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Verifying nuclear arms control and disarmament

Edward M. Ifft

The period between 2000 and mid-2001 was a slow one in multilateral arms control.[1] Essentially, no progress was made in the Conference on Disarmament (CD) in Geneva, Switzerland, since delegates failed to agree a Programme of Work. Efforts to initiate negotiations on a Fissile Material Cut-off Treaty (FMCT) stalled because some members insisted on a linkage with more controversial parts of the CD agenda, such as arms control in outer space.[2] An FMCT would add a binding multilateral commitment to existing constraints on nuclear weapons material. The US stopped producing fissile material for nuclear weapons in 1992, and Washington and Moscow signed a bilateral agreement in 1994 to halt plutonium production for nuclear weapons. Russia and the UK announced in 1995 that they had ceased production of fissile material for use in nuclear weapons, and France made a similar statement in 1996.[3]

The situation regarding Nuclear Weapon-Free Zones (NWFZ) also did not change markedly. The treaties of Bangkok, Pelindaba, Rarotonga and Tlatelolco create one contiguous zone in most of the Southern Hemisphere. Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan are seeking to establish a NWFZ in Central Asia.[4] The United Nations General Assembly (UNGA) welcomed and encouraged the initiative at its 2000 session. Mongolia, while a single state and thus not meeting the general definition of a 'zone', declared its 'nuclear weapon-free status' in 1992.[5] In November 2000, the UNGA again adopted a resolution calling for the creation of a NWFZ in the Middle East.[6]

In view of the scant progress made in multilateral and regional arms control, this chapter focuses primarily on the nuclear agenda of the US and certain countries that used to be part of the Soviet Union. An important milestone was reached in 2001, as the five implementing states parties to the 1987 Intermediate-range Nuclear

Forces (INF) Treaty successfully completed the 13 years of on-site inspections and monitoring specified by the accord. Meanwhile, the ambitious and frequent inspections and monitoring provided for under the Strategic Arms Reduction Treaty (START) continued without change.

In January 2001 the administration of US President George W. Bush assumed office and initiated a comprehensive review of the US approach to international security, including nuclear arms control. A new emphasis on ballistic missile defence and a renewed interest in less formal methods of controlling nuclear arms were apparent which could have profound effects on the future course of arms control and disarmament. The government also made clear its intention to carry out further reductions in nuclear weapons, a move supported by many countries.

The INF Treaty

A major development in 2001 was the conclusion of the INF inspection and monitoring regime. Under the terms of the agreement, which entered into force on 1 June 1988, the states parties agreed that inspections would continue for 13 years, ending by 31 May 2001. The five implementing parties hosted final inspections—Belarus in February, Ukraine in March, Kazakhstan in April and Russia and the US in May 2001—and held appropriate closing ceremonies.

These events brought to an end a remarkable chapter in arms control verification. During these 13 years a total of 851 inspections were conducted. US inspectors carried out approximately 60 percent of them at 130 sites in Belarus, Kazakhstan, Russia and Ukraine. Around 40 percent were conducted by the other parties at 31 sites in the US and in the five Western European INF basing countries (Belgium, Germany, Italy, the Netherlands and the UK).[7] The inspections were of five types:

- **Baseline inspections** Conducted from July–August 1988 to help verify data on items prohibited by the treaty.
- **Closeout inspections** Carried out at eliminated facilities to verify that all activities related to INF had ceased. Closeout inspections were completed in August 1991.
- **Elimination inspections** To confirm that missiles, launchers and associated support equipment had been destroyed according to specified procedures. All of the required eliminations were completed by May 1991, the former Soviet

Union and the US eliminating 1,846 and 846 missiles respectively. The total numbers of items eliminated during this three-year period were 5,439 for the former Soviet Union and 2,332 for the US.

- **Quota or short-notice inspections** To confirm the number or absence of items banned by the treaty at a site. For the first three years, 20 inspections per treaty year were permitted for the US and the four successor states (aggregated) of the former Soviet Union—Belarus, Kazakhstan, Russia and Ukraine. This fell to 15 per treaty year for the next five years and 10 for each treaty year between 1 June 1996 and 31 May 2001.
- **Inspections by means of continuous monitoring** Allowed at one former missile assembly facility in the Soviet Union and one in the US to determine that prohibited missiles were not being produced and shipped. The US site was the former Pershing II production facility at Magna, Utah, while the site in the former Soviet Union was the former SS-20 final assembly facility at Votkinsk, Russia. Up to 30 inspectors could be permanently stationed outside each facility to monitor items leaving the plant. INF operations at both sites ceased on 31 May 2001. However, US personnel remain at the Votkinsk site in accordance with START I, since Inter-Continental Ballistic Missiles (ICBMs) for mobile launchers are still produced there.

The hundreds of inspections that took place demonstrated that, for the first time, highly intrusive inspections of very sensitive facilities could be successfully carried out in a manner that protects the legitimate interests of the inspecting and the inspected party. In many important respects, the procedures stipulated in the INF treaty became the model for inspection regimes in later agreements, such as the Conventional Armed Forces in Europe (CFE) Treaty and the START accords.

The INF treaty is of unlimited duration, so the legal obligations remain in force for the US and the 12 successor states of the former Soviet Union (the three Baltic states were not considered parties to the accord). The parties now rely on national technical means (NTM) and notifications for monitoring and verification. The Special Verification Commission (SVC) will continue to meet as required to resolve any questions relating to compliance and to agree on such measures as may be necessary to improve the viability and effectiveness of the agreement.

The START Treaty

Inspections continue under the START treaty. In general, these are more intrusive and elaborate than those under the INF accord. Given that the latter eliminated an entire class of weapon systems, inspectors only had to confirm the absence of these systems—at least for the period after 1991. START, though, reduces and otherwise constrains a variety of strategic weapon systems. Monitoring the quantity and technical characteristics of hardware is a complex undertaking.

The treaty provides for 12 distinct types of inspections.[8] At present, each side is conducting approximately 25–30 inspections per year, comprising: up to 15 Data Update Inspections at declared facilities to monitor the status of treaty-limited items; up to 10 Re-entry Vehicle Inspections to verify that the number of re-entry vehicles on deployed ballistic missiles does not exceed the amount allowed for that type of missile; up to three Formerly Declared Facility Inspections to determine that closed-out facilities remain consistent with treaty requirements; as well as other types of occasional inspections. In addition, a significant number of notifications are exchanged on a daily basis between the parties' Nuclear Risk Reduction Centers in accordance with treaty requirements.

Because the treaty specifies a numerical limit on the number of ICBMs for mobile launchers of ICBMs, as many as 30 US personnel are allowed to conduct Perimeter and Portal Continuous Monitoring (PPCM) at the Votkinsk Machine Building Plant, where final assembly of such missiles takes place.[9] Whereas the task of INF monitors was to confirm that Intermediate-Range Ballistic Missiles (IRBMs) were not leaving the plant, START monitors have the simpler job of counting the number of ICBMs for mobile launchers of ICBMs. The treaty gives the four successor states of the former Soviet Union the right to carry out a similar function at the Thiokol Plant in Promontory, Utah, where the first stage of the Peacekeeper (MX) missile was produced. This right has not been exercised and the aforementioned production has ended.

Compliance with the treaty appears to have been very good. Yet, as might be expected under a verification regime as complex as START, Russia and the US have different views on how the other side has implemented certain treaty requirements. They continue to pursue these matters in the Joint Compliance and Inspection Commission (JCIC), which generally meets twice a year in Geneva.[10] Discussions

START I aggregate numbers of strategic offensive arms

Country	Cat.1[1]	Cat.2[2]	Cat.3[3]	Cat.4[4]
Belarus	0	0	0	0
Kazakhstan	0	0	0	0
Russia	1,198	5,858	5,232	3,563.6
Ukraine	13	130	130	52.65
FSU total	1,211	5,988	5,362	3,616.25
US	1,299	7,013	5,695	1,795.2

NOTES 1 Deployed ICBMs and their associated launchers, deployed SLBMs and their associated launchers, and deployed heavy bombers; 2 Warheads attributed to deployed ICBMs, deployed SLBMs and deployed heavy bombers; 3 Warheads attributed to deployed ICBMs and deployed SLBMs; 4 Throw-weight of deployed ICBMs and deployed SLBMs (MT). Levels to be attained by 5 December 2001 in the four categories are 1,600, 6,000, 4,900 and 3,600, respectively.

SOURCE US Department of State, Fact Sheet, 1 October 2001.

in the JCIC and the SVC are classified and thus further analysis of specific compliance issues is not possible here.

Progress made by the sides in reducing their strategic offensive forces as required by the treaty is illustrated in the table above. The treaty requires that reductions be completed by 5 December 2001, when the seven-year reduction period, which began at entry into force on 5 December 1994, comes to an end. As shown in the table, by 31 July 2001 the two sides had already reduced below required levels in certain categories. It is important to note, however, that, although all nuclear warheads were removed from Ukraine several years ago, certain systems (ICBM launchers and heavy bomber airframes) remain accountable under the treaty. This is due to the fact that START I limits, for example, 'deployed missiles and their associated launchers'. Under the counting rules in Article III, a deployed launcher is considered to contain a deployed ICBM until it is eliminated according to agreed procedures. What are actually empty launchers are thus counted against the deployed missile and warhead aggregates until eliminated (analogous provisions apply to heavy bomber airframes). These eliminations are proceeding under the Co-operative Threat Reduction Program between Ukraine and the US.

START II

Russia and the US signed START II on 3 January 1993. It reduces by two-thirds the strategic nuclear arms of the two countries allowed before START I[11] came into effect, and contains important qualitative stabilising features. START II, as written, cannot exist without START I, since it relies heavily on the latter's definitions, counting rules and verification. It does, however, provide for additional types of on-site inspection to the 12 noted above.

The parties signed a protocol to START II on 26 September 1997, extending the implementation period to 31 December 2007 in order to grant Russia extra time to carry out the reductions. A subsequent joint statement and an exchange of letters between them in June 1992 further clarified the parties' undertakings.[12] The US Senate gave its advice and consent to ratification of the basic treaty on 26 January 1996. The protocol, however, has not been submitted to the Senate. Russia ratified the treaty and the protocol in April 2000, but placed conditions on entry into force. Russia would only exchange its instruments of ratification with the US if Washington ratified not just START II and its protocol, but also a set of agreements signed by the Russian and US foreign ministers in New York on 26 September 1997. These are: a Memorandum of Understanding, which would define the successor states to the former Soviet Union for the purposes of the 1974 US–Soviet Anti-Ballistic Missile (ABM) Treaty; an agreement on confidence-building measures related to theatre missile defence; and two 'demarcation agreements' that address the problem of how to distinguish between theatre and strategic ballistic missile defence systems. These conditions are unacceptable to the US and, as a result, START II faces an uncertain future.

START III and beyond

At the Helsinki summit in 1997, former US and Russian Presidents Bill Clinton and Boris Yeltsin agreed an ambitious framework for a possible START III treaty. It included an understanding on the establishment, by 31 December 2007, of lower aggregate levels of deployed strategic nuclear warheads for each side, to between 2,000 and 2,500. The framework also called for 'measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads and any other jointly agreed technical and organisational measures, to

promote the irreversibility of deep reductions including prevention of a rapid increase in the number of warheads'. Consequently, the new framework would move beyond monitoring nuclear warheads actually deployed on strategic missiles and heavy bombers, as under START I. It would now deal with non-deployed warheads—the warheads by themselves being smaller items that are more difficult to monitor. The sides also agreed to consider issues related to transparency in nuclear materials and to explore, as separate matters, possible measures pertaining to nuclear long-range sea-launched cruise missiles and tactical nuclear systems, including appropriate confidence-building and transparency initiatives.[13] Scientists in several countries are tackling the formidable verification challenges posed by such possibilities. It is clear that, as deployed systems are reduced, non-deployed systems and the fissile material removed from them become increasingly important. This is not only because of the verification requirements of any agreements themselves, but also because of nonproliferation and environmental concerns. It would be premature to render a judgement on the extent to which the technical and political problems can be solved, but the significance is obvious. It should be noted that, regardless of the fate of START II and a possible START III, these matters will have to be addressed.

The world community demands that continuing progress be made in this area. The consensus document issued at the end of the 2000 Nuclear Non-Proliferation Treaty (NPT) Review Conference contains 'an unequivocal undertaking by the nuclear-weapon States to accomplish the total elimination of their nuclear arsenals leading to nuclear disarmament to which all States Parties are committed under Article VI'.[14] Some observers considered this language to be the strongest commitment ever made by the five nuclear weapon states, although substantively it differs little from previous formulations. The document also urged the early entry into force and full implementation of START II and the conclusion of START III as soon as possible, in addition to addressing the ABM treaty.

Meanwhile, a reduced role for nuclear weapons was apparent in the new Strategic Concept of the North Atlantic Treaty Organisation (NATO) released in April 1999. It noted that the circumstances in which any use of nuclear weapons might be contemplated are 'extremely remote'. NATO drew attention to: its dramatic reduction in sub-strategic forces, including the elimination of all nuclear artillery and ground-

launched short-range nuclear missiles; a significant relaxation of the readiness criteria for forces with nuclear roles; and the termination of standing peacetime nuclear contingency plans.[15] Following up on these points, the Alliance called, in December 2000, for greater transparency and openness with Russia on nuclear weapon and safety issues. Specific areas identified by NATO include an enhanced dialogue on matters related to nuclear forces and their state of readiness, plus exchanges of information on the safety features of nuclear weapons and on US and Russian sub-strategic forces. The mechanism for such an enhanced dialogue would be the NATO–Russia Permanent Joint Council.[16] One benefit of these measures would be to enhance transparency about, and knowledge of, the size of US and Russian sub-strategic stockpiles. This could help to clarify uncertainties regarding implementation of the 1991–92 Presidential Nuclear Initiatives (see below).

For its part, Russia called for reductions in strategic nuclear arms even below START III levels. However, the new Russian Military Doctrine, promulgated in January 2000 by the government of Russian President Vladimir Putin, also used a new formulation in describing the circumstances in which Russia asserted the right to use nuclear weapons. This was widely interpreted as placing greater reliance on tactical nuclear weapons as a means of compensating for the deterioration of the country's conventional forces.[17]

An interesting question concerns the extent to which further progress will take the form of legally binding agreements, less formal parallel unilateral actions or even independent moves by individual states. The Bush administration has shown a strong interest in less formal means of making nuclear reductions and of enhancing international security. In a speech on 1 May 2001, Bush suggested that the US would 'lead by example' and stated a goal of moving quickly to reduce nuclear forces.[18] The range of possibilities was highlighted by US Secretary of Defense Donald Rumsfeld, when he told NATO's North Atlantic Council in June 2001 that: 'Moving to lower numbers could be done in a number of ways, including reciprocal approaches, arms control, unilateral initiatives—or some combination'.[19]

The final document of the 2000 NPT Review Conference addressed these issues in general terms and appeared to want it both ways. On the one hand, the conference endorsed the principle of 'irreversibility' as applied to nuclear arms control measures and called for 'the further development of the verification capabilities that will

be required to provide assurance of compliance with nuclear disarmament agreements . . .'. On the other hand, it endorsed 'further efforts by the nuclear-weapon states to reduce their nuclear arsenals unilaterally'.[20]

A useful precedent exists in the Presidential Nuclear Initiatives taken by former US President George Bush, former Soviet President Mikhail Gorbachev and former Russian President Boris Yeltsin in 1991–92.[21] These led, for example, to the withdrawal of large numbers of tactical nuclear weapons from Europe, the cancellation of certain nuclear weapon programmes and changes in the operational practices of Russia and the US.[22] These initiatives were achieved quickly and were widely acclaimed. Yet, because they were unilateral actions without verification measures, questions have been raised regarding the extent to which Russia has implemented some of them. The possible movement of nuclear weapons into the Kaliningrad enclave on the Baltic is a case in point. Although INF inspections (while they were being conducted), or inspections under the CFE treaty, might help to clarify such a situation, these regimes were not designed to deal with unilateral commitments.

The verification aspects are complicated. Less formal arrangements do not generally contain the strict verification requirements that were thought necessary at the formal level. But they offer more flexibility and could be achieved much faster than formal treaties, which tend to involve long and extensive negotiations and ratification procedures. It may also be true that the greater trust and openness that has accompanied the end of the Cold War makes more rigorous verification no longer necessary. One could argue, though, that uncertainty, or outright cheating, will increase when levels begin to get very low, and, therefore, that there is even more need for effective verification. Perhaps the creative use of transparency—through declarations, data exchanges, periodic visits and a variety of *ad hoc* arrangements—could combine the advantages of both approaches.

Another uncertainty regarding the future of verification regimes arises from indications that Russia might pull out of existing arrangements if the US withdraws from the ABM treaty. In an interview with the German newspaper *Welt am Sonntag* on 11 June 2000, Putin stated that 'destruction of that Treaty would make further reduction of strategic offensive arms under START I impossible . . . The START II Treaty could not enter into force and it would become impossible to conclude the START III Treaty'. More recently, in an interview with US journalists in Moscow,

Putin is reported to have said that both START I and II would be negated by a US decision to build missile defences in violation of the ABM accord. He added that such a step would eliminate verification requirements, reviving an era in which Russia would hide its abilities and intentions.[23] However, in the second half of 2001, Russia appeared to be moving toward a compromise on this issue.

Disposing of highly enriched uranium

In February 1993 Russia and the US signed a bilateral agreement on the disposition of highly enriched uranium (HEU) from Russian nuclear weapons.[24] In January 1994 they signed an accord calling for the US Enrichment Corporation (USEC) to purchase, over a 20-year period, 500 metric tonnes of HEU from dismantled Russian nuclear weapons. This would be enough material for approximately 20,000 nuclear weapons, using International Atomic Energy Agency (IAEA) determinations of the minimum amount of fissionable material needed to produce a nuclear weapon. The HEU is diluted in Russia to low-enriched uranium (LEU), and then delivered to the US for use in the manufacture of fuel for commercial reactors. The fuel prepared from the more than 10,000 metric tonnes of LEU could generate a quantity of electricity equal to that used by the entire world for almost three years.

Verification is achieved through 'transparency rights', assuring the US that the Russian LEU is derived from HEU and assuring Russia that the US is not using the LEU to produce weapons-grade uranium. The US Department of Energy (DOE) and the Russian Ministry of Atomic Energy (MINATOM) worked out these transparency rights. The DOE maintains a presence at Novouralsk, Russia, where the HEU is blended down to LEU. Up to four US monitors are afforded daily access to the facilities and to material related to the conversion process. Other monitors are allowed access over a five-day period up to six times a year to the three other Russian plants involved in this activity (Mayak, Seversk and Zelenogorsk). At each facility, a low-resolution gamma spectrometer is used to determine the level of enrichment of HEU, which arrives from Russian dismantlement facilities in sealed containers.[25] Although these monitoring arrangements are impressive, confidence would be increased if the monitors were permitted to begin the tracking process directly at the dismantlement sites, since this would provide greater confidence in the provenance of the HEU.

For their part, the Russians have a permanent presence at the gaseous diffusion plant at Portsmouth, Ohio, where the LEU has been sent since shipments began in 1995. They also make periodic visits to the five US facilities where the LEU is fabricated into fuel assemblies and review documentation on the distribution of the LEU to commercial power plants.[26]

Unforeseen economic issues have complicated the HEU purchase programme. The USEC, a government agency when the original agreement was signed, was privatised in 1998, introducing commercial considerations into the equation that are not necessarily consistent with US national security or Russian economic interests. Before privatisation, the USEC entered into a five-year fixed-price contract with Russia under which its LEU would be bought at a price below its resale value. With the expiration of the original contract in 2001 and changes in market conditions, the USEC has reportedly pressed for even lower prices and sought agreement to sell some commercial nuclear fuel along with the LEU. Russia has reportedly sought to bring the new prices closer to market levels. It is important to resolve this issue, since the flow of fuel from Russian nuclear weapons has become essential to the 100 US nuclear power plants that supply more than 20 percent of US electricity. In addition, the cash flow from the programme is very important to nuclear nonproliferation efforts in Russia. Possible solutions could include government subsidies to the USEC or the involvement of additional US partners to promote competition.[27]

The Trilateral Initiative

A verification initiative that is potentially important whether or not START III is ever negotiated is the Trilateral Initiative, launched in 1996.[28] The initiative involves three parties—Russia, the US and the IAEA—in examining the technical, legal and financial implications of Russia and the US going beyond their voluntary offer agreements with the Agency and verifying the status of fissile material removed from dismantled nuclear weapons. Under this arrangement, the IAEA would verify that such material was not returned to weapons use and that other fissile material declared surplus to defence programmes was not diverted. Russia and the US would submit such material to IAEA verification, and procedures and methods would be devised to allow the Agency to draw credible and independent conclusions

about whether or not the verification objectives had been met. Russia has already declared that 40 percent of the plutonium removed from its nuclear weapons will be stored under IAEA supervision at the Mayak facility in Ozersk, Russia. The US storage site will be at the K-area Material Storage Facility at the Savannah River site in South Carolina. Under its Voluntary Offer Agreement with the IAEA the US already has some such materials under safeguards.[29]

Any arrangement devised for such a verification scheme would have to take into account the fact that Article I of the NPT requires that the Agency does not gain access to information relating to the design or manufacture of nuclear weapons—especially because it uses inspectors from non-nuclear weapon states. The two countries may also have their own concerns about revealing sensitive information and about not violating their nonproliferation commitments under Article I of the NPT. Good progress has been made on finding possible technical solutions to the problem. The approach that is emerging involves the use of gamma spectrometry to detect the presence of plutonium, high-resolution gamma spectrometry to detect the presence of weapons-grade plutonium, and neutron multiplicity counters to determine the presence of plutonium of at least an agreed threshold mass. All of this must be carried out without revealing attributes that could contain weapons design information. A key element of this approach is 'information barriers': a computer uses algorithms that evaluate the validity of the data, but the result is displayed only in a yes/no format. More detailed information regarding the sample does not leave the 'black box'. In addition the information is not stored in the computer (or elsewhere) and is automatically purged after the authentication process is complete. Technical requirements for the system have been provisionally agreed. US scientists have demonstrated their approach to Russian and IAEA experts at the Los Alamos National Laboratory in California. Russian scientists discussed a similar approach of their own at a meeting in Vienna, Austria, in January 2001.[30]

Substantial progress has been made towards finalising a Model Verification Agreement as the basis for bilateral agreements between the Agency and each country. A draft will possibly be submitted to the IAEA Board of Governors in 2002. The question of who will pay for the verification is one that still needs to be resolved. The consensus final document of the 2000 NPT Review Conference

underlined the importance of the Trilateral Initiative and called for its completion and the implementation of its conclusions.[31]

The plutonium disposition agreement

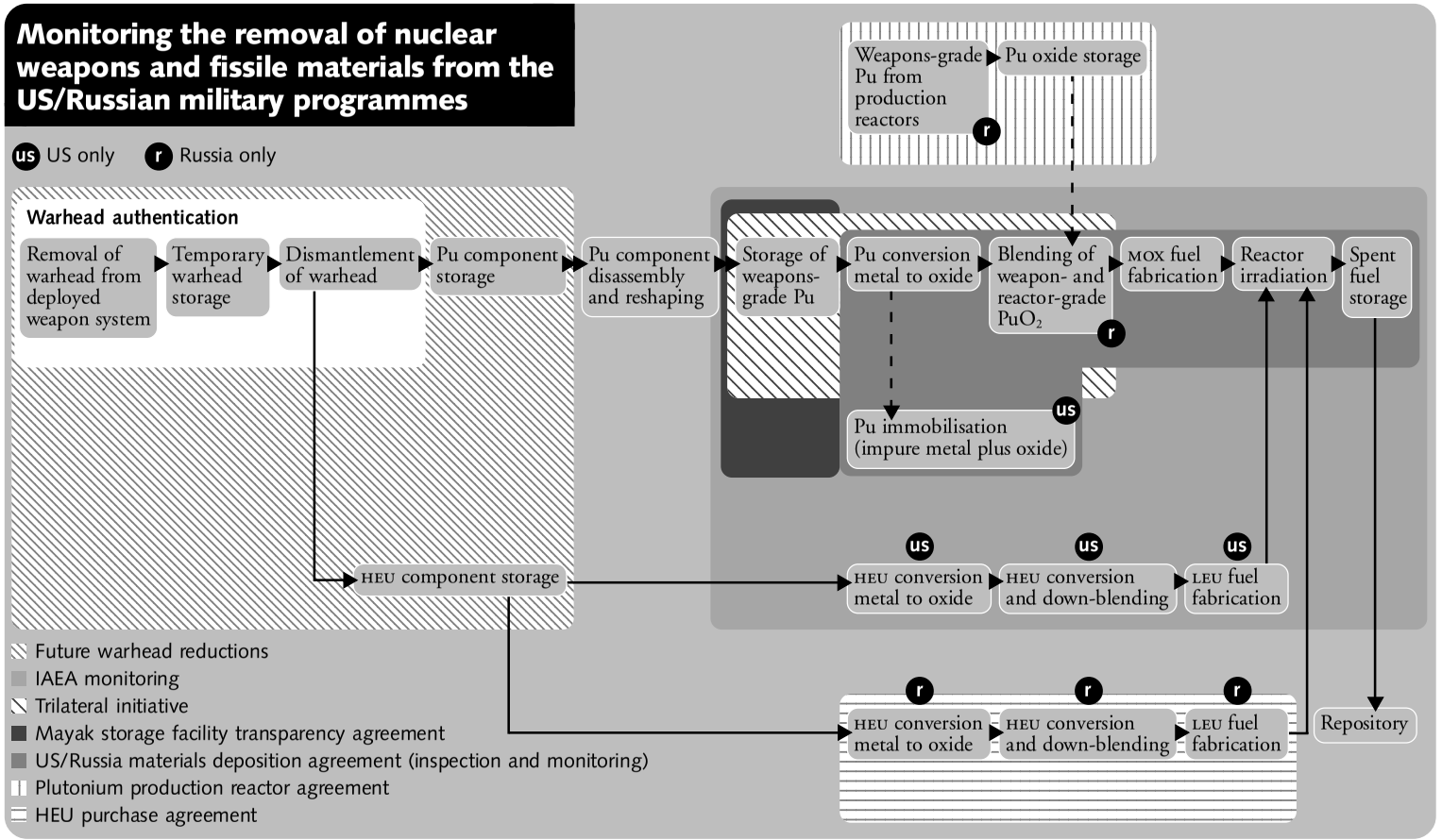
A further development occurred on 1 September 2000 when the United States–Russian Federation Plutonium Management and Disposition Agreement was signed and provisionally applied. Under this deal, each side will dispose of 34 metric tonnes of plutonium withdrawn from their weapons programmes, either by irradiating it as fuel in reactors or by immobilising it with high-level radioactive waste, rendering it suitable for geologic disposal. The agreement sets 2007 as the target date to begin operating the new facilities needed to convert and fabricate two metric tonnes of plutonium per year into mixed-oxide fuel (MOX) in both countries and to immobilise some of the US plutonium. The procedures in the agreement will ensure that this plutonium is never used for military purposes. Both the processes and the end products will be monitored, raising a number of technical problems.

To ensure that there is funding for Russia's involvement, G-8 leaders at their 2000 summit in Okinawa, Japan, called for the development of an international financing plan.[32] Since 1992 the US has allocated more than US$5 billion to Kazakhstan, Russia and Ukraine to facilitate nuclear disarmament and nonproliferation, and other countries have also made significant contributions. The Bush administration's proposed budget for fiscal year 2002 contained cuts of about US$100 million in areas that would have an impact on nonproliferation initiatives in Russia. But the possibility of changes in the budget, as well as of re-allocating existing funds, make the situation fluid.

The chart overleaf illustrates the process envisioned for monitoring the removal of nuclear weapons and fissile material from US and Russian military programmes.[33]

Future work and unsolved problems

In addition to the programmes discussed above, there remains the issue of monitoring nuclear reductions and disarmament. At present, monitoring involves only Russia and the US. Eventually, however, one could expect all states with nuclear weapons to be engaged in the process. In the INF and START agreements, the former


Monitoring the removal of nuclear weapons and fissile materials from the US/Russian military programmes
US US only
r Russia only
Warhead authentication
Removal of warhead from deployed weapon system
Temporary warhead storage
Dismantlement of warhead
Pu component storage
Pu component disassembly and reshaping
Storage of weapons-grade Pu
Weapons-grade Pu from production reactors
Pu oxide storage
Pu conversion metal to oxide
Blending of weapon- and reactor-grade PuO2
MOX fuel fabrication
Reactor irradiation
Spent fuel storage
Pu immobilisation (impure metal plus oxide)
HEU component storage
HEU conversion metal to oxide
HEU conversion and down-blending
LEU fuel fabrication
HEU conversion metal to oxide
HEU conversion and down-blending
LEU fuel fabrication
Repository
Future warhead reductions
IAEA monitoring
Trilateral initiative
Mayak storage facility transparency agreement
US/Russia materials deposition agreement (inspection and monitoring)
Plutonium production reactor agreement
HEU purchase agreement

Soviet Union and the US developed quite intrusive and quite effective techniques for monitoring rather large and well-defined military objects, such as ballistic and cruise missiles and their launchers, deployed warheads and heavy bombers. In addition to further reductions in these traditional weapon systems, there is a need to begin dealing with smaller items related to nuclear weapons, including non-deployed warheads separated from their delivery vehicles and various forms of fissile material. The fact that such materials give off heat, gamma rays and neutrons allows, in principle, for their detection and characterisation. Yet a host of technical and political problems immediately arise. One problem is that neither the US nor Russia (nor, presumably, any other nuclear weapon state) currently has a dismantlement facility that could be dedicated exclusively to operations monitored by other states or by the IAEA. This means that dismantlement might have to be conducted at a facility that was simultaneously engaged in sensitive non-treaty operations, thereby greatly complicating or restricting the monitoring activities that were feasible. In the US, the most likely facility would be the Pantex plant in Texas. Russia would presumably designate one of its plants used for weapons assembly and disassembly (Avangard, Penza-19, Zlatoust-36 or Sverdlovsk-45).[34]

A comprehensive solution will require effective methods to monitor storage and dismantlement facilities, the processes by which fissile material is changed into other forms and disposed of, and the chain of custody during changes in location. Tags and seals, PPCM, remote sensing, remote monitoring, on-site inspection, and various types of data exchange and notification can all play a part. Key objectives of such monitoring would be: to provide a high level of confidence that declared warheads were being dismantled; to increase accountability in relation to fissile material; to prevent classified data from being compromised; to conduct activities at a reasonable cost and with a minimal impact on facility operations; to meet facility safety and security requirements; and to minimise the need for the presence of inspectors.

As discussed above, work is proceeding in many of these areas.[35] A major issue will be whether states will be able to grant sufficient verification access to sensitive facilities to enable other countries to have confidence that what is taking place is as agreed. Another issue is who will do the verifying or monitoring—and whether and to what extent a verification regime might be established? Depending on the

verification goals, should it be a bilateral, multilateral or an international organisation? Finding the proper balance between 'trust' and 'verify' will have a major impact on how these problems are resolved.

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Endnotes

[1] The views expressed are those of the author and do not necessarily reflect US government policy.
[2] 'Deadlocked and waiting at the UN Conference on Disarmament—an interview with Ambassador Robert T. Grey, Jr.', *Arms Control Today,* December 2000, pp. 3–8.
[3] *Fissile Material Cutoff Treaty,* US Department of State Fact Sheet, 29 June 1999.
[4] Zachary S. Davis, 'The spread of nuclear-weapon-free zones: building a new nuclear bargain', *Arms Control Today,* February 1996, pp. 15–19.
[5] 'Mongolia's nuclear-weapon-free status', available at www.opanal.org.
[6] 'Disarmament Resolutions and Decisions of the Fifty-Fifth Session of the United Nations General Assembly', UN Department for Disarmament Affairs, October 2000, pp. 7–9, 34–37, 57–59, 72–73 and 105–106.
[7] Office of Public Affairs, Defense Threat Reduction Agency, Washington, DC.
[8] These are explained in Annette Schaper, 'Verifying nuclear arms control and disarmament', *Verification Yearbook 2000,* Verification Research, Training and Information Centre (VERTIC), London, 2000, p. 60.
[9] Whereas in the INF treaty, PPCM is considered a form of on-site inspection, in the START accord, PPCM is a system of monitoring separate from the 12 types of on-site inspection in the treaty.
[10] US Department of State, *Annual Report to Congress on Activities in Arms Control, Nonproliferation, and Disarmament*, Washington, DC, 2000, p. 44.
[11] START became known as START I only after START II was negotiated.
[12] *Arms Control-Related Material from the Summit Meeting between US President Bush and Russian Federation President Yeltsin*, Washington, DC, 16–17 June 1992, US Department of State Fact Sheets.
[13] *Joint Statement on Parameters on Future Reductions in Nuclear Forces*, White House Press Release, 21 March 1997.
[14] '2000 NPT Review Conference Final Document', *Arms Control Today,* June 2000, p. 31.
[15] *The Alliance's Strategic Concept*, NATO Press Release NAC-S(99)65, 24 April 1999, p. 25.
[16] *Report on Options for Confidence and Security Building Measures (CSBMs), Verification, Non-Proliferation, Arms Control and Disarmament*, NATO Press Communiqué M-NAC-2(2000)121, 14 December 2000.
[17] 'Russian Federation military doctrine', *Nezavisimaya Gazeta,* Moscow, 22 April 2000. For English translation, see 'Russia's military doctrine', *Arms Control Today*, May 2000.
[18] *Remarks by the President to Students and Faculty at National Defense University,* White House Press Release, 1 May 2001.
[19] Donald H. Rumsfeld, Prepared Remarks to NATO North Atlantic Council, 7 June 2001.
[20] See endnote 14.
[21] *Presidential Initiative on Nuclear Arms*, White House Fact Sheet, 27 September 1991; President Gorbachev's Reply to President Bush's Nuclear Initiative, Soviet television, Moscow, 5 October 1991. See also Fact Sheet, Office of the White House Press Secretary, 27 September 1991 and Fact Sheet, Arms Control Association, Washington, DC, December 1991.
[22] Note that France and the UK also made significant unilateral reductions in their nuclear forces during the 1990s (see endnote 13, pp. 6–9).
[23] Patrick E. Tyler, 'Putin says Russia would counter US shield', *New York Times,* 19 June 2001, p. 1.
[24] 'Agreement Between the Government of the United States of America and the Government of Russia Concerning the Disposition of Highly Enriched Uranium Extracted from Nuclear Weapons', Washington, DC, 18 February 1993.
[25] *Megatons to Megawatts*, US Department of Energy, UCRL-TB-133506, July 1999. See also James E. Doyle, 'New Requirements for Monitoring Nuclear Materials', Los Alamos National Laboratory, LA-UR-01-2037.
[26] The five facilities are Westinghouse Nuclear Fuel, Columbia, South Carolina; Global Nuclear-Fuel

Americas, Wilmington, North Carolina; Framatome Cogema, Lynchburg, Virginia; ABB Combustion Engineering, Hematite, Missouri; Siemens Power Corporation, Richland, Washington.

[27] Thomas L. Neff, 'Decision time for the HEU deal: US security vs private interests', *Arms Control Today,* June 2001, pp. 12–17. See also 'Clinton protects Russian HEU deal assets', *Arms Control Today,* July–August 2000, pp. 34–36, and the response by the United States Enrichment Corporation in *Arms Control Today,* September 2000, p. 35.

[28] *IAEA Verification of Weapon-Origin Fissile Material in Russia and the United States,* IAEA Press Release, 19 September 2000. See also *The Control of Nuclear Proliferation: Future Challenges,* address by Mohamed ElBaradei to the Swedish Institute of International Affairs, 23 April 1998.

[29] ElBaradei (see endnote 14).

[30] Doyle, pp. 16–17.

[31] See endnote 14, p. 31.

[32] See endnote 10, p. 4.

[33] Chart courtesy of James E. Doyle, Applied Monitoring and Transparency Laboratory, Los Alamos National Laboratory. It reflects a notional view of process steps that may be monitored under the proposed agreements based on current open source descriptions. Some of these agreements are under negotiation. The process steps subject to monitoring may change if and when these agreements are finalised.

[34] Doyle, p. 6.

[35] More detailed discussions of these issues are found in *Confidence, Security and Verification: the challenge of global nuclear weapons arms control,* United Kingdom Atomic Weapons Establishment (Aldermaston, UK), April 2000; Kenneth N. Luongo, 'The uncertain future of US–Russian cooperative nuclear security', *Arms Control Today,* January–February 2001; Matthew Bunn, *The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Material,* Carnegie Endowment for International Peace, March 2000; James W. Tape, *How to Deal With Monitoring and Verification Challenges in a World with Low Numbers of Weapons and Large Stocks of Nuclear Material?,* Los Alamos National Laboratory, LA-UR-00-5543; James E. Doyle, *New Requirements for Monitoring Nuclear Materials,* Los Alamos National Laboratory, LA-UR-01-2037.