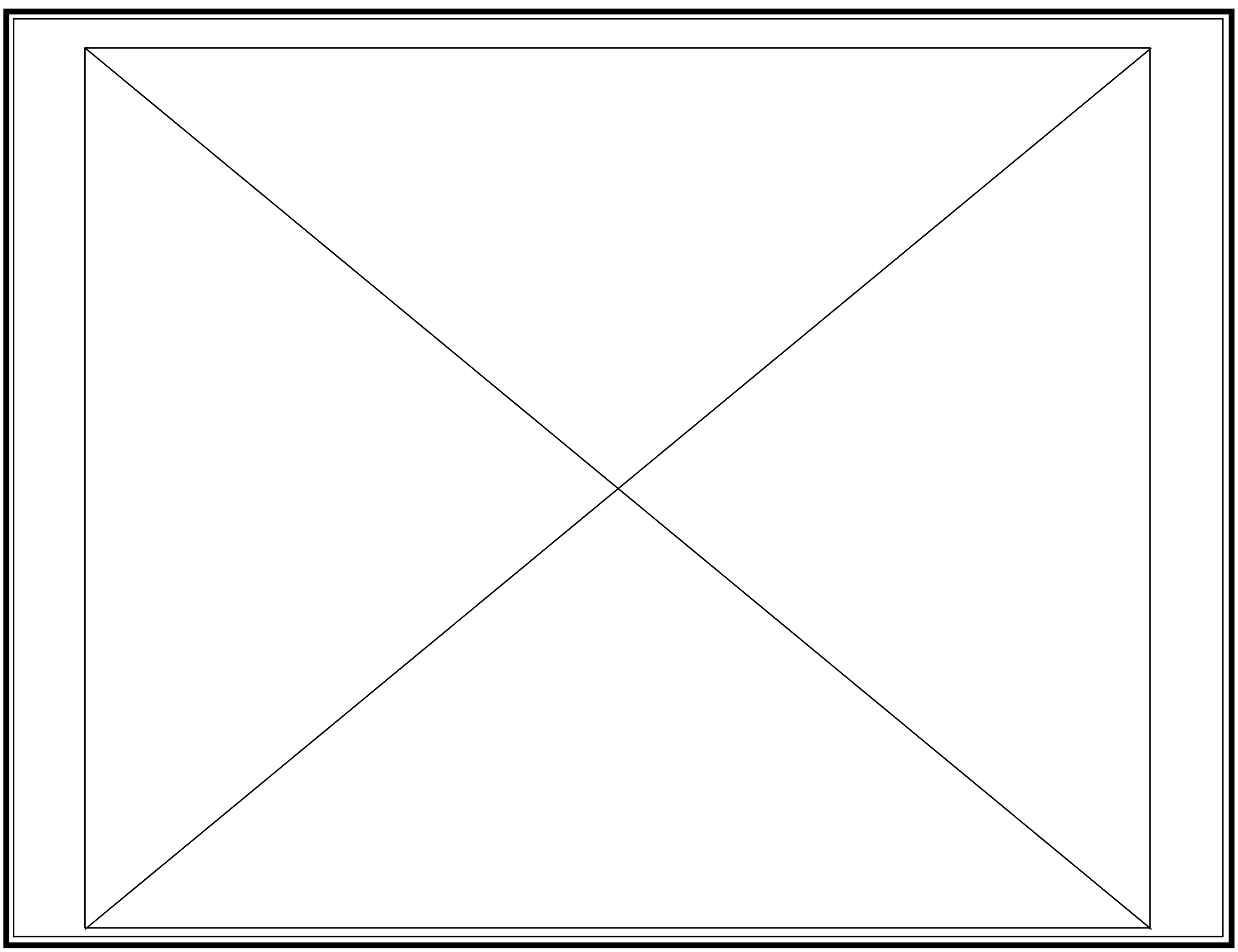
2,500 deployed strategic warheads by 2007 and 1,700 warheads by 2012.

CONFIDENCE-BUILDING AND TRANSPARENCY OPTIONS

As previously mentioned, this article proposes phased implementation of transparency and monitoring measures to accompany U.S.-Russian agreements on nuclear arms reductions. These measures could be initiated through a series of joint monitoring experiments (JMEs).[11] The primary objective of these measures would be to increase mutual confidence that nuclear arms reductions are taking place as declared without negotiating and implementing formal verification provisions, and to develop a path towards a broader U.S.-Russian nuclear transparency regime. If integrated with a set of related activities, this approach could offer added advantages for intensifying bilateral nuclear security cooperation and establishing an improved U.S.-Russian strategic framework.

The two major activities that could be integrated with new monitoring initiatives are the U.S.-Russian Cooperative Threat Reduction (CTR) programs implemented by the U.S. Department of Defense (DOD), and elements of U.S. Department of Energy National Nuclear Security Agency (NNSA) programs in Russia focusing on safety, security, and transparency for nuclear warheads and fissile materials. Both the CTR and NNSA programs already include efforts to improve transparency and predictability in the U.S.-Russian nuclear posture and offer the means to provide both technical and financial assistance to Russia. Specifically, these programs have established contractual and administrative procedures for implementing joint science and technology activities between private firms, laboratories, and institutes in the

Table 2: Russian Strategic Nuclear Weapons[10] (continued from page 5)

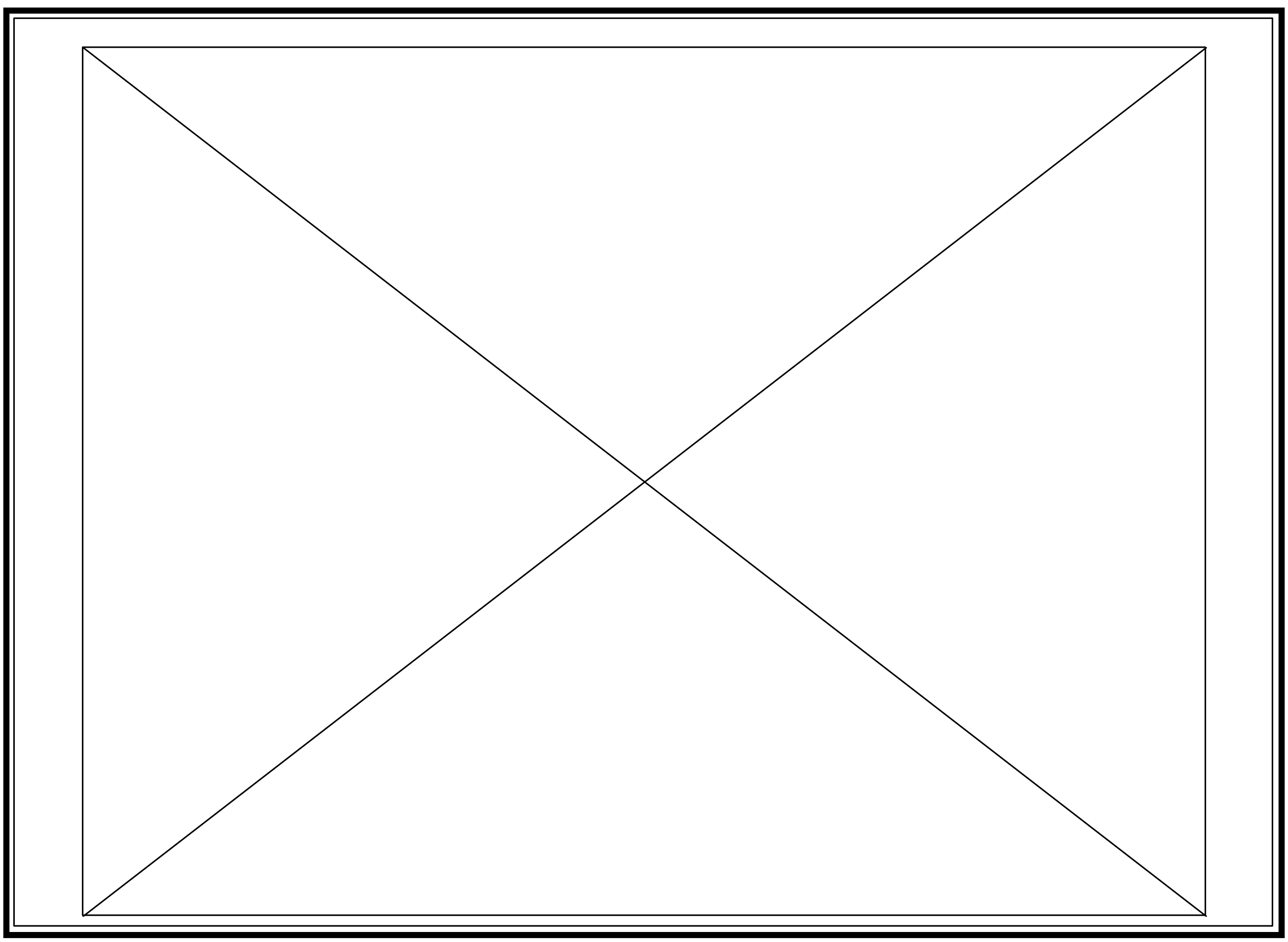


United States and Russia. These ongoing programs, integrated with a series of new JMEs, could constitute an important new initiative with Russia supporting a posture of transparency for arms reductions and coordinated security management.[12] In addition, some elements of the treaty regimes established by the Intermediate-Range Nuclear Forces Treaty (INF) and the Strategic Arms Reduction Treaty (START I), such as methods for data exchange, notifications of inspections, and precedents and protocols for the use of various measurement technologies during inspections, would be very useful for implementing new transparency measures.

The scope of anticipated U.S.-Russian nuclear arms reductions will take most of a decade to implement. This time period lends itself to the phased implementation of transparency and confidence-building initiatives, starting with JMEs focused on less intrusive near-term activities such as launcher elimination and warhead storage. Expanded CTR activities and NNSA-supported warhead dismantlement transparency projects would parallel and be coordinated with the implementation of JMEs. Later, after these efforts have produced mutally acceptable methods and technologies, more intrusive JMEs dealing with warhead dismantlement might be undertaken. A notional timeline for a phased and integrated set of initiatives is provided in Figure 1.

If properly phased-in and integrated, these measures could greatly enhance mutual transparency and predictability regarding nuclear forces and postures. For example, JMEs could begin in 2003, focusing on launcher elimination and warhead removal and storage. Later, possibly by 2006, the monitoring methods demonstrated in earlier JMEs could be applied to all strategic warheads

Figure 1: Notional Integrated U.S.-Russian Nuclear Security Cooperation Timeline.



removed from missiles in the course of reductions and placed in central storage awaiting disassembly; applied to portions of the U.S. and Russian active and reserve stockpiles; and applied to portions of tactical nuclear weapon stocks.[13] Eventually, the United States and Russia could implement a comprehensive warhead and fissile material transparency regime that would be based on technologies and procedures developed for JMEs and NNSA-sponsored projects.

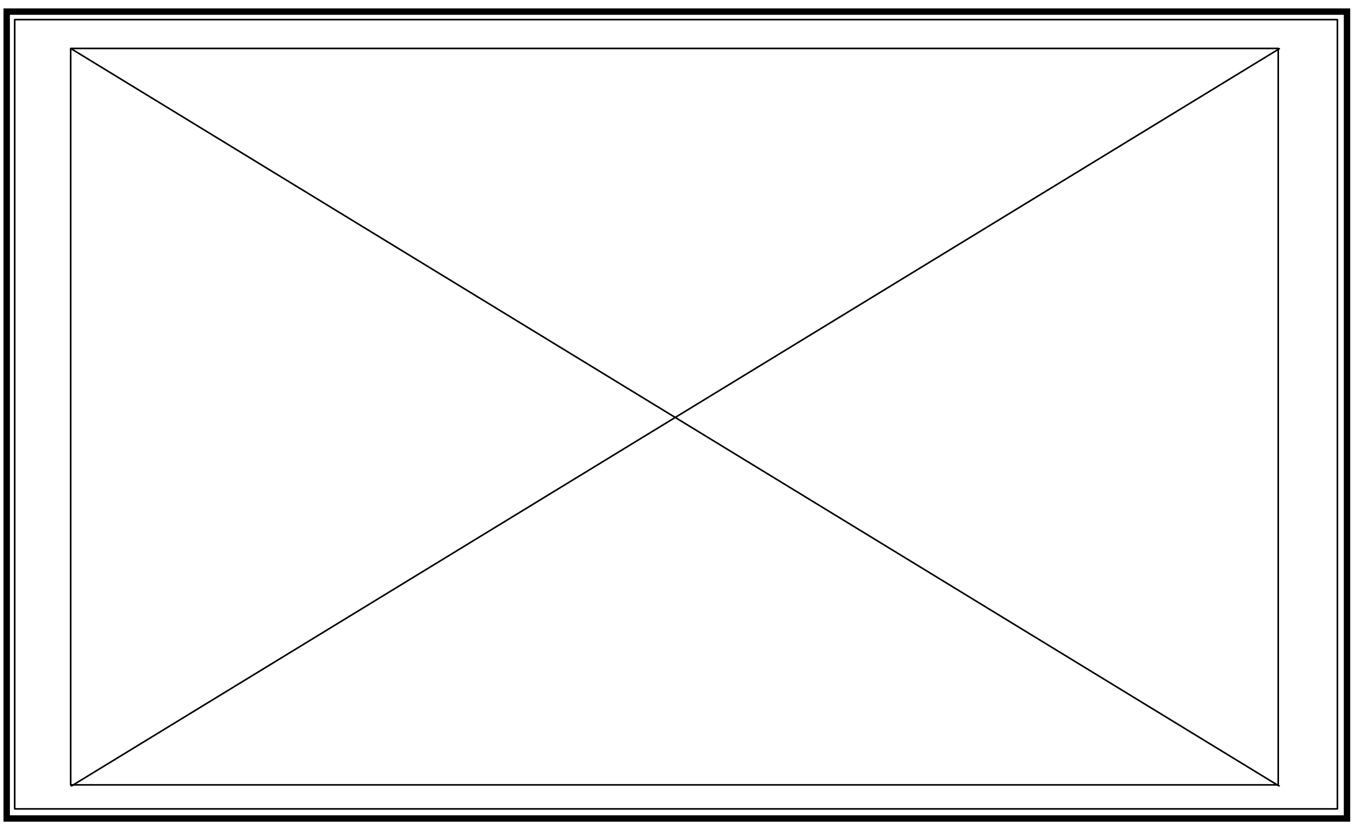
Mutual confidence in the reduction process gained through implementation of JMEs would be supplemented by the expansion of CTR industrial activities. This expansion would support an increased tempo of warhead removal from launchers, launcher elimination, and warhead dismantlement in Russia and would further increase safety and security of warheads during transportation and storage. These expanded activities and the later JMEs focusing on warhead dismantlement would require support from ongoing U.S.-Russian cooperative technology development initiatives. For example, new technical approaches would need to be developed and validated for monitoring warheads in transit. Additional development of radiation measurement and information barrier technologies would be required for increased confidence in warhead authentication and dismantling.

JOINT MONITORING EXPERIMENTS FOR NUCLEAR ARMS REDUCTIONS

A program of JMEs for strategic arms reductions could involve provisions for elimination of launchers as well as reductions in corresponding stockpiles of nuclear warheads. As mentioned, JMEs could utilize precedents established by INF and START I verification protocols and procedures. These measures generally have a broad acceptance in both the United States and Russia.[14] INF and START monitoring provisions that could be particularly useful in the context of proposed reductions are

- data exchange on locations, numbers, and types of nuclear weapon systems to be eliminated, which in the future could also include declarations on the intended disposition (reuse, strategic reserve, or dismantlement) of nuclear warheads;
- the existing Nuclear Risk Reduction Centers (NRRCs) notification system that could be used to transmit exchange data, notifications, and declarations;

Table 3: Joint U.S.-Russian Radiation Measurement Technology Demonstrations on Classified Nuclear Weapon Components[15]



- general procedural framework and logistical infrastructure for conducting site visits; and
- methodology for conducting radiation measurements that could be used for measurements on missile front-sections and containerized items such as warheads, warhead components, and fissile materials (see Table 3).

Monitoring approaches for nuclear warheads would in many ways go well beyond INF and START I verification provisions. As mentioned, the beginning elements of a U.S.-Russian initiative to develop monitoring technologies and procedures for warheads and materials have already been established within the NNSA and DOD and jointly explored in cooperation with Russian nuclear weapons institutes. Potentially useful technology development areas include radiation measurements and information barrier systems to protect sensitive information, chain-of-custody methods and procedures, and remote monitoring. The United States and Russia have already conducted bilateral technology demonstrations that could become important building blocks for future transparency measures (see Table 3). These efforts could be further coordinated and expanded under the U.S.-Russian Weapons Safety and Security Exchange Agreement (WSSX).

JME 1: Monitoring Measures for Launcher Elimination

A joint experiment for monitoring the deactivation and elimination of launchers or delivery platforms would generally involve START I-type activities supported by CTR-type assistance programs. The United States and Russia have completed arms reductions under the START I Treaty, which remains in force until 2009.[16] Initially, the parties would provide each other with information about specific weapons systems to be eliminated, consistent with negotiated terms, as well as time, location, and scope of planned elimination activities. These notifications would be transmitted through the Nuclear Risk Reduction Centers located in Moscow and Washington, DC, respectively. For example, the United States is expected to begin the deactivation of its MX Peacekeeper and Trident weapon systems in 2002 at F.E. Warren AFB in Wyoming and Bangor Submarine Base in Washington state, respectively. Rus-

RADIATION DETECTION UNDER THE INF AND START I TREATIES

INF radiation detection inspections were actively conducted until 1995. Their purpose was to ensure that intermediate- and shorter-range missiles are not present on former SS-20 (intermediate-range missile) bases, which have been converted to SS-25 (ICBM) bases. INF inspectors use a neutron detector system consisting of a power source and counter (Eberline ESP-2); a programmable calculator; a coordinate grid (4 x 4 meters); a tripod; and a calibration source. According to INF inspection procedures, a neutron detector is placed at predetermined locations beneath and on top of the warhead portion of a missile canister. Under inspector observation, the escorts position a detector and take measurements. The number of neutrons is counted and is compared to the benchmark. The benchmark measurements were conducted in the summer of 1989 in Lutsk (on a SS-20 IRBM) and Teykovo (on a SS-25 ICBM).

The START I Treaty contains provisions for radiation detection inspections of two types:

- Re-entry vehicle on-site inspections (RVOSI) are conducted to determine whether an object on a missile front section is nuclear. Radiation measurements in this case are an option of the inspected party.
- The inspecting party has a right to use radiation detection measurements during inspections of heavy bomber weapons storage areas (WSA) to determine whether an object is a long-range nuclear air-launched cruise missile (LRNA). Heavy bomber base inspections have been conducted at all of U.S. B1-B and B-2 bomber bases.

According to RVOSI procedures, inspectors select the location of a measurement point. After that, under the direction of inspectors, the escorts position a neutron detector and take measurements. Measurements are taken at one point on a missile front section or at four points along the length of an ALCM container. The results are recorded in the inspection report. No benchmark measurements are needed.

The operational experience of radiation detection inspections under the INF and START I treaties demonstrated that the existing equipment is rugged, transportable, and operable under all-weather conditions. It is also low cost and amenable to long-term storage. The two parties also developed a set of agreed procedures and "policies" regarding the use of radiation detection equipment.

sia, at that time, will be retiring a variety of ICBM and SLBM/SSBN systems currently deployed at a number of locations throughout Russia. Nuclear Risk Reduction Center notifications would facilitate satellite observation of elimination activities and on-site inspections.

The actual inspections component of JME 1 could be conducted on a subset of weapon systems to be eliminated and would be coordinated with the proposed nuclear warhead-related JMEs (see below). Each party could invite a team of observers to an operational base to confirm the type of missile being deactivated and to observe its removal. For example, Russian observers could be invited to F.E. Warren AFB to observe the removal and disposition of some MX missiles, and U.S. observers could correspondingly be invited to one of the Russian SS-18 missile bases and the Surovatikha SS-18 missile elimination facility near Nizhny Novgorod. JME 1 would allow the United States and Russia to maintain particularly useful and appropriate elements of START I inspections (such as data update and conversion or elimination inspections) and discontinue inspections of some other types (for example, inspections to measure technical characteristics of strategic missiles).[17]

The continuing implementation of the CTR program would further increase confidence in launcher elimination. Currently, the program provides industrial support to the Russian launcher elimination process under the START I Treaty. For example, the CTR program has provided assistance to increase the missile elimination rate at the Surovatikha facility. Participation of U.S. military and civilian contractor personnel in elimination activities in Russia and CTR program requirements for audits and examination would supplement a schedule of direct observations and provide added confidence that launcher systems are eliminated according to declarations. Indeed, according to Senator Lugar, "[A]nyone who has witnessed the contractual negotiating process involved in undertaking and implementing a Nunn-Lugar project, as well as the role of American firms in managing such projects on site and the auditing practices to ensure proper utilization of U.S. funds, can attest that the inspection and verification procedures associated with the program are every bit as stringent and intrusive as similar measures under a formal arms control regime."[18] A new phase of CTR industrial assistance activities beginning in 2003 could be integrated with JME 1 to support the monitored elimination of strategic missiles, bombers, and submarines in Russia. To provide for reciprocity, Russian observers could be given the opportunity to visiting comparable elimination facilities in the United States.

JMEs 2-5: Confidence-Building for Warhead and Material Stockpile Reductions

Developing confidence-building measures for warhead stockpile reductions constitutes a new and more difficult challenge. Each country considers nuclear warhead-related information and procedures highly sensitive. (These sensitivities may even increase as Russia becomes concerned about vulnerability of its warheads to a future U.S. ballistic missile defense system.) The two parties would have to move carefully and incrementally to maintain confidence in warhead reductions over time.

A potentially promising approach would be for the two countries to conduct, in parallel, the following set of JMEs on a relatively small number of warheads (on the order of ten) as they move from a deployment location to a dismantlement facility and through elimination:

- JME 2: warhead removal from a missile
- JME 3: temporary warhead storage
- JME 4: warhead transportation to a dismantlement facility
- JME 5: warhead dismantlement

Starting these activities on a small number of warheads would limit the overall level of intrusiveness, locations affected, quantity of information exchanged, and cost. As the United States and Russia became more comfortable with warhead monitoring (possibly around 2006), the scope of JMEs could be expanded gradually to cover additional stocks of warheads.

JME 2 could begin in the fall of 2003 and would coincide with downloading of W62 warheads from Minuteman III missiles in the United States.[19] The W62 is the only warhead in the U.S. stockpile that is projected for retirement by 2009. The elimination of all W62 warheads from active stockpiles would reduce the concern that monitoring experiments would result in a loss of warhead design information and increase warhead vulnerability to countermeasures. In Russia, JMEs could be conducted, for example, on SS-18 warheads, all of which could also be expected to be removed from the stockpile after the retirement of the SS-18 force, projected by 2010. If the SS-18 warhead would be judged unacceptable because of its design commonalties with other warheads, warhead-related JMEs could be conducted on warheads deployed on SS-24 ICBMs—all of which are projected for retirement by 2007.[20]

JME 2 would be immediately followed by JME 3, which could focus on the remote, unattended monitoring of removed warheads in storage at their missile bases. Beginning storage monitoring experiments at missile bases would give the two countries additional time to resolve access arrangements to highly sensitive locations, such as central warhead storage facilities and warhead assembly/disassembly plants.

JME 3 would continue as long as it is necessary to prepare the warhead disassembly facilities—the Pantex plant in the United States, and the Trekhgorny and/or Lesnoy facilities in Russia—for monitored warhead dismantlement. At that time, possibly in 2006, JME 4 to monitor warheads in transit would take place, immediately followed by JME 5 on monitored warhead dismantlement.

JME 2: Monitoring of Warhead Removal

For JME 2, the host state would provide the monitoring state information on the number and types of warheads to be removed from a deactivated launcher, and locations of the deactivation point and warhead storage facility.

In the United States, initial monitoring experiments could be conducted at Malmstrom Air Force Base near Great Falls, Montana (see Box: *Malmstrom Air Force Base*). Malmstrom AFB is one of two ICBM bases in the United States that maintains Minuteman III missiles with W62 warheads.[21] The other Minuteman III/W62 base—Francis E. Warren AFB near Cheyenne, Wyoming—might be less suitable for the purpose of JME 2 because it has already reconfigured all of its 150 Minuteman IIIs from three multiple-reentry vehicles to a single reentry vehicle (SRV) per missile.[22] Malmstrom AFB has already hosted Russian inspections of its operational missile maintenance and storage areas under the START I Treaty and has an infrastructure to support foreign visits.[23] In Russia, initial monitoring activities could take place at one of its four active SS-18 missile bases, for example, the Kartaly Strategic Rocket Forces (SRF) base, which has 46 SS-18 missiles.[24]

JME 2 would begin with an invitation to the Russians to visit Malmstrom AFB. The Russian team would be taken to a Minuteman missile silo, where it would observe U.S. personnel opening a silo cover. Although the external shape for W62 warheads is unclassified, some tooling and warhead-missile interface equipment could be classified, and warhead demating and removal operations would be conducted behind a shroud. After the bus with three warheads is pulled out and placed inside a transportation vehicle, the Russians would be given an opportunity to conduct radiation (neutron detection) measurements inside the silo head-space to confirm that no warheads remain on top of the missile. The Russians would conduct a radiation sweep of all containers that are declared not to contain warheads. Radiation measurements could also be conducted on declared warhead containers to confirm that they contain nuclear materials. The fact that declared warheads were removed from an operational missile would be a very strong indication that they are authentic warheads.

The warheads would then be transported by a truck to the weapons storage area of Malmstrom AFB. Russian

MALMSTROM AIR FORCE BASE

Malmstrom AFB is one of three ICBM bases in the United States. The base is located just outside (east) of Great Falls, Montana. It is a home to four (10th, 12th, 490th, and 564th) Minuteman III missile squadrons of the 341st Space Wing of the 20th Air Force (Air Force Space Command). Each squadron contains 50 ICBMs organized into five clusters of ten missiles and a launch control facility. The 200 missile silos are dispersed across 60,865 square kilometers (23,500 square miles) in north-central Montana (Malmstrom deployment area). Of these, 150 ICBMs are armed with three W78 MIRV warheads each (a total of 460 including spares). The remaining 50 carry three older W62 warheads each (a total of 150).

The base itself is located on approximately 1,300 hectares of land. In addition to the housing area, the base has a runway, which was closed to fixed-wing aircraft in 1996, a weapons storage area, a missile booster area, and various administrative and support structures.

***Sources*:** William M. Arkin, Robert S. Norris, and Joshua Handler, *Taking Stock: Worldwide Nuclear Deployments 1998* (Washington, DC: Natural Resources Defense Council, 1998); Federation of American Scientists, "Nuclear Forces Guide," <http://www.fas.org/nuke/guide>.

observers would be given an opportunity to follow and maintain visual contact with the warhead convoy to the base. At the base, the warheads would be taken to a servicing area for separation from the bus, safing, and preparation for storage or transfer to U.S. Department of Energy (DOE) couriers. (These preparations could, for example, involve a removal of a tritium reservoir and certain other components.) The warheads would then be placed inside storage and transportation containers.

Russian observers would be given an opportunity to conduct radiation sweeps of the servicing area and declared non-nuclear containers before and after warhead servicing operations to confirm that the declared warheads have not been substituted or hidden. They also would place unique tamper-indicating tags and seals on containers declared to hold the removed warheads, and, possibly, conduct simple radiation detection measurements on these containers to confirm that they contain radioactive materials. This would conclude JME 2 in the United States.

During a reciprocal visit to the Kartaly missile base, U.S. observers would observe the opening of a selected silo and the installation of the protective tent over it (see Box: *ICBM Deactivation in Russia*). The U.S. team would not see the bus with warheads being disconnected from the missile and placed on a transportation vehicle. They, however, would be able to conduct post-removal neutron detection measurements in the silo head-space and on non-warhead containers. Similar to their Russian counterparts, U.S. observers would escort the convoy with the warheads to the Kartaly SRF base warhead maintenance and storage facility (RTB). They would conduct a before-and-after radiation sweep of the warhead servicing area and apply tags and seals to declared warhead containers.

ICBM DEACTIVATION IN RUSSIA

ICBM deactivation and retirement begins with the opening of the silo cover and installation of a protective tent over its head-space. The tent shields the weapons system from inclement weather and provides additional security. The missile storage canister is then opened, providing access to the missile. Missile officers then remove the aerodynamic shroud, disconnect the post-boost vehicle (the bus) from the missile top stage. The bus and the warheads are then lifted from the silo and transported to the servicing and maintenance base (RTB) located inside the main base area. At the RTB, each warhead is removed from the bus, prepared for storage and transportation, and placed inside storage-transportation containers. The containers are staged at warhead storage bunkers on the base prior to their transportation by rail to a Ministry of Defense (MOD) central warhead storage facility. After the removal of warheads, the missile is defueled and transported to the base missile storage area. Eventually, it is eliminated either by conversion to a space launch vehicle or by demolition.

JME 3: Monitored Storage of Warheads

Both at Malmstrom AFB and Kartaly SRF base, tagged and sealed containers with warheads would be placed inside a dedicated storage magazine that would be sealed and fenced-off from the other warhead-storage magazines.[25] The removed warheads would remain in base storage for an extended period until the time comes to send them to a dismantlement plant for elimination.

A JME to confirm that warheads remain in storage could then involve periodic (every several months) reciprocal visits to warhead magazines to check tags and seals on the warhead containers. Another useful approach would be to conduct unattended remote monitoring of storage magazines between visits. Remote monitoring systems employ a variety of sensors including video, motion detection, monitored seals, and other technologies that would detect in real time any attempt to enter or remove the contents of a sealed magazine. Live data from these surveillance systems can be exported and viewed remotely. As long as the observers are assured that the data is authentic, they do not have to visit the storage facility to confirm that its contents have not been tampered with nor removed. The development of monitoring technologies and procedures for warheads in storage, including field trials at DOD nuclear weapon storage facilities, has already been carried out by NNSA national laboratories in the United States.

JME 4: Monitoring of Warhead Transportation

As the two countries become prepared for a monitored dismantlement experiment, the warheads would be shipped to the corresponding warhead disassembly facilities. In the United States, warheads would be trucked from Malmstrom AFB to the Pantex plant near Amarillo, Texas by DOE transport vehicles. In Russia, warheads would be loaded on a train and shipped by rail to the disassembly facility, presumably in the closed city of Trekhgorny.[26]

JME 4 would be conducted to monitor warheads during transportation. Such monitoring represents an important challenge. For example, transport of warheads from Malmstrom AFB to Pantex would cover more than 1,000 miles and would take days to complete. The periods during which warheads are being transported present significant challenges to confidence-building. Current approaches to monitoring items during transportation include the application of tags and seals that are inspected prior to and following transportation. However, most tags and seals are vulnerable to defeat, given sufficient time and resources. New and more robust monitoring approaches are needed to help the respective countries feel confident that sealed warhead containers have not been tampered with during lengthy periods of transportation. One approach could be to provide the inspecting party with live sensor data on the status and integrity of the containers without revealing the precise location of the shipment. (For safeguards and security purposes, the precise location of a warhead transport is kept secret both in the United States and in Russia.) Additional research and development efforts are necessary to develop and implement such transportation monitoring technologies.

JME 5: Monitored Warhead Dismantlement

The principal objective of JME 5 would be to increase confidence that warheads removed in the course of arms reductions are irreversibly eliminated. This experiment would be conducted at warhead dismantlement and fissile material storage and disposition facilities.

The United States could invite Russian observers to the DOE Pantex plant (see Box: *Nuclear Warhead Dismantlement in the United States*). Russian inspectors could examine tags and seals on the containers with the warheads after their delivery to Pantex. They also could be permitted to conduct neutron measurements on containers to confirm that they continue to hold radioactive materials.

Warhead dismantlement then would take place inside a dedicated area at Pantex. The Russians would conduct a radiation sweep of the area to confirm the absence of nuclear materials before dismantlement operations commence. They would then again check tags and seals on warhead containers entering the dismantlement area. After the dismantlement is completed, the observers would conduct another radiation sweep of the dismantlement area and non-nuclear containers to confirm that they do not contain nuclear materials. Containers with fissile materials would then be re-tagged and resealed.

U.S. inspectors would be expected to conduct similar activities at the Russian dismantlement facilities (see Box: *Nuclear Warhead Dismantlement in Russia*).

Storage, conversion of highly enriched uranium (HEU) metal components to uranium oxide powder, and

NUCLEAR WARHEAD DISMANTLEMENT IN THE UNITED STATES

Nuclear warheads are delivered to Pantex by the DOE courier service in safe and secure transportation vehicles. Upon the arrival, warheads undergo safety and safeguards checks and are placed in temporary storage prior to dismantlement. Warhead dismantlement begins with mechanical disassembly of a re-entry vehicle and separation of a nuclear explosive package inside one of the Pantex assembly bays. The nuclear explosive package, which contains fissile materials and high explosives, is then moved to a gravel gertie assembly cell, where it is further disassembled to separate the plutonium pit, the high explosive components, and the thermonuclear secondary (canned secondary subassemblies, or CASs). The plutonium pit is packaged in a fissile material container and is moved to a storage area at Pantex. The HEU secondary is shipped to the Y-12 Plant in Oak Ridge, Tennessee. Other warhead components are sorted, sanitized to remove classified information (if not intended for reuse), and sent to other DOE facilities or commercial companies for recycle, recovery of valuable materials, or disposal.

Plutonium components, if determined to be excess for defense requirements, would eventually be sent to the DOE Savannah River Site (SRS) facility for conversion to plutonium oxide and disposition. The HEU components would be converted to metal ingots and stored at the Y-12 Plant pending down-blending at the BXWT HEU processing facility in Lynchburg, Virginia. It is expected that the United States would place the fissile material disposition facilities on the IAEA voluntary safeguards offer list.

Sources: U.S. Congress, Office of Technology Assessment, *Dismantling the Bomb and Managing the Nuclear Materials*, OTA-O-572 (Washington, DC: U.S. Government Printing Office, 1993); Chapter 3: Batelle Pantex/Mason & Hanger Corporation, Pantex Operations Programs, *1998 Programmatic Information Documents For Pantex Plant*.

down-blending of HEU materials would then be monitored through the arrangements negotiated under the U.S.-Russian HEU agreement.

The United States, Russia, and the IAEA are currently discussing monitoring measures for conversion of plutonium weapon components to unclassified shapes and isotopic compositions and its subsequent storage and disposition. Tagging of containers with weapons components at the dismantlement facility would greatly increase confidence in its weapons origin.

A JME at national warhead assembly/disassembly facilities would be a fundamental breakthrough in U.S.-Russian nuclear security relations. Arranging for such experiments, however, would not be easy. Each country considers its warhead production facilities as highly sensitive and has not yet allowed representatives of the other country to visit them.

A paramount concern in the United States and Russia is the protection of classified weapons data as well as other sensitive information (for example, safeguards and security data and warhead and material shipment schedules). Facility managers and security personnel in each country are also concerned with operational impacts the monitoring activities might have on facility safety and production schedules. Finally, the two countries would have to work out issues associated with considerable asymmetries that exist between the U.S. and Russian nuclear weapon dismantlement infrastructures and operations.

However, arranging for a monitoring experiment at a dismantlement facility might be easier in comparison to negotiating a formal verification regime, as was proposed under the START III treaty. Indeed, such an experiment would involve a limited dismantlement campaign: it would be of limited duration and would also be less complex and intrusive. And conducting a limited-scaled experiment could significantly reduce operational impacts and security concerns, requiring less modification of warhead and materials flows within the dimantlement facility. For example, warheads could be shipped to a dismantlement facility in small batches just in time for dismantlement to avoid the need for additional monitoring activities at plant warhead storage areas.

Security reviews, personnel training, rehearsals, facility modernization (construction of additional fences or even new buildings), and other preparations for a warhead elimination monitoring experiment would likely take several years. Much of this work could be done under the WSSX agreement by technical experts from DOE, the Russian Ministry of Atomic Energy (Minatom), and national nuclear weapons laboratories and production facilities. Required construction or facility modification could be implemented through CTR-type industrial projects.

NUCLEAR WARHEAD DISMANTLEMENT IN RUSSIA

Slated-for-dismantlement strategic warheads are delivered by the Ministry of Defense to the Trekhgorny and/or Lesnoy serial warhead assembly/disassembly facilities, which could be operating in sequence. (According to Minatom's plans, warhead-dismantlement activities at Russia's two other facilities in Sarov and Zarechny will be phased out by 2003.) After receiving a containerized warhead, warhead disassembly technicians open the container, conduct entry radiological control of warhead surfaces, and verify documentation. After that, a dismantlement authorization decision is made and the warhead enters the disassembly process.

Warhead disassembly takes place in specialized concrete cells. The dismantlement process includes the following steps: separation of the nuclear explosive package from the warhead, removal of the primary from the physics package; separation of fissile materials from the primary and secondary subassemblies; packaging and temporary storage of fissile materials; and mechanical disassembly of non-nuclear parts. High-explosive components are burned. Other non-nuclear components are sanitized (for example, ballistic casings are deformed) and are recycled or disposed of.

After interim storage at the dismantlement facilities, the HEU components from retired warheads are shipped to Ozersk or Seversk for further processing and disposition. Excess HEU is converted to oxide, purified, and downblended as UF6 gas to low-enriched uranium for delivery to the United States under the 1993 HEU agreement.

The plutonium components are delivered to Ozersk for conversion to metal spheres and long-term storage at the safe and secure storage facility, which is being constructed there with U.S. assistance. Eventually, excess plutonium will be disposed of as MOX fuel in nuclear power reactors. The United States and Russia are currently discussing potential options to monitor non-intrusively the conversion of plutonium warhead components to unclassified metal spheres. The storage and disposition of plutonium are expected to involve U.S.-Russian bilateral and/or IAEA safeguards.

***Sources*:** Yu. Zavalishin, *"Avangard" Atomic* (Saransk, Russia: Krasny Oktyabr, 1999); Podvig, ed., *Russian Strategic Nuclear Forces*.

TOWARDS A COMPREHENSIVE WARHEAD AND FISSILE MATERIAL TRANSPARENCY REGIME

The ultimate goal of JMEs would be to pave the way for a more comprehensive warhead and fissile material monitoring regime. Such a regime could be vital to building a truly cooperative U.S.-Russian nuclear security relationship. A system of comprehensive monitoring would also be particularly important if the United States, Russia, and possibly other nuclear weapon states were to reduce their future nuclear forces to the levels of hundreds of warheads.

A comprehensive monitoring regime would need to be designed to develop confidence that each of the major steps in the nuclear weapons reduction cycle was consistent with the agreements reached between Washington and Moscow. Several of these steps are briefly described in Box: *Monitored Elimination of Nuclear Warheads and Materials*.

A comprehensive monitoring regime would include an extensive exchange of data on warhead and fissile material inventories, planned and implemented warhead dismantlement operations, and other related warhead and nuclear materials activities.

Additional monitoring arrangements would likely be required to verify declarations and increase confidence that declared items are authentic nuclear warheads and that these warheads have been permanently dismantled. Several U.S.-Russian joint technology development initiatives could help implement such a monitoring regime and are envisioned as proceeding in parallel with later phases of the JME series.

One technical initiative that could have important transparency benefits is joint remote monitoring of stored warheads. Such systems, if installed by Russia and the United States on select portions of warhead inventories, could provide clear evidence that those stocks were not being used for rapid uploading or force reconstitution. Storage monitoring might also be able to confirm that non-strategic nuclear forces remained in central storage locations and were not forward-deployed. Eventual monitoring of a significant portion of Russia's estimated inventory of such weapons could ease U.S. concerns regarding the purpose of retaining large stocks of non-strategic nuclear forces.

Another initiative could be aimed at continued joint research on methods and technologies for building confidence that nuclear warheads had been dismantled. For example, the joint development of inspection systems using passive and active radiation measurements to determine the presence or absence of weapons-grade fissile material and high explosives in a sealed container offers one possible component of a procedure for authenticating declared items as nuclear warheads. Other systems that combine tags, seals, and live video data could be developed to provide remote monitoring of the actual warhead dismantlement process. Used in combination with observations at warhead deployment sites and methods for monitoring transportation, these measures may provide adequate evidence that warheads had been dismantled in a manner consistent with declarations.[27]

Other technical initiatives that have been suggested to increase transparency in the nuclear weapons complexes in Russia and the United States include:

- jointly developed measures for confirming the shutdown of warhead assembly/disassembly and fissile component manufacturing facilities,
- the establishment at nuclear weapon laboratories of cooperative centers for the development of safe and secure transparency technologies, and
- joint studies on future nuclear stockpile and infrastructure requirements.

If implemented, these activities could make U.S. and Russian force reconstitution, or "breakout," more difficult, time-consuming and detectable by the other side. These steps could provide greater mutual confidence that excess warheads are being dismantled and production infrastructures are being reduced.

CONCLUSION

Since the end of the Cold War, the U.S.-Russian strategic relationship has improved dramatically. However, remaining uncertainties regarding nuclear weapon inventories (strategic and tactical), warhead production infrastructures, and fissile material stocks continue to inhibit the transition to truly transparent and cooperative nuclear security postures. Adopting an arms reduction strategy that forgoes any type of transparency or verification measures runs the risk of increasing remaining uncertainties.

Reducing these uncertainties will require increased—not decreased—levels of transparency.

The joint monitoring and transparency measures proposed in this article are intended to reduce remaining strategic uncertainties while simultaneously implementing activities that intensify and accelerate the positive

MONITORED ELIMINATION OF NUCLEAR WARHEADS AND MATERIALS

Monitoring Stockpile Declarations

A key element of an improved U.S.-Russian nuclear security posture would be official declarations of their nuclear warhead and fissile material inventories. These declarations could be updated at negotiated intervals. Such declarations have been proposed in the context of U.S.-Russian discussions on potential future nuclear arms reductions.* Declarations on the locations of deployed strategic arms and accountable warheads have already been exchanged between the United States and Russia under the START I Treaty. However, confirming the number of both deployed and nondeployed warheads within the context of a new U.S.-Russian nuclear security posture would require measures supplementing current START inspection protocols.

Certifying Warheads and Fissile Materials

One of the most significant monitoring and transparency challenges of an improved U.S.-Russian nuclear security relationship may be the need to certify (or authenticate) and monitor small items such as nuclear warheads and containers of fissile materials (as opposed to large items like strategic missiles and bombers). As deployed nuclear forces are reduced, deactivated warheads and fissile materials become key to assessments of breakout potential and other infrastructure asymmetries that are vital to maintaining nuclear stability.

Monitoring Warhead Dismantlement

Because of the sensitive and secretive nature of nuclear warheads, nuclear weapon components, and the dismantlement process itself, it is difficult to envision monitoring means that provide confidence in warhead dismantlement while protecting classified information. This problem has been the subject of joint U.S.-Russian research for several years. However, the joint development of inspection systems using passive and active radiation measurements to determine the presence or absence of weapons-grade fissile material and high explosive in a sealed container offers one possible component of a procedure for authenticating declared items as nuclear warheads. Other systems that combine tags, seals, and live video data could be developed to provide remote monitoring of the actual warhead dismantlement process. Used in combination with observations at warhead deployment sites and methods for monitoring transportation, these measures may provide adequate confidence that warheads had been dismantled in a manner consistent with declarations.

Monitoring Transportation

Monitoring the transportation of weapons and materials presents an important challenge. During the dismantlement, storage, conversion, and disposition processes, nuclear weapons and materials are transported many times. These movements may be across great distances, taking weeks to complete, or may be only over a few miles, between buildings of a large facility. Many steps along the way pose risks of diversion or substitution of items. For security purposes, the precise location of nuclear weapons and components during transportation is kept secret. Monitoring transportation within a large facility may be complicated by the abundance of items not being monitored and items with similar characteristics to those being monitored. Current approaches to monitoring items during transportation include the application of unique identifying tags and tamper-indicating seals that are inspected prior to and following transportation. Unfortunately, given sufficient time and resources, most tags and seals are vulnerable to defeat.

Monitoring Fissile Material Conversion and Disposition

Key technology challenges for monitoring the conversion of weapons-usable materials into nonweapons-usable forms include demonstrating continuity of knowledge regarding accountable materials during the transition from item accountability to bulk processing and back to item accountability. In the case of plutonium, monitoring technologies are needed to confirm that weapons components comprising declared quantities of Pu metal are converted to oxide and then fabricated into mixed-oxide (MOX) fuel assemblies for burning in reactors. Similar approaches are needed for monitoring the down-blending of highly enriched uranium (HEU).

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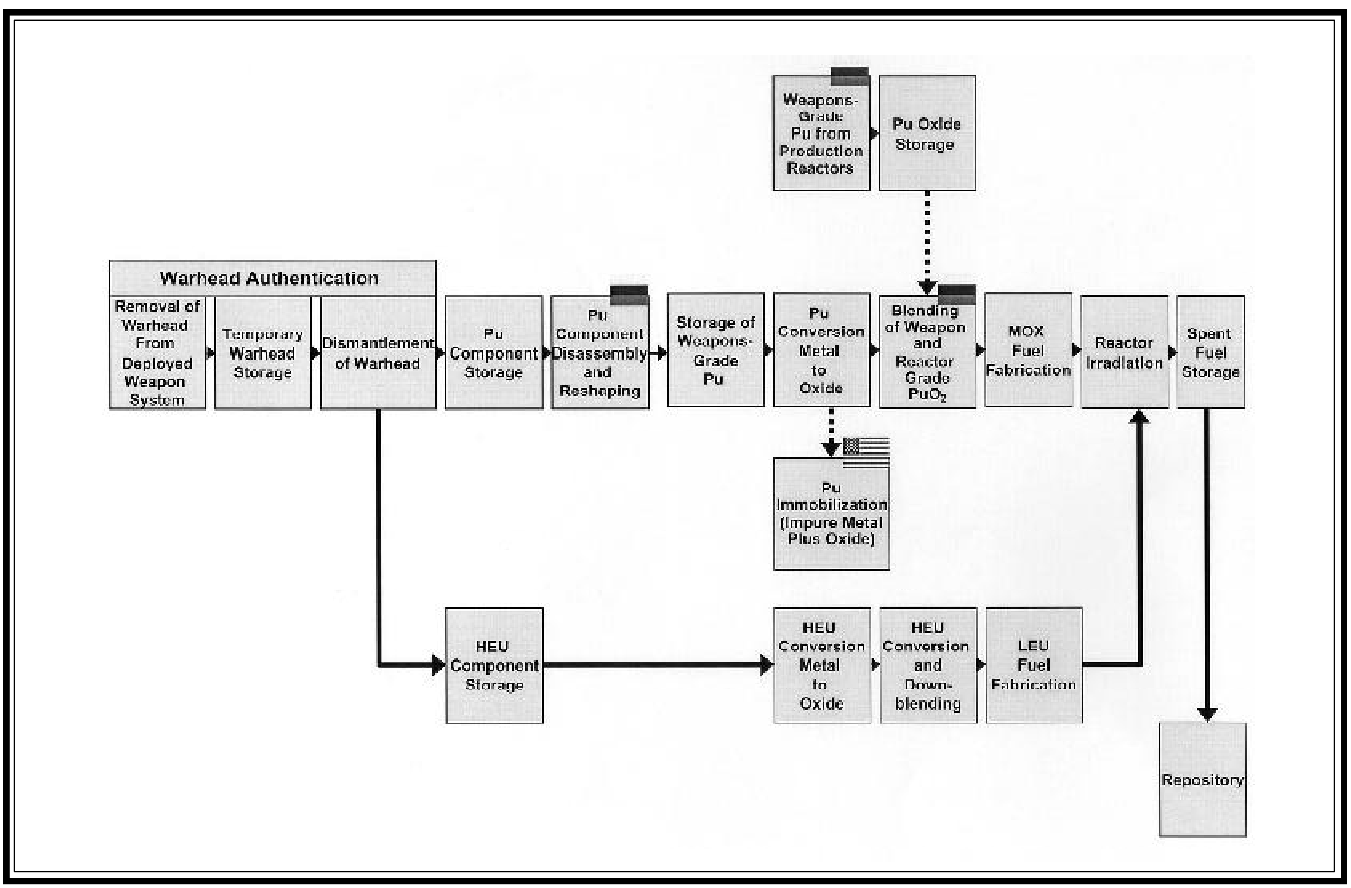
* In June 1995, the United States proposed a modest stockpile data exchange agreement, as called for by the U.S.-Russian joint summit statement just one month earlier. This proposal was rejected by Russia in December 1995. See Robert Gromoll, "A Nuclear Warhead Control and Elimination Regime: Problems and Prospects," Paper Presented at the 38th Annual INMM Conference, July 1997. These previous efforts to reach an agreement with Russia to exchange limited amounts of classified data might be revitalized. Such an agreement might make building mutual confidence much easier in an era without formal verification measures.

transformation of the U.S.-Russian nuclear security relationship. Although they are initially focused on building confidence in strategic force reductions, they are also clearly designed as a "test bed" for developing the technologies and procedures for monitoring the deactivation, storage, and dismantlement of nuclear warheads. Over time, they could also be used to increase confidence in the accuracy of mutual stockpile data declarations that could be exchanged to improve transparency and predictability without requiring verification in the near term.

Developing reliable means to account for nuclear warheads between formerly hostile states is a difficult, but essential task. As was emphasized in a 2001 report issued by the National Academy of Sciences: "[I]f significant further reductions in nuclear weapons are to succeed, the present regime will need to be enhanced with new approaches [to monitor warheads] to provide greater assurance that reductions are taking place, whether through formal agreements or unilateral measures.…Over the long term, confidence in arms reductions will be much higher if we begin to build a system [of monitoring nuclear warheads and materials] today when stockpiles are high. If we wait until most of the existing warheads have been eliminated under a shroud of secrecy, we will have less confidence in our knowledge of the stockpile of weapons and fissile materials."[28]

Because nuclear warhead facilities and operations are shrouded in secrecy, neither the United States nor Russia would allow their warheads to be monitored by systems developed independently by the other state. The JMEs proposed above would be integrated with science and technology programs dedicated to the cooperative development and testing of such systems. The mutual interest of the two sides in developing technical methods for monitoring warhead dismantlement was confirmed on April 5, 2000, under a Joint Statement signed by the U.S. Department of Energy and the Russian Ministry of Atomic Energy. This statement asserts that the sides, "Agreed to continue work on issues related to warhead dismantlement within the framework of the U.S.-Russian Agreement on the Exchange of Technical Information in the Field of Nuclear Warhead Safety and

Fig. 2. Nuclear Warhead Dismantlement and Fissile Material Management Process.



Security." In fact, cooperative development of warhead authentication and storage monitoring systems is currently being pursued under this agreement.

Cooperative development of transparency technologies has important side benefits, such as increasing incentives for transparency implementation in Russia, intensifying transparency R&D between U.S. and Russian labs, and providing non-weapons employment for workers in Russian closed nuclear cities. Cooperative development could provide U.S. financial assistance for Russian system fabrication and preserve potential opportunities for Russian enterprises if monitoring systems enter serial production. Finally, the industrial partnering methods used for cooperative development of transparency technologies will create valuable experience that could be applied to other CTR initiatives or civilian R&D efforts.

Taken together, an ongoing series of JMEs, continued CTR programs, and joint transparency technology development efforts for warhead safety, security, and dismantlement offer another key benefit to both states. Thanks to the resulting data exchanges, frequent visits to key facilities, and access to nuclear custodians on a cooperative working level, these integrated programs could also serve as a vital supplement to traditional systems for indication and warning regarding changes in intentions and capabilities with respect to nuclear postures. In this way, the transparency activities proposed above can be both a barometer for the status of a U.S.-Russian partnership on nuclear security and a vehicle for improving that partnership over time.

[1] "Text of the U.S.-Russia Treaty on Nuclear Arms," *Washington Post*, May 24, 2002.

[2] The White House, Press Release, May 24, 2002, "Text of Joint Declaration on the New Strategic Relationship."

[3] Joseph R. Biden Jr., "Beyond the Moscow Treaty," *Washington Post*, May 28, 2002, p. A17.

[4] See, for example, U.S. Senate, Strategic Subcommitte of the Armed Services Committee, "Tesitomony of Admiral Richard Mies (USN), Commander in Chief, U.S. Strategic Command," 107th Congress, 2nd Session, Washington, DC, July 11, 2001, <http://web.lexis-nexis.congcomp>.

[5] A possible conversion approach would involve modification of missile launch tubes. Most tubes would be modified to accommodate a canister with seven conventionally armed Tomahawk cruise missiles (a total of 154 per boat). Two tubes would be configured for use by special forces. See, for example, Robert Green, "Conventionally-Armed UK Trident?" *Disarmament Diplomacy*, No. 56 (April 2001), pp. 2-7.

[6] Warheads in the active stockpile have tritium and other limited-life components and are fully available for operational deployment. Inactive warheads do not contain limited-life components.

[7] There are typically two Trident submarines in overhaul at any given time.

[8] For strategic missile systems, see U.S. Department of State, "START I Aggregate Numbers of Strategic Offensive Arms, START Treaty Memorandum of Understanding Data for the United States of America, Effective Date: 1 January 2002," <http://www.state.gov>. The number of bombers is also based on U.S. Senate, "Testimony of Admiral Richard Mies."

[9] 2012 levels are the authors' projections based on further strategic delivery vehicle reductions and missile downloading.

[10] U.S. Department of State, "START I Aggregate Numbers"; John Wolfsthal, Cristina Chuen, and Emily Ewell Daughtry, eds., *Nuclear Status Report* No. 6 (Monterey, CA and Washington, DC: Carnegie Endowment for International Peace and Monterey Institute of International Studies, 2001), pp. 1-31.

[11] These JMEs could be similar in many ways to the joint verification experiments held between U.S. and Russian scientists to agree on ways to verify the Threshold Test-Ban Treaty.

[12] Lewis Dunn, "Coordinated Security Management: or Towards a New Strategic Framework," *Survival*, (forthcoming 2002), and Lewis A. Dunn and Victor Alessi, "Arms Control by Other Means," *Survival* 42 (Winter 2000-2001), pp. 129-40.

[13] See Nikolai Sokov, "Strengthening The 1991 Declarations: Verification And Transparency Components," paper presented at the seminar "Time to Control Tactical Nuclear Weapons," United Nations Institute for Disarmament Research (UNIDIR), UN Headquarters, New York, NY, September 24, 2001.

[14] For example, according to Igor Sergeev, an assistant to Russian President Putin, "Regardless of how the [new] reductions are conducted, including in parallel or unilaterally,…they still need a legal basis.…The unprecedented system of controls, which was developed under the START I Treaty, could be retained fully or in part; that is, it could be codified and its implementation could be extended. In the future, it also could be used if other members of the nuclear club were to agree to reduce their forces under multi-lateral agreements." I. Barsukov and A. Shitov, "Results of the Russian-American Summit in Lublyany are 'Beyond All Expectations,' According to Marshal Sergeev," ITAR-TASS, June 18, 2001.

[15] Andrew Bieniawski, "Historical Review," *Fissile Material Transparency Technology Demonstration*, briefing materials, August 14, 2000, Los Alamos, LA-UR-00-2239.

[16] U.S. Department of State, "START Treaty Final Reductions, a Fact Sheet," Washington, DC, December 5, 2001, <http://www.state.gov>.

[17] The INF Treaty provided for five types of inspections including baseline, short-notice inventory, close out, and portal perimeter continuous monitoring (PPCM). The START I Treaty provides for PPCM and 12 types of inspections including baseline, data update, new facility, suspect site, conversion or elimination, close out, formerly declared facility, suspect site, and others.

[18] Senator Richard Lugar, "Nunn-Lugar: A Tool for the New U.S.-Russian Strategic Relationship," speech delivered to the 2001 Carnegie Nonproliferation Conference, June 18-19 2001, Washington, DC.

[19] Because the replacement of W62s with W87s will not begin until 2006, warhead removal would be a part of a Minuteman III downloading effort. In particular, Russian observers would observe the removal of three W62 warheads from a missile. After they leave, a single W62 warhead would be installed on the same missile.

[20] While SS-18 warhead design concepts (and, possibly, subassemblies and components) have been utilized in warheads of other strategic and tactical nuclear weapon systems, it appears that the SS-24 warhead was developed specifically for the SS-24 ICBM system and thus could be expected to be completely removed from the stockpile after the retirement of all SS-24 missiles. (See, for example, Analytical Center for Nonproliferation, *Manuscript on the History of the Soviet Nuclear Weapons and Nuclear Infrastructure*, Technical Report, ISTC Project 1763, (Sarov, Russia: All-Russian Scientific Design Institute of Experimental Physics, 2001).

[21] William M. Arkin, Robert S. Norris, and Joshua Handler, *Taking Stock: Worldwide Nuclear Deployments 1998* (Washington, DC: Natural Resources Defense Council, 1998).

[22] Melissa Phillips, "Missile Maintainers Finish Treaty Requirement Early," AFPN, August 13, 2001, <http://www.af.mil/news/Aug2001/n20010813_1106.shtml>. The SRV program at F.E. Warren AFB began on November 23, 1998 and was completed on August 6, 2001. It was implemented under the START I Treaty, which mandates that the United States reduce its strategic missile force to 6,000 warheads.

[23] Wendy Frable, "START Inspections Begin," AFPN, March 9, 1995, <http://www.af.mil/news/Mar1995/n19950309_199.html>.
[24] Wolfsthal, et al., eds., *Nuclear Status Report*.
[25] Aerial imagery of the Malmstrom AFB weapons storage area suggests that the base has approximately four warhead storage magazines. Russian SRF RTB bases typically have three bunkers capable of holding 25-30 warheads each.
[26] See, for example, Pavel Podvig, ed., *Russian Strategic Nuclear Forces* (Cambridge, MA: MIT Press, 2001).
[27] Vitaly P. Dubinin and James E. Doyle, "Item Certification for Arms Reduction Agreements: Technological and Procedural Approaches," in *Proceedings of the 41st Annual Meeting of the Institute of Nuclear Materials Management, New Orleans, July 16-20, 2000*, and Eric R. Gerdes, Roger G. Johnston, and James E. Doyle, "A Proposed Approach for Monitoring Nuclear Warhead Dismantlement," *Science & Global Security* 9, (2001), pp. 113-41.
[28] National Academy of Sciences, *A Comprehensive Nuclear Arms Reduction Regime: Interim Report* (Washington, DC: National Academy of Sciences, 2001), <http://books.nap.edu/books/NI000347/html/1.html#pagetop>. Developing the means for warhead arms control is also clearly advocated by the 1997 U.S.-Russian Helsinki Summit Statement, in which the two states agreed that future arms control agreements should contain "measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads." The White House, "Joint Statement on Parameters on Future Reductions in Nuclear Forces," Press Release, March 21, 1997.