PRELIMINARY REPORT

VERIFICATION MATTERS

Laying the Foundations

Verifying the transition to low levels of nuclear weapons

Patricia M. Lewis

April 1997

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Preliminary Report

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Written by Patricia M. Lewis,
Executive Director VERTIC

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VERIFICATION TECHNOLOGY INFORMATION CENTRE
Carrara House, 20 Embankment Place, London WC2N 6NN
Tel: +44 (0)171 925 0867
Fax: +44 (0)171 925 0861
E-mail: info@vertic.org

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Executive Summary

- This paper discusses the approach to verifying the transition to low-levels of nuclear weapons, with a view to laying the foundations to move on to the transition to zero nuclear weapons. Low-levels are defined as being in the hundreds per nuclear weapon state (NWS) rather than the thousands that now exist in the US and Russia.
- To reduce nuclear forces dramatically, and eventually eliminate them, puts the world at risk to a number of possibilities. How sure can we be that all nuclear weapons have been accounted for and destroyed? How sure can we be that the verification system will be able to detect any clandestine nuclear weapons programme in time for it to be stopped? Can a stringent verification regime give us the security we require?
- There are risks whatever course of action is decided on.
- There can be no such thing as 100 per cent certainty when verifying the numbers of nuclear weapons. Verification provides a system for risk-reduction and a system for deterring cheating.
- The process of reducing the large numbers of nuclear weapons that still exist in the world will rely on a system of verification that has its cornerstone in the verification regimes of the INF Treaty, and START 1 and 2.
- For reductions to low-levels per se, the verification regime need not be so stringent but if the intention is to go to zero then the verification regime needs to be much more more watertight. The verification regime established in this period will be the foundations of the verification regime required for the transition to zero and beyond. Verification should be seen as an investment in the future if we are eventually to go to zero.
- Enthusiasm for transparency and verification now is a litmus test for enthusiasm for disarmament in the future.
- Verification could provide the confidence needed to take the final steps and eliminate nuclear weapons. Verification cannot provide 100 per cent certainty, nothing can, but after a period of several years of monitoring and inspections for the transition to low-levels of nuclear weapons, a pattern of knowledge would be built-up, so that confidence in the process would be high. Once that process includes all the nuclear weapon states and any *de facto* nuclear weapon states, then further reductions to zero nuclear weapons, with a high degree of confidence, would be possible.

Introduction

This paper is a preliminary report of what will be the first in a series produced by the Verification Technology Information Centre (VERTIC) which aims to investigate the possibility of verifying a world without nuclear weapons. The series is divided into four. In the first place, the approach to verifying the transition to low-levels of nuclear weapons is discussed, with a view to laying the foundations to move on to the transition to zero nuclear weapons. We define low-levels as being in the hundreds per nuclear weapon state (NWS) rather than the thousands that now exist in the US and Russia. For the sake of argument this figure will probably be in the region of 500 or less, rather than between 500 and 1,000, although if proportional reductions are made, these numbers will probably not be equal unless zero is reached.

For reductions to low-levels per se, the verification regime need not be so stringent but if the intention is to go to zero then the verification regime needs to be much more more watertight. So, although a highly intrusive verification regime may be considered too expensive and intrusive for merely going to lower levels, it should be seen as an investment in the future if we are to go to zero — enthusiasm for verification now is a litmus test for enthusiasm for disarmament in the future.

The second paper in this series will look at the opportunities and pitfalls in reducing from low levels to a global zero. The third and fourth papers will look at the long-term problems of verifying a world free of nuclear weapons, how to maintain long-term enthusiasm and funding for a comprehensive and expensive verification regime and how to provide back-up in case the verification regime is not strong enough to deter break-out from a treaty banning nuclear weapons world-wide.

From 1968, when the Non-Proliferation Treaty (NPT) was negotiated, there has been highs and lulls in the process of disarmament. However, since the INF Treaty in 1987, there have been steady reductions in the numbers of nuclear weapons — through both agreed and unilateral measures. The Chemical Weapons Convention is to enter into force at the end of April 1997, there are procedures in place for strengthening compliance with the 1972 Biological Weapons Convention and the Comprehensive Test Ban Treaty was agreed in 1996. The next stage for the Strategic Arms Reduction Talks (START 3) looks likely to commence — a process which aims to reduce US and Russia's strategic arsenals to approximately 2,000 – 2,500 each.

Since the indefinite extension of the NPT in 1995, and the simultaneous adoption of the Principles and Objectives Document for the Treaty which reiterated the commitment to eliminate nuclear weapons, there have been numerous calls for the process of complete nuclear disarmament to begin[1]. However, there is a great deal of institutional reluctance

[1] *Most notable was the Canberra Commission on the Elimination of Nuclear Weapons which produced its report in August 1996 and concluded that the threats from nuclear proliferation and terrorism are growing and that "immediate and determined efforts need to be made to rid the world of nuclear weapons and the threat they pose to it." The Commission put forward a series of "practical, realistic and mutually reinforcing steps" that could be taken immediately. These include: taking nuclear forces off alert; removal of warheads from delivery vehicles, ending deployment of non-strategic weapons; further negotiations to reduce US and Russian nuclear arsenals; and no-first use and no use against non-nuclear weapons states' undertakings. One of the Commission, General George Lee Butler, called for the abolition of nuclear weapons at the US National Press Club in December. His stance was supported by other generals and admirals from around the world. See George Lee Butler, "Time to End the Age of Nukes", The Bulletin of the Atomic Scientists, Vol.*

to actually begin such a process, despite the international commitment on paper. This is in part due to the perceived benefits of nuclear weapons (deterrence, power, status) and in part due to the fear of change and the new set of risks that the world may face as a result[2]. In addition, whilst there is a great deal of opposition to nuclear weapons in the military, there are also institutional forces within the military that work against deep cuts in the nuclear arsenal (i.e. below about 2,000 warheads)[3].

There are risks whatever course of action is decided on.

To leave nuclear forces at high levels leaves the risk of accidental launches and explosions high. Such inaction may increase the risk of proliferation over a long period because non-nuclear weapon states (NNWS) see that the nuclear weapons states (NWS) view nuclear weapons as essential for security, whatever the political circumstances. It would lessen the degree of trust between the NWS and the NNWS because the NWS would be continuing to fail to meet their obligations under the NPT. Deciding not to reduce nuclear weapons dramatically, with a view to eventual elimination, begs the question — for how long do those who advocate such inaction think that nuclear weapons will be wanted? Do they ever see a time when the elimination of nuclear weapons could be a possibility, or do they see this as being an inevitable state of affairs, unless some new and even more destructive technology supplants the role nuclear weapons now play? Why is it that many who advocate nuclear deterrence believe it is possible to eliminate chemical and biological weapons but not nuclear weapons?

To reduce nuclear forces dramatically, and eventually eliminate them, puts the world at risk to a number of possibilities. The most important, assuming that all relevant states cooperate in the negotiations, is how sure can we be that all nuclear weapons have been accounted for and destroyed? How sure can we be that the verification system will be able to detect any clandestine nuclear weapons programme in time for it to be stopped? Can a stringent verification regime give us the security we require? Or will other back-up systems such as a UN nuclear force, or "virtual nuclear arsenals"[4], or missile defence systems[5], or other "counter-proliferation measures", be viewed as necessary? Or will the norm against nuclear weapons grow strong enough to make the preferred response to a rogue state, or organization, which attempts nuclear blackmail in an (otherwise) nuclear-weapon-free world, be an all-out conventional attack? Would the elimination of nuclear weapons so dramatically alter the power relations by loss of status for the NWS, that the world may become more unstable?

There can be no such thing as 100 per cent certainty when verifying the elimination of nuclear weapons. Verification provides a system for risk-reduction and a system for

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53 No. 2, March/April 1997, p 33. See also the reports of the Steering Committee Project on Eliminating Weapons of Mass destruction, Henry L. Stimson Centre, Washington DC, 1995-1997.

2 *See for example, Robert G. Sulak Jr. "The Case in Favor of US Nuclear Weapons", Parameters, Spring 1997, pp. 106-118.*

3 *"Military Can Meet Threat With 2,000 Nukes, But Not Less", Inside the Air Force, March 28, 1997.*

4 *Michael J. Mazarr, "Virtual Nuclear Arsenals", Survival, International Institute for Strategic Studies (Oxford University Press), Autumn 1995, pp. 7-26*

5 *In his book "The Abolition" (Picador, London, 1984) Jonathon Schell advocates missile defences as a hedge against breakout. As this book was written before the Stockholm Accord and INF Treaty when intrusive verification measures provided a realistic deterrence against cheating, Schell did not believe that verification of the abolition of nuclear weapons would be adequate. Whether this is still the case is the subject of this paper.*

deterring cheating. If set up carefully and painstakingly, verification can provide a very high level of confidence that states are abiding by their commitments and that nuclear materials are being physically protected.

It is up to the NWS and the NNWS to decide whether the elimination of nuclear weapons is worth the set of risks such a path poses and whether this set of risks is more acceptable than the set of risks posed by refusing to reduce and eliminate them. It is also up to governments to decide how much they are prepared to accept highly intrusive inspections, and how much they are prepared to spend in terms of hard cash and valuable resources to provide a high-confidence verification regime. To advocate nuclear disarmament without being prepared to accept intrusiveness and a verification bill is to just spout hot air.

This paper is termed a preliminary report because it invites comment and criticism from those who read it. VERTIC welcomes comments on, and contributions to, this report, which, if they arrive at the VERTIC office by the end of May 1997, will be taken into account when finalising the paper. Comments can arrive by e-mail, post or fax. For the relevant addresses and numbers please see the contents page.

Background

Verification[6]

Verification is a process that establishes whether all parties are complying with their obligations under an agreement. The success of any agreement depends on building an atmosphere of trust. This trust can only be maintained if all sides are aware that cheating is likely to be detected.

However, there is no such thing as 100 per cent certainty in verification. The important role of verification is to ensure that a party contemplating cheating on a treaty cannot do so without running a substantial risk of being found out. The design of verification regimes determines whether the likelihood of catching significant cheating is very high (say, 80–100 per cent) or is low (say, below 50 per cent). Generally, the more effort, money and resources put into verification, the higher the probability of detecting cheating.

The process of verification includes the collection of information relevant to obligations under arms limitation and disarmament agreements, analysis of the information, and reaching a judgement as to whether the specific terms of an agreement are being met[7].

The purpose of verification is to make it unacceptably risky for any party to cheat on an agreement. If the verification provisions of an agreement are comprehensive, then parties will be deterred from cheating because they know that they run a high risk of getting caught. This is called "verification deterrence".

In this way agreements can be "built to last" and states can develop other elements of their security framework that are based, in part, on the knowledge obtained through comprehensive verification.

Treaties

There are a number of treaties which have relevance for the elimination of nuclear weapons. Because this paper focuses on the transition to low-levels, the treaties outlined here are those which would affect this process. The obligations and verification procedures for the INF Treaty, START 1 and 2 and the CTBT, are discussed here as a way of laying the foundations for verifying a transition to low-levels of nuclear weapons in all the NWS.

The Non Proliferation Treaty (NPT)

The nuclear Non-Proliferation Treaty, negotiated between the years of 1965 and 1968, entered into force on 5 March 1970 and now has 186 member states — the significant outsiders being Israel, India and Pakistan.

Adherence to the treaty is monitored by the International Atomic Energy Agency (IAEA) in Vienna through bilateral safeguards agreements between the Agency and each member state. However, IAEA membership is not the same as NPT membership.

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[6] *Taken from Patricia M. Lewis, "Verification as Security", VERTIC Matters No 8, VERTIC, London, 1995.*
7 *"Verification in all its aspects: Study on the role of the United Nations in the field of verification", United Nations document, A/45/372, 28 August 1990.*

The treaty was severely undermined by the discovery of: (i) Iraq's nuclear weapon programme; and (ii) the suspicion over the capabilities and intentions of North Korea (DPRK) and the long refusal of North Korea to fulfil its safeguards obligations. North Korea's agreement with the USA on the freezing of the DPRK's nuclear weapons capability and the substitution of its current reactor programme with light water reactor technology has begun to ease the situation. However, the issue of on-site inspections to undeclared sites is likely to cause problems by the end of the century, when these inspections are eventually to take place.

On the plus side, the destruction of South Africa's nuclear weapons demonstrated that while it may not be possible to "disinvent" nuclear weapons, it is possible to dismantle a nuclear weapon arsenal and to verify the dismantlement of the whole programme.

Iraq's situation demonstrated deep flaws within the IAEA safeguards system — lack of resources within the IAEA, inspection criteria leading to numerous inspections of installations in Germany, Japan and Canada and a only a handful of inspections of facilities in Iraq, and the failure of the international community to promote the use of special or challenge inspections. Since the discoveryof a clandestine nuclear weapons programme in Iraq and the IAEA's detection of suspect activity in North Korea, the IAEA has had to take a long, hard look at the effectiveness of its safeguards programme.

If the IAEA is to detect undeclared, illegal activities in the future, safeguards need to be strengthened and reinforced. In 1993, the IAEA embarked on a two-year programme (called "93+2") to evaluate the technical, financial and legal aspects of a wide set of measures. They include new techniques, new types of on-site inspection and much more information to be provided by States Parties[8].

The programme was divided into two parts. Part 1 measures are those which do not require any new protocol between the IAEA and a State Party. The IAEA began to implement these in 1995. They include such improvements as: expanding a state's declaration to include a history of nuclear activities prior to verification of a state's initial report; past accounting and operating records; all activities involving nuclear materials (including R&D); no-notice inspections at strategic points; and the use of environmental monitoring techniques at strategic points. Part 2 measures do require a new protocol between the IAEA and a State Party. These measures are more contentious and include: declarations on activities relevant to nuclear activities; domestic manufacture of nuclear equipment and materials; and access for inspectors beyond strategic points at sites and to nuclear-related facilities; environmental monitoring at places other than strategic points; visa-less or multi-visa travel for inspectors; and simplified inspector designation procedures.

By early 1996, it became apparent that the passage of Part 2 measures was not going to be smooth. There were a number of concerns from states (the strongest being those from Germany and Japan) over the requirement for information on, and access, to facilities where no nuclear material is held, particularly with regard to the protection of commercially-sensitive information. There has also been a great deal of concern about the increased reporting and inspection burden on states such as Germany and Japan, which, because of their large nuclear industries are already subjected to a large number

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[8] *Suzanna van Moyland, "The IAEA's Programme "93+2"", Verification Matters No. 10, VERTIC, London, January 1997*

of inspections. It is also pointed out that the nuclear-weapon states, because they are not subjected to such safeguards, will be at a commercial advantage with fewer reporting requirements and inspections. To this end in mid-1996, a special Safeguards Committee was established to negotiate the Part 2 measures. The Committee met in July and October, and by January 1997 had achieved a great deal of agreement on the scope and implementation of the Part 2 measures. In April 1997, the final text for the additional protocol was agreed. It can now go to the Board of Governors for approval.

Increased costs should be partly offset by a reduction in frequency of on-site inspections under certain conditions and by the provision of information by States. There will be a large increase in cost-effectiveness.

At the NPT Review and Extension Conference in 1995, it was decided to extend the treaty indefinitely. Not only does the NPT commit the parties to negotiate "in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament ... under strict and effective international control", but the indefinite extension of the NPT was a result of a package deal in which States were committed to the eventual elimination of nuclear weapons.

The Principles and Objectives for Nuclear Non-Proliferation and Disarmament were adopted on 11 May 1995, at the NPT Review and Extension Conference. Of particular significance for this paper are the principles and objectives on nuclear disarmament, safeguards and peaceful uses of nuclear energy[9].

Nuclear Disarmament: The Principles and Objectives document language refers to easing of international tension, strengthening trust between States and fulfilling their undertakings with regard to nuclear disarmament. Specific objectives include an internationally and effectively verifiable Comprehensive Test Ban Treaty (CTBT) no later than 1996 (achieved, see below); early conclusion of a ban on the production of fissile materials for nuclear weapons purposes; and systematic and progressive efforts to reduce nuclear weapons globally, with the ultimate goal of elimination.

Safeguards: The document reaffirms the role of the International Atomic Energy Agency (IAEA) to verify compliance with the NPT. It specifically states that IAEA safeguards should be regularly assessed and evaluated — it does not say by whom. The document also states that decisions adopted by the IAEA Board of Governors, aimed at further strengthening the effectiveness of IAEA safeguards, should be supported and implemented, and that the IAEA's capability to detect undeclared nuclear activities should be increased. Significantly, the document recommends that fissile material, when transferred from military use to peaceful nuclear activities, be placed under safeguards in the framework of voluntary agreements in the nuclear weapon states, and that safeguards be universally applied once the complete elimination of nuclear weapons has been achieved.

Peaceful Uses: The inalienable right of States Parties to develop nuclear energy for peaceful purposes was reiterated by the Principles and Objectives document. The stress on preferential treatment to be given to non-nuclear weapon states was tempered by advocating transparency in nuclear related export controls within the framework of dialogue and cooperation among all interested States Parties. Specific reference was

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9 *Trust and Verify, special supplement, VERTIC, London, May 1995*

made to the standards of accounting, physical protection and transport of nuclear materials, and to the adequate resourcing of the IAEA to ensure that it meets its responsibilities.

Until the 1995 NPT Review and Extension Conference, the review meetings of the NPT took place once every five years. Thanks to the package of proposals adopted at the Extension Conference, the review process will now be strengthened "with a view to assuring that the purposes of the Preamble and the provisions of the Treaty are being realised". The Review Conferences shall continue to be held every five years but, from 1997, the Preparatory Committee for the Review Conference will hold a meeting in each of the three years prior to the Review Conference. Unlike previous Preparatory Committee meetings (PrepComs), the purpose of these enhanced PrepComs would be to consider principles, objectives and ways, in order to promote the full implementation of the Treaty and to make recommendations thereon to the Review Conference. The first of these meetings takes place in April 1997.

The Intermediate-range Nuclear Forces (INF) Treaty

The 1987 bilateral Intermediate-range Nuclear Forces Treaty[10] between the USA and USSR (Russia) which eliminated a class of land-based nuclear missiles (range 1,000 – 5,500 km) has a highly intrusive verification regime which has built confidence and trust in the treaty and has, in itself, been the foundations for the START agreements. The treaty eliminated a whole class of ground-launched missiles over a period of 3 years and the on-site checking has been in operation ever since. Earlier in the negotiations it looked likely that the treaty would allow for provision of 100 INF missiles on each side and the verification measures would have had to have been even more stringent for the same level of certainty. In 1987, it was agreed that the Treaty would eliminate all INF weapons and consequently, because the INF infrastructure would eventually be shut down, the verification measures could be relaxed as a result. The example of the INF Treaty negotiations demonstrates the difference between verification requirements of a treaty banning a whole class of weapons and of a treaty limiting the numbers of a class of weapons. In the case of the former, high confidence in compliance with the treaty can be obtained with routine measures, but in the case of limits (as in this paper) verification regimes have to be more stringent for the same level of certainty. If negotiations produce a verification regime which cuts corners (and most do) then a lower level of confidence in the treaty's implementation will result.

The INF Treaty verification provisions set the standard and tone for the START 1 and 2 agreements and will likely also set the pattern for any follow-on agreements — with the exception that warhead destruction will also have to be verified in the future. They are therefore worth outlining in some detail.

In the first place, the data exchanged between two sides was checked by a series of baseline on-site inspections. This process meant that both sides were clear about the starting positions, and from then on had only to monitor change. Thereafter, the withdrawal and destruction of the missiles were witnessed by inspectors from both sides, and bases which had all of their assigned missiles removed were closed-out under observation. Warheads were not affected by the INF Treaty and they are assumed to

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10 *Treaty between the United States of America and the Union of the Soviet Socialists Republics on the elimination of their Intermediate-Range and Shorter-range Missiles, December 1987.*

have returned to the national stockpiles for re-use in some form. Active bases were visited by inspectors to check the deployed numbers of deployed missiles at short notice. These bases were located in a number of countries, including some of the successor states to the Soviet Union. Separate memoranda have been signed with those countries which house such bases and are therefore subject to inspections. From mid-1988 to mid-1991, there were twenty such inspections allowed per annum, per Party, for the following five years, 15 challenge inspections were allowed and for the final three years of the treaty, ten per annum are the maximum. On the production side of INF missile verification, the US has monitored the SS-25 production facility at Votkinsk and the Russian Federation has monitored the Hercules production plant at Magna, Utah. In order to monitor that legal SS-25 production facility at Votkinsk was not hiding the production of banned SS-20's, the USA installed a portal perimeter monitoring system[11] that consisted of 25-30 personnel, an infra-red profiler, an X-ray cargo scanner[12] and a room full of computers to drive, monitor and analyse the system.

The treaty pays significant attention to the role of national technical means (NTM). In particular it contains a provision for a cooperative measure which grants the right to request open displays of road-mobile, ground-launched, ballistic missiles at operating bases. No later than six hours after such a request is received, roofs of all launcher structures are slid open and missiles and launchers moved into the open for a period of 12 hours. Each side was allowed six such requests per annum. This treaty article (Article XII) contains an interesting reference to strategic arms reductions — linking the INF treaty to a START treaty. The open display provision was in effect until either START 1 entered into force, or for no more than three years after the INF treaty became effective (START 1 did not enter into force until 1994). The article also prohibits the interference with NTM by either Party.

There have been a few problems[13] with the INF treaty but the verification regime, particularly the close collaboration between the USA and Russia which has been needed to operate the regime, has enabled these problems to be sorted out in an amicable fashion without threatening the treaty.

The Strategic Arms Reduction Treaty 1 (START 1)

The START 1 agreement, signed in 1991, was the third series of US-Soviet strategic arms reduction talks. The Strategic Arms Limitation Talks (SALT), held from 1969 to 1979, produced the 1972 SALT I Interim Agreement, the 1972 Anti-Ballistic Missile (ABM) Treaty, and the SALT II Accord.

START 1 actually reduces, in addition to setting upper limits on, the number of weapons by limiting missiles and warheads rather than limiting launchers. Both missiles

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[11] The portal perimeter monitoring system was developed at Sandia National Laboratory, USA, primarily for use in monitoring strategic arms.

[12] The installation of the X-ray cargo scanner has been fraught with difficulties. See The Arms Control Reporter 21/11/88 (403.B.713), 11/1/89 (403.B.727),9/2/90 (403.B.743) and 11/3/90 (403.B.745) and "Trust and Verify", (Bulletin of the Verification Technology Information Centre, London), Issue No. 8, March 1990

[13] For example, in 1990 Czechoslovakia reported that SS23 missiles had been deployed there since just before the signing of the INF treaty yet never declared (the same turned out to be also true for the GDR and Bulgaria) and certainly never spotted by US intelligence satellites. (Trust and Verify, the bulletin of the Verification Technology Information Centre, London Nos. 9 (April 1990) and 13 (Aug/Sept 1990)). This caused grave concern, particularly with the fuss that the USSR made over the German Pershing 1A's before the signing of the Treaty.

and bombers, referred to as strategic nuclear delivery vehicles (SNDVs), and warheads themselves are limited by the Treaty. (Nuclear gravity bombs and short-range attack missiles (SRAMs) are also limited by the Treaty). Each side agreed to reduce to the following numbers and sub-limits over the course of seven years, which was divided into three periods of three, two and two years:[14]

1600 SNDVs (ICBMs, SLBMs or nuclear-carrying heavy bombers) with 6000 warheads

4900 maximum warheads on ICBMs and SLBMs combined

54 maximum heavy ICBMs (SS-18) with 1540 maximum warheads

1100 maximum warheads on mobile missiles (SS-24 and SS-25s, potentially Midgetman, potential MX/Peacekeepers).

In addition, START 1 specifies how many warheads are counted for each type of missile or launcher (counting rules). They are as follows:

US: MX/Peacekeeper – 10; Minuteman II – 1; Minuteman III – 3; Trident I – 8; Trident II – 8; Poseidon – 10

Soviet Union (Russia): SS-11=1; SS-13=1; SS-17=4; SS-18=10; SS-19=6; SS-24=10; SS-25=1; SS-N-6=1; SS-N-8 =1; SS-N-17=1; SS-N-18=7; SS-N-20=0; SS-N-23=4

To simplify the disarmament process, each side has the option of downloading up to 1,250 warheads from up to three different missile types. Downloading is the removal of a fraction of the total number of warheads on a missile. Along with dismantling missile systems, downloading is an additional way of reducing warheads to the specified sublimits.

Mobile missiles are given special consideration in the START 1 agreement. Road-mobile missiles will be confined to a restricted area of 25 square-kilometres. These missiles may be deployed only within a 125 square-kilometre area. However, in a time of national emergency these restrictions will not apply. Rail-mobile missiles will be confined to a rail garrison, but there will be an unlimited deployment area. However, there are limits on the number of rail-mobile missiles which can be housed in sheds and garages, so that there is a counting rule of one missile per garage. Neither cruise nor ballistic missile launchers can be placed on or tethered to the ocean floor, the seabed, beds of internal waters, or the subsoil thereof. Sea-launched cruise missiles are not covered under the treaty. In a separate, politically binding agreement, each side is allowed 880 nuclear SLCMs with a range of greater than 600 kilometres. However, in September 1991, President Bush announced the withdrawal of all US nuclear Tomahawk cruise missiles from US ships and submarines and nuclear bombs aboard aircraft carriers[15]

Heavy bombers have their own constraints. Each bomber carrying nuclear gravity bombs and/or nuclear short-range attack missiles (SRAMs) counts as 1 SNDV with 1 warhead. Under START 1, a bomber is considered an ALCM carrier if it holds nuclear ALCMs with a range greater than 600 kilometres. The first 150 US ALCM carriers (B-1

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[14] *Watching START Take Off: The Verification of a Complex Arms Control Treaty, Verification Matters No 4, July 1990.*

[15] *President George Bush, "Nuclear Initiative Speech" 27 September 1991, reproduced in "Verification Report 1992: Yearbook on Arms Control and Environmental Agreements" Eds. J.B. Poole and R. Guthrie, VERTIC, London, 1992, pp.295-296.*

or B-52) count as having 10 warheads. The first 210 Soviet ALCM carriers (Bear and Blackjack bombers) count as having 8 warheads. Beyond those numbers, the ALCM carriers count as having as many warheads as actually carried and 150 US ALCM carriers may not carry more than 20 ALCMs. 210 Soviet ALCM carriers may not carry more than 12 ALCMs. Although unlimited numbers of ALCMs can be produced, they cannot be stored near bomber bases. Non-nuclear heavy bombers are not limited by the Treaty and the Backfire bombers are not limited by START 1.

Modernization of weapons is, in general, not limited. This had been an issue in the case of the SS-18; it was resolved that new models of the SS-18 could not carry any heavier payload than the existing SS-18s, including warheads. There is a restriction on heavy missiles (defined as having a throw-weight greater than or equal to that of the SS-18). Neither side can develop and deploy new types of heavy missiles or new types of missiles with more than ten warheads. Other modernization, such as improved accuracy, fuel efficiency or warheads, will not be limited.

Missiles which are follow-ons from older missiles are defined as new if their change in throw-weight is at least 21 per cent and in length 5 per cent. Such changes have to be demonstrated in flight testing over a minimum range of 11,000 km.

The START 1 verification regime includes: data exchanges — each side will provide the other with numbers and locations of treaty-limited weapons (TLIs); baseline inspections: —inspections will be held to verify the data exchanges, providing baseline figures from which to work; on-site observation of weapons elimination; continuous on-site monitoring of critical production and support facilities (perimeter portal monitoring); short-notice on-site inspection of undeclared and formerly declared operational facilities; short-notice inspections of covert, suspected activities (within agreed limits); non-interference with National Technical Means (NTMs); cooperative measures to enhance NTM (a continuation from the INF Treaty)

Parts of the verification regime were new for START 1 and parts were implemented in the INF Treaty.

There are several types of on-site inspections (OSI) which include: short-notice OSI of declared facilities; suspect-site inspections — (1) challenges to undeclared facilities (with right of refusal)and (2) challenges to declared facilities where TLIs are not supposed to be deployed (no right of refusal); OSI of production facilities; continuous monitoring of key production facilities; inspection of elimination; inspections of closing down or converting deployment and production sites; inspections of repair and storage facilities; inspections of re-entry vehicles; inspection of missile exhibitions.

START 1 entered into force at the end of 1994. The instruments of ratification from Russia, Ukraine, Belarus, Kazakstan and the USA were exchanged in Budapest on 5 December 1994.

Despite the delay of entry into force, both sides had been reducing their weapons apace. At the beginning of March 1995, the START baseline inspection period began. For the following 16 weeks US inspection teams conducted 74 inspections, consisting of 67 baseline inspections, five close-out inspections, one elimination inspection and one exhibition. From January 1995, continuous monitoring had been executed at two production facilities. By the end of 1995, following the baseline inspection period, the

US had carried out 37 inspections on CIS sites and the CIS has carried out 24 inspections on US sites. Russia had not taken up its right to continuously monitor the MX final assembly plant in Promonotory, Utah. In the second year of implementation, by the end of 1996, the US carried out 33 START on-site inspections in CIS states (24 in Russia, 2 in Kazakstan and 7 in Ukraine) and the US received a total of 27 on-site inspections.

The START inspection process has been hailed as a great success so far — as has the rate at which the weapons were dismantled. By late November 1996, the final nuclear weapon had been transported from Belarus back to Russia, so that all nuclear warheads have now left the territories of Kazakstan, Ukraine and Belarus[16].

One difficulty within the implementation process was the issue of using missile stages as parts of space launch vehicles. Such a conversion process is allowed, in a limited fashion, by the Treaty but notice must be given. In order to reconcile the difficulties, the Joint Compliance and Inspection Commission issued a joint statement (number 21) at the end of September 1995 stating the agreed terms by which conversion of rocket stages from missile to space launchers would be mutually acceptable.

By the end of 1996, the US, Russia and Ukraine declared the following strategic arsenals:

	Russia	Ukraine[17]	USA
Deployed ICBMs, SLBMs, launchers and heavy bombers	1,505	159	1,564
Warheads attributed to deployed ICBMs and SLBMs and heavy bombers	6,758	1,226	8,111

Source: Arms Control Reporter, 611.E.01, Institute for Defense and Disarmament Studies, Cambridge, MA, March 1997

The Strategic Arms Reduction Treaty 2 (START 2)

START 2 however has had a more difficult time. Although it was signed at the beginning of 1993, the Treaty has yet to enter into force. START 2 incorporates two phases of elimination, the first running concurrently with START 1 and the second due to end on 1 January 2003. The US ratified the Treaty on 26 January 1996 but, at the time of writing, the Russian Duma has yet to ratify the agreement, although the March 1997 Summit between Presidents Yeltsin and Clinton, may speed the process up (see below).

In the Treaty itself, START 2 reductions are in two phases. Phase 1 runs to 5 December 2001 and Phase 2 to 1 January 2003. By the end of Phase 1, strategic arsenals are due to be below 4,250 on both sides and by the end of Phase 2, below 3,500. Warhead sub-

16 *Arms Control Reporter, 611.B.897, September 1996, and 611.B.905, December 1996.*

17 *Although Ukraine has transferred all of the warheads back to Russia, there are still launchers, silos and sites left to dismantle. Consequently, warheads attributed to those launchers are still declared by Ukraine, even though they have gone to Russia.*

limits are: MIRVed ICBMs — 1,200(Phase 1) and 0 (Phase 2); SLBMs — 2,160(Phase 1) and 1,750(Phase 2); and Heavy ICBMs — 650(Phase 1) and 0 (Phase 2). Verification of START 2 is a direct follow-on from verification of START 1 with some additions such as observation of SS-18 silo conversion and exhibitions, and inspection of heavy bombers. Although START 2 limits the number of warheads, there are no verification provisions for warhead dismantlement — a defect likely to be rectified by START 3.

However at the March 1997 Helsinki Summit, President Clinton and President Yeltsin agreed that the date for the end of Phase 2 should be delayed (subject to Congressional and Duma approval) to the end of 2007 with warhead deactivation being delayed to the end of 2003. These new dates are linked in to START 3 agreements (see below). The United States is providing Nunn-Lugar[18] assistance to facilitate early deactivation and the elimination of strategic offensive arms in Russia. Up to the end of 1996, this assistance has totalled $239 million (out of a total of $2.458 billion for the whole Nunn-Lugar program). An additional $60 million is planned for fiscal year of 1997[19].

Perhaps the main concern for Russia is the inequality of the US and Russian status following the achievement of START 2 limits. There is a strong sense in the Duma that the treaty was negotiated very badly from Moscow's point of view. For example, there are genuine concerns over the capability of the USA to quickly upload Minuteman IIIs, Trident IIs and convert heavy bombers.

Not only has the ratification process been hampered by concerns over the Treaty terms, but also by the state of Russia's conventional forces, costs, the linkage to NATO enlargement, Anti-Ballistic Missile (ABM) Treaty demarcation negotiations and lack of political focus (due, in part, to the presidential election and to President Yeltsin's ill-health). In February 1996, the Duma established a special commission on START 2 ratification (set up by the committees on international affairs, defence, security and geopolitics). In addition, many analysts believe that because of Russia's ageing missiles and lack of finance to replace them, strategic forces may well shrink to START 2 levels or lower over the next few years. If this proves to be the case then, legislators may decide that it would be better to ratify START 2, so that the USA is similarly forced to down-size.

The Strategic Arms Reduction Talks 3 (START 3)

With the backdrop of NATO expansion, ABM Treaty demarcation difficulties and no ratification of START 2 by Russia, proposals for a START 3 have been seen as a possible way out of the impasse. In March 1997, Presidents Yeltsin and Clinton met in Helsinki and, along with resolving a number of other issues, agreed that START 3 negotiations would begin immediately after START 2 was ratified by Russia. The two presidents agreed that START 3 negotiation would cap the number of strategic warheads at 2,000 to 2,500 each and that the reduction would finish by 2007 (as the new date for START 2 reduction completion).

In addition to the agreement to begin START 3 negotiations on Russian ratification of START 2, the presidents agreed that START 3 will be the first strategic arms control

[18] *The Cooperative Threat Reduction Program emerged from legislation co-sponsored by Senators Sam Nunn and Richard Lugar in November 1991.*

[19] *Jason Ellis, "Nunn-Lugar's Mid-Life Crisis", Survival, Vol. 39, No. 1 Spring 1997, pp. 84-110.*

agreement to include measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads. The presidents also agreed that both sides will consider the issues related to transparency in nuclear materials.

The Presidents also agreed to explore possible measures relating to long-range, nuclear, sea-launched cruise missiles and tactical nuclear systems. These discussions will take place separate from, but in the context of, the START 3 negotiations

The Comprehensive Test Ban Treaty (CTBT)

The Comprehensive Test Ban Treaty, signed in 1996, commits each State Party to not carrying out any nuclear weapon test explosion or any other nuclear explosion, and to prohibit and prevent any such nuclear explosion at any place under its jurisdiction and control. Each State Party is further committed to refrain from causing, encouraging, or in any way participating in, the carrying out of any nuclear weapon test explosion or any other nuclear explosion.

To implement the Treaty and the verification regime, the CTBT Organization (CTBTO) will be established in Vienna. In March 1997, the Provisional Technical Secretariat was established at the International Centre in Vienna, under the leadership of Ambassador Wolfgang Hoffman of Germany. All States Parties shall be members of the CTBTO and the Executive Council shall consists of 51 members, with representation divided geographically.

The mainstay of the verification regime will be an International Monitoring System (IMS) comprised of four basic technologies — seismic, radionuclide, infrasound and hydroacoustic detector networks[20]. In addition, there is provision for on-site inspections, consultation and clarification, and confidence-building measures.

The IMS will consist of 50 primary and 120 auxiliary seismic stations, a network of 11 hydroacoustic monitors, 60 infrasound stations and 80 stations for measuring atmospheric radionuclides. There are provisions for 40 of the 80 stations measuring radioactive particles to be also capable of monitoring the presence of noble gases such as xenon and argon. There are also provisions for the "improvement of the verification regime", allowing electromagnetic pulse (EMP)detection, satellites or other technology to be incorporated in the IMS, subject to the consensus of the Executive Council, without requiring the full process of an Amendment Conference.

The International Data Centre (IDC) — under the Technical Secretariat — will process raw data from the IMS stations and send it to States Parties. The IDC will screen data in accordance with internationally standardised criteria established by the CTBTO, filter it according to nationally requested criteria, and provide some additional technical assistance to States Parties.

On-site inspections and how to decide whether to carry one out has been a constant source of tensions within the negotiations.

The Treaty allows an on-site inspection to be triggered by any relevant kind of information "consistent with generally recognised principles of international law" — including national technical means (NTM) but excluding espionage. The Executive

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[20]*For detailed explanation of hydroacoustic detection see Ruth Weinberg, "Hydroacoustic monitoring of the World's Oceans", Test Ban Verification Matters, No. 8, VERTIC, London, January 1995.*

Council must decide to carry out an inspection by 30 affirmative votes of the members. If the Executive Council does not approve the inspection, all preparations for the inspection must be stopped.

A decision on the OSI has to be taken by the Executive Council within 96 hours of receiving a request and an inspection team has to arrive within 6 days of the receipt of request. The time-frame for an inspection is 60 days, with the possibility of extending by up to 70 days, subject to a majority decision of the Executive Council. Also included in the OSI provisions are overflights and managed access. States are allowed to protect sensitive facilities and information unrelated to compliance with the Treaty. The inspection should move from less intrusive to more intrusive procedures. Inspectors and access points have to be identified to the CTBTO within 30 days of the treaty's entry into force for it (and updated as appropriate).

The Treaty includes penalties if the Executive Council deems a request to have been "frivolous or abusive." Failure to comply with Treaty obligations or abuse of the Treaty's provisions can result in penalties ranging from suspension of membership rights, collective measures in conformity with international law, and the taking of urgent cases to the United Nations.

Confidence-building measures are included in the Treaty to "contribute to the timely resolution of any compliance concerns" and to assist in the calibration of detector stations belonging to the IMS. Specific confidence-building measures, outlined in Part III of the Protocol to the Treaty, include the voluntary provision of information on large chemical explosions, on-site visits of the Technical Secretariat to location of large chemical explosions, and liaison with calibration explosions.

However, the main concern over the CTBT is that it may never enter into force. Article XIV stipulates that the CTBT shall enter into force 180 days after the date of the deposit of the instruments of ratification by all States listed in Annex 2, and no earlier than two years after its opening for signature. Annex 2 States are members of the CD and listed in the International Atomic Energy Agency's April 1996 edition of "Nuclear Power Reactors in the World" or the December 1995 edition of "Nuclear Research Reactors in the World". Notably this list includes the nuclear weapons states and the "*de facto* nuclear weapon" states[21], Israel, India and Pakistan. Because of Article XIV's wording, if India does not join the Treaty (India has so far stated that it will not join the Treaty and Pakistan will not join up unless India does), the Treaty provisions cannot be implemented (unless under provisional application). In particular this means that the verification provisions cannot be implemented. The CTBT has been signed (and perhaps will be ratified) by a large number of countries all of which will adhere to the treaty provisions (under the 1969 Vienna Convention on the Law of Treaties, states which have signed a treaty are obliged to refrain from any acts which would defeat the purpose of the treaty) but the Treaty may not enter into force.

Article XIV on entry into force also contains provision for a conference to take place if the "treaty has not entered into force three years after the date of the anniversary of its

[21]*These states are often referred to as the "threshold states", the "hold-out states" or the "undeclared nuclear weapon states". In this preliminary report they shall be referred to as the "de facto nuclear weapon states" as an attempt to try to portray the reality of the political, if not the technical, situation. By the end of a deep cuts process, these de facto nuclear weapon states may be fewer or more in number.*

opening for signature". This conference would examine the extent to which the conditions for entry into force had been met and "consider and decide by consensus what measures consistent with international law may be undertaken to accelerate the ratification process in order to facilitate early entry into force". This process would be repeated annually until the Treaty's eventual entry into force. Dubbed the "hand-wringing conference" because it is envisaged that States' representatives will sit around wringing their hands crying "what shall we do, what shall we do?", it may be the only ray of hope for treaty implementation.

If the required 44 States do not sign and ratify the CTBT, then the States Parties may decide to provisionally apply the Treaty. This has been done with other treaties (for example the Conventional Forces in Europe Treaty) although it may be difficult to sustain provisional application over a long period.

The Vienna Convention on the Law of Treaties states in Article 25 that:

1. A treaty or part of a treaty is applied provisionally pending its entry into force if: (a) the treaty itself so provides; or (b) the negotiating States have in some other manner so agreed.

2. Unless the treaty otherwise provides or the negotiating States have otherwise agreed, the provisional application of a treaty or part of a treaty with respect to a State shall be terminated if that State notifies the other States between which the treaty is being applied provisionally of its intention not to become a party to the treaty.

There are two issues for the CTBT arising from Article 25 of the Vienna Convention (it is also important to note that not all states are parties to the Vienna Convention). The first is whether the term "negotiating States" would include all the states at the CD, or all the states which voted for the adoption of the Treaty text in the UN General Assembly, or whether that term would just refer to the State Parties to the CTBT negotiating at the "hand-wringing" conference. The second is that, if negotiating states means the CD membership, whether States which intended to remain outside the Treaty would take the option of notifying the other States of their intention not to become a party to the Treaty, thereby allowing the Treaty to be provisionally applied.

If the Treaty were then provisionally applied then the CTBTO could be established and the Treaty be implemented. This would mean, if the Parties were in agreement, that the Technical Secretariat and the Executive Council could be active and implement the International Monitoring System and perhaps even allow provision for on-site inspections.

In addition to Treaty implementation, if deemed desirable it may be possible, under certain circumstances, under provisional application, for the States Parties to amend the treaty to change the wording of the Article XIV on entry into force or change the list of states in Annex 2, thus allowing the Treaty to come into force properly without the full 44 required States. There are obvious dangers in attempting to amend the Treaty, not least of which is the possibility that States Parties may use the opportunity to try to amend other articles of the Treaty, thus blowing it apart. On the other hand, with an extremely disciplined Chair of an amendment conference — who had sought agreement beforehand that only Article XIV was open for discussion — such an approach may be possible.

Perhaps a more satisfactory approach would be to actively seek to alleviate concerns on nuclear disarmament. If the NWS were to announce a series of meetings at which they would outline a plan for global nuclear disarmament, then it may be possible to convince hold-outs that the CTBT is a true disarmament measure. These meetings could begin with considering how to establish a confidence-building regime which could prepare the ground for nuclear disarmament. They could go on later to agree a step-by-step plan for nuclear disarmament, with a stringent verification regime as an integral part of the plan. Another alternative — which could work in parallel — would be to begin talks for a mandate for the negotiation of a Nuclear Weapons Convention at the CD. However there is currently a great deal of opposition from the NWS over such proposals.

Approach

Following on from the above treaties — assuming that limits for START 3 are agreed at around the levels indicated by Presidents Clinton and Yeltsin at Helsinki in March 1997 or lower — then it will be important to begin a process of nuclear disarmament in order to fulfil obligations under the NPT. This will necessarily include — at some point — China, France and the UK. Both China and the UK have a stated position that not until the US-Russia levels are near the levels of the respective States, will either of them consider joining in reduction negotiations. With a change in government, this position may well change in the UK, but it is unlikely to change in China — although events may well influence further thinking there.

Barring a major domestic incident, none of the P5 will consider aiming for a nuclear-weaponless status unless a number of criteria are fulfilled:

1) That all the P5 are involved;

2) The *de facto* nuclear weapon states (India, Pakistan and China and any other potential states at that point) are also involved in the process;

3) Transparency and verification regimes provide enough assurance that the process is going ahead without cheating;

4) There is a clear strategy of how to deal with the fissile materials and that this strategy will be environmentally safe in all countries, whilst at the same time not being vulnerable to theft;

5) The CWC and BWC are adhered to by all significant states and that the level of certainty for judging compliance increases;

6) The possibility of break-out is taken into account and that measures are in place to counter such a situation;

7) Verification measures are in place for the long term so that defence planning can go ahead with some level of certainty that nuclear weapons are not a feature on the longer-term horizon.

This process of disarmament will likely take place over a protracted period (decades) — if not due to the politics, then due to the practicalities. The START 1 and 2 agreements have already demonstrated the enormous effort that will have to go into dismantling nuclear weapons, storage of materials and verification. To complicate this process by adding in more Parties with different infrastructures and nuclear histories will slow down rather than speed up the procedures. In addition, politics will likely determine — even if there is agreement that the end-goal is elimination — a "look before we leap" approach[22], whereby the disarmament process will be staged and at each stage, the negotiators will assess how confident they feel about proceeding to the next step. That confidence will depend to a large extent on verification and the trust built up between the parties.

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22 *Clifford E. Singer, "Look before you Leap: Practical steps towards reduction and possible eventual elimination of assembled nuclear explosive holdings" forthcoming in Washington Quarterly, private*

Right now, perhaps it is more important to bring in China, France and the UK into a process of transparency and confidence-building, than it is to insist that they start negotiating reductions in their nuclear arsenals.

Knowing the nuclear history[23] of a country is crucial for preparing for a transition to low levels of nuclear weapons with a view to going on to zero. For example, when South Africa destroyed its small nuclear arsenal in 1990, the only way that the IAEA had to verify this declaration (not made until March 1993) were the declarations made by the government backed up by the original, hand-written, operating records of the uranium enrichment plant at Valindaba[24]. Although there are few who doubt the dismantling of nuclear weapons in South Africa, the experience illustrated how difficult verifying such a declaration can be years after the event when little of the civil nuclear programme had been independently monitored.

It is this period, therefore, of reducing to very low levels, which is vital for building up a databank of knowledge on the nuclear weapons programmes of each of the P5 and, eventually, on each of the *de facto* nuclear weapon states.

If we assume that the START 3 process will get underway very soon (following the ratification of START 2 in the Russian Duma), and that the US and Russia reduce their strategic arsenals to 2,000 or 2,500 apiece by 2007 (see above), then follow-on negotiations between Russia and the US could bring numbers of strategic weapons down to about 1,000. There are still numerous tactical weapons to be taken care of. For example, it is estimated that there are between 5,000 and 12,000 tactical warheads in Russia to be retired[25].

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communication. Professor Singer proposes a formula whereby the NWS agree to reduce their arsenals by a specified factor throughout a series of agreed periods.

[23] *Steve Fetter, "Nuclear Archaeology: Verifying Declarations of Fissile Material" Science and Global Security, Volume 3 No. 3-4, 1993.*

[24] *Steve Fetter, Verifying Nuclear Disarmament, Henry L. Stimson Center, Washington DC, Occasional Paper No. 29, October 1996.*

[25] *National Academy of Sciences, Committee on International Security and Arms Control, "Management and Disposition of Excess Weapons Plutonium", National Academy Press, Washington DC, 1994.*

Proposals for Deep Cuts

Following on from START 3, the US and Russia could make deep cuts in their nuclear arsenals (strategic and tactical), which could then lead on to very substantial cuts in the nuclear weapons of all NWS. There have been a number of proposals[26] for phased reductions in nuclear weapons, based on a recognition that following on from the end of the Cold War, there is no justification left to retain the large numbers of warheads and missiles in the NWS. Although it is important that the ultimate goal of eliminating nuclear weapons be the driving force for deep cuts, there is a sense that until the NWS reach that position of hundreds of nuclear weapons each, then it will not be possible to make the final decision to proceed to zero. Only at that point will the NWS be able to assess the confidence that they have in the verification regime, the nuclear status of the *de facto* nuclear weapon states (they may have already dismantled their weapons programme after the fashion of South Africa, they may have already joined in the transparency process, they may be prepared, at that stage, to join in the reduction process, or they may need further persuasion that the process is real, and in their security interests).

One possible scheme for deep cuts is as follows:

START 3

A reduction to 2,000 – 2,500 strategic warheads by the year 2007 by Russia and the US.

Taking nuclear forces off alert.

TARTs — Tactical Arms Reduction Treaties

As an opening agreement, the US and Russia could agree to reduce their stockpiles of tactical nuclear weapons to a few hundred.

This could be followed by a final agreement eliminating short-range systems altogether (as in the INF Treaty).

P5 transparency and confidence-building system

After START 3 and TARTs have been agreed, the other NWS could be brought into a process of transparency and confidence-building.

This would include a register of nuclear weapons history, deployments and storage[27], and on-site inspections to check declarations.

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26 *See for example: Frank von Hippel, "A Program of De-Alerting and Deep Cuts", Bulletin of Atomic Scientists, to be published; Stimson Center Project Steering Committee on Eliminating Weapons of Mass Destruction, " A Four Step Program to Nuclear Disarmament", Bulletin of the Atomic Scientists, Vol. 52, No.2 March/April 1996; Jack Mendelsohn, "START II and Beyond", Arms Control Today, Vol. 26, No. 8, October 1996.*

27 *Harald Müller, "Transparency in Nuclear Arms: Towards a Nuclear Weapons Register", Arms Control Today, Vol. 24, No. 8, October 1994, pp. 3-7.*

P5 proportional or gradual reductions

Having established a framework for transparency, the NWS could then embark on reductions.

These could either be in a form of reductions to bring them all to the same level by the end of the process, or to bring them to unequal levels by a series of proportional reductions.

Proportional reductions could either be in set amounts to be agreed at each set of negotiations, or they could be in a formula that sets out percentage reductions at each specified time interval[28].

Multilateral transparency and confidence-building system

Having reached very low-levels, or even during that process, any *de facto* nuclear weapon states in existence could be brought into the transparency arrangements in preparation for their involvement in the reduction process.

Very Low levels

At the end of this process, the NWS should be left with very low-levels of nuclear weapons. They will be participating, with the *de facto* nuclear weapon states, in a transparency regime. It will be at that point that the decision to go onto the final elimination of nuclear weapons would be made.

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28 *Clifford E. Singer, Op Cit. Note 22*

Verification Scheme for Deep Cuts

START 3

- Bilateral; USA and Russia
- Data exchange and transparency
- On-site inspections
- Information from satellite and aircraft
- Verify missile reductions
- Warhead dismantlement monitoring
- Nuclear materials safeguards
- Verify the halt of fissile material production

P5 transparency and confidence-building system

- Multilateral; USA, Russia, China, UK and France
- Before any reductions
- Data exchange and transparency
- On-site inspections. These inspections would be carried out by inspectors from the NWS. That the inspections are carried out correctly could be verified by the IAEA[29].
- Information from satellites and aircraft
- Nuclear materials safeguards
- Verify the halt of fissile material production

P5 proportional or gradual reductions

- Multilateral; USA, Russia, China, UK and France
- Data exchange and transparency
- On-site inspections
- Information from satellite and aircraft
- Verify missile reductions
- Warhead dismantlement monitoring
- Nuclear materials safeguards
- Verify the halt of fissile material production

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[29] *Richard Guthrie, "The Transition to a Nuclear Weapon Free World: A new model for the verification framework", Verification Matters Briefing paper 97/1, April 1997, VERTIC, London.*

Multilateral transparency and confidence-building system

- Multilateral; USA, Russia, China, France, UK
- Before any reductions
- Data exchange and transparency
- On-site inspections
- Information from satellites and aircraft
- Nuclear materials safeguards
- Verify the halt of fissile material production

Very Low levels

- Multilateral; USA, Russia, China, UK and France
- Few hundred nuclear weapons each,
- Not necessarily equal across the five states (e.g. US and Russia have more than other three)
- Data exchange and transparency
- On-site inspections
- Information from satellite and aircraft
- Verify missile reductions
- Warhead dismantlement monitoring
- Nuclear materials safeguards
- Stay at this low level until political conditions are right for moving on

Technical Issues[30]

Transparency and data exchanges

It is important for the process of confidence-building that as much as possible is revealed about the types, status and locations of nuclear weapons.

Annually updated, data exchanges and a nuclear weapons register could include a wide range of information such as:

- numbers and locations of warheads deployed, in storage, awaiting dismantlement, decoupled from the delivery vehicle and so on;
- aggregate amounts and locations of weapons-grade fissile material in the forms of active warheads, stored warheads, dismantling facilities, production facilities, stored pits, scrap, waste and so on;
- aggregate amounts and locations of fusion material such as tritium and lithium deuteride;
- numbers and locations of missiles, bombers and other delivery vehicles deployed, in storage, in production, awaiting dismantlement, transferred for space launches and so on;
- location, purpose and layout of facilities that produce nuclear weapon components such as fissile materials, fusion materials, high-explosives, fusing and firing assemblies, and so on;

These data can be checked by on-site inspection and NTM, in the first place as a one-off initial inventory and thereafter through routine and random inspections. The inspectors could only be citizens of the Parties involved in the transparency arrangements. However, for the purpose of long-term confidence-building, and for the purpose of being prepared to move onto the total elimination of nuclear weapons at a later date, it would be advisable for the IAEA to carry out independent verification of the process. That is, not to carry out the inspections themselves but to satisfy the Agency that the inspections have been conducted correctly[31].

Nuclear archaeology[32]

As a complement to verifying data exchanges, and as an adjunct to the data the NNWS will be supplying under the new strengthened safeguards agreements with the IAEA[33], it would be useful if the NWS, and eventually the *de facto* nuclear weapons states were to

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30 *For an excellent summary of the wide range of technologies and methods see the following papers in the Background Papers to the Canberra Commission on the Elimination of Nuclear Weapons, Canberra, August 1996: Christopher E. Paine, Thomas B. Cochran, Robert S. Norris, "Techniques and procedures for verifying nuclear weapons elimination", p.167; Christopher E. Paine, Thomas B. Cochran, Robert S. Norris, "Technical realities confronting transition to a nuclear weapon free world", p.109; Christopher E. Paine, Thomas B. Cochran, Robert S. Norris, "Practical interim steps toward nuclear weapons elimination and a fissile material control regime for nuclear weapon states", p. 99.*

31 *Richard Guthrie, Op Cit. Note 29*

32 *Steve Fetter, "Nuclear Archaeology", Op Cit. note 23, pp. 237-259.*

33 *Suzanna van Moyland, Op Cit. note 8.*

provide as complete a set of data as possible on the history of each nuclear explosive device, the operating records of the warhead and missile facilities, and the production records of the production and enrichment sites. The records could be inspected, checked for internal and external consistency, and then used to confirm activities such as plutonium production at certain facilities.

De-alerting missiles

Despite the end of the Cold War, nuclear forces are still operating in a mode of alert. This means that they are ready to be launched in response to an attack (launch on warning status). There have been a number of proposals[34] recommending that strategic weapons systems be taken off alert status.

In 1994[35] there were statements from the US, Russia, UK and China that strategic nuclear missiles on alert were no longer targeted at each other, however, there is no way of checking the truth of such statement and in any case it would take a minuscule amount of time to input targeting information. Although these statements did help to build confidence between the NWS, they are not sufficient to significantly reduce the possibility of accidental launch.

There have been some practical actions carried out. The US removed bombers from 15 minute alert so that they no longer stand, fully armed at the end of runways and Russia reduced the number of SSBN patrols and decommissioned some submarines earlier than planned[36]. There are other technical measures that could be carried out, such as: "safeing" silo-based missiles so that the ignition system is physically blocked (e.g. by a special pin as was used in 1991 for 450 Minuteman II missiles[37]; decoupling warheads from the missiles and physically placing them in a separate location; removing weapons from heavy bombers; and reducing strategic submarines and eliminating operational patrols; physically separating guidance equipment from missiles; removing warhead covers; and physically separating missiles from their engines. All of these steps could be subject to inspection, either by on-site inspectors or by satellites. Surveillance cameras could be installed to monitor any potential re-loading at silos, submarine bases and mobile missile sheds. Some of these steps could be unilaterally declared and some may be negotiated, either way they could all be subjected to checks.

Missile monitoring

Because nuclear warheads in themselves, without some means of delivery, were not perceived as the threat during the Cold War, the INF and START 1 and 2 agreements focused on reducing the numbers of launchers, missiles and bombers.

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[34] *Bruce G. Blair, "Global Zero Alert for Nuclear Weapons", The Brookings Institution, Washington DC, 1995.*

[35] *Marco De Andreis and Francesco Calogero, "The Soviet Nuclear Weapon Legacy", SIPRI Research Report No. 10, Oxford University Press, 1995, p67.*

[36] *Alexei Arbatov, "Dealerting nuclear forces: a substitute or supplement to disarmament?", Background Papers to the Canberra Commission on the Elimination of Nuclear Weapons, Canberra, August 1996, p. 303.*

[37] *Christopher E. Paine, Thomas B. Cochran, Robert S. Norris, "Practical interim steps toward nuclear weapons elimination and a fissile material control regime for nuclear weapon states", Background Papers to the Canberra Commission on the Elimination of Nuclear Weapons, Canberra, August 1996, p. 102.*

Although START 3 and beyond will address the destruction of warheads, the means of delivery will remain just as important to control.

Verification measures which would be able to say how many nuclear weapons were on board ships and submarines and what type, would play an important role. Before START 1 was even negotiated,Russian inspectors were allowed to look from the deck of a US submarine into an empty Trident missile tube (in order to check that the missile had been removed) and then follow the missile as it was carried to a disassembly facility[38]. There are a number of procedures which allow verification of naval missiles which do not require on-board inspections. These include portal perimeter monitoring systems at the loading bays of ships and submarines. Nuclear detectors placed at the loading points could monitor the on and off loading of nuclear missiles and there could be spot check inspections to other ports to check that facilities for handling nuclear weapons are not available for clandestine deployment.

The issue of dual capability is difficult to resolve. Because a number of missiles can carry both nuclear and conventional warheads and because the difference between them is not easy to discern from the outside[39], it could be relatively easy to substitute nuclear missiles for the declared conventional. Portable nuclear radiation detectors measuring radiation emanating from the warhead as described (below) would be used to distinguish between them.

As the NWS go down to low levels of nuclear missiles the reduction process is vulnerable to the possibility of a small clandestine store of extra nuclear weapons possessed by one of the NWS. For example, if the numbers agreed to between the NWS were 100 each, then a hidden 50 would increase by 50 per cent the force of the cheating state with respect to the complying states. Such a possibility could block any moves to make further reductions and eventual elimination. It is imperative, therefore, that the verification of these low levels must be extremely stringent.

One way which would increase confidence in the verification regime would be to close down all but a few missile sites and platforms in each NWS. These sites could then be carefully monitored, any missile found elsewhere than the allowed sites or platforms would be an obvious violation. Tags would greatly help in such a verification process. If only tagged weapons were allowed, any untagged weapon or wrongly tagged weapon found is in contravention with the treaty. Inspectors then only have to check tags on weapons and check that all weapons have valid tags. Sampling of missile tags is then possible, rather than having to account for each and every one.

Warhead monitoring

Since the end of the Cold War and the break-up of the Soviet Union, there has been great concern over the number of warheads, and the materials from those warheads, that are vulnerable to theft. Accounting for all the warheads that are deployed or stored is a critical part of laying the foundations of a comprehensive verification regime. If there is little faith in the accuracy of the accounting procedures, then it will be hard for

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[38] *Trust and Verify Issue 13, August/September 1990, The Verification Technology Information Centre, London.*

[39] *V. Thomas, Verification of Limits in Sea-launched Cruise Missiles, in Reversing the Arms race - How to Achieve and Verify Deep Reductions in the Nuclear Arsenals, Eds F. von Hippel and R. Sagdeev, Gordon and Breach Science Publishers 1990, pp147 - 172.*

a NWS to believe that the other NWS are not able to squirrel away some warheads. This could be achieved, for example, by substituting dummy warheads for real ones during an inspection, and having the dummies erroneously labelled as genuine.

Concerns over how many warheads a missile truly contains, or whether there is a nuclear device inside a nose cone at all (or inside any other container) can be alleviated in a number of ways.

In the first place, visual inspection by removing the nose cone shroud is a simple, effective method for counting the number of warheads. However, it would be necessary to back up visual inspection with radiation detection, so that non-nuclear or dummy warheads are not mis-labelled and thus accounted for incorrectly.

During on-site inspections, including during baseline inventory inspections, warheads would be monitored to check for radiation and "fingerprinted", so that the type of warhead would be known. Detectors could measure the gamma ray and neutron flux emanating from the warhead, along with the dimensions, weight and heat output[40], thus recording a unique signature or "fingerprint" for the warhead. These measurements could be conducted automatically and encoded so that the inspectors were not privy to sensitive design information. The warheads could then be tagged with this information thus being uniquely identifiable on inspection by the tag-reading equipment.

Containers which are large enough to contain nuclear warheads may also be subject to radiation detectors, both active and passive.

Passive radiation detectors simply measure the radiation that comes from the nuclear material. Active nuclear detectors use the transmission gamma rays or neutrons from an external source and measure their passage through the item under investigation. An X-ray picture of what is inside the container can be built up from the measurements, and neutron activation analysis can yield detailed information on the composition of the materials inside. Such detection equipment is now readily portable and is used routinely in industry and in forensic science.

A secure central inventory, with identifying but not sensitive, information could be housed electronically and accessed by the inspecting parties. The inventory could be automatically updated at each inspection and as warheads are transported for dismantlement.

Missile destruction

There is now a great deal of experience in monitoring and tracking the destruction of intermediate-range and long-range ballistic and cruise missiles.

Excess missiles can be destroyed in a variety of ways, such as slow burning or controlled explosions. Each of the methods used in the INF and START agreements can be employed and some missiles could be transferred, under the strictest controls, for use in the civil sector as space launchers. As numbers of missiles (or warheads) decrease, verification becomes more and more important — small infringements take on a new significance as they become a larger and larger percentage of the whole.

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[40] *Steve Fetter, "Verifying Nuclear Disarmament", Op Cit. note 24 pp. 10-11.*

Warhead dismantling

Although the verification of warhead dismantling was not part of the INF or START 1 and 2 agreements, there has been substantial work done on the techniques and technologies that would be required for this next step[41], including US government work in 1969[42].

Those warheads scheduled for dismantling would go to a dismantling facility (as this may also be a maintenance and assembly facility, it would be necessary to monitor all those warheads coming in and out and carry out periodic inventories on the site[43] — such a process is called portal-perimeter monitoring and there is a great deal of experience in such techniques from the INF and START 1 agreements). Their identifying tags would be read on arrival, any untagged warheads could be fingerprinted and tagged there. If there were any doubt as to whether an item contained a nuclear explosive device, active radiation measurements could be made (see below) so that any radiation shielding that may be in place would be detectable.

A major problem when monitoring the destruction of warheads is the protection of sensitive information of the warhead designs. Inspectors need to be certain that the warheads have been destroyed without gaining any highly classified information on warhead design. This can be achieved in a simple way by a series of steps[44]:

1. The warheads would be brought to a warhead dismantling facility having been tracked throughout their whole transit. Tamper-resistant locks which sealed the warhead containers when they were removed from their deployment sites, would be checked and the warheads would be removed from the transit container. The type of nuclear warhead would be fingerprinted and the information stored.

2. The warheads would then be taken to the dismantling plant which could be inspected before and after, but not during, the removal of sensitive material. The warhead could then be dismantled by technical experts from the NWS that owns the warheads and split into nuclear and non-nuclear components.

3. All of the parts would then shown to the other NWS inspectors and checked against the record taken in step 1. Parts could be crushed, fissile and fusile material put under safeguards and taken to interim storage awaiting disposal. The inspectors would witness the removal of all the parts and, due to portal perimeter monitoring and periodic whole-

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41 *See for example, Theodore B. Taylor, "Verified Elimination of Nuclear Warheads", Science and Global Security, Vol. 1, 1989, pp. 1-26; Steve Fetter, Valery A. Frolov, Marvin Miller, Robert Mozley, Oleg F. Prilutsky, Stanislav N. Rodionov and Roald Z. Sagdeev, "Detecting Nuclear Warheads", Science and Global Security, Volume 1, Nos. 3-4, 1990, pp. 225 - 302; Robert Mozley, "Verifying the Number of Warheads on Multiple-Warhead Missiles through On-site Inspections "Science and Global Security, Volume 1, Nos. 3-4, 1990, pp. 303-321; Steve Fetter and Frank von Hippel, "Measurements of Radiation from a Soviet Warhead", Science and Global Security, Volume 1, Nos. 3-4, 1990, pp. 323-327; S.T. Belyaev, V.I. Lebedev, B.A. Obinyakov, M.V. Zemlyakov, V.A. Ryazatsev, V. M. Arashove, and S.A. Voshchinin, " The Use Of Helicopter-Borne Neutron Detectors To Detect Nuclear Warheads In The USSR-US Black Sea Experiment", Science and Global Security, Volume 1, Nos. 3-4, 1990, pp. 328 - 333.*

42 *Frank von Hippel, "The 1969 ACDA Study on Warhead Dismantlement". Science and Global Security, Volume 2, No. 1, 1990, pp. 103-108.*

43 *Steve Fetter, "Verifying Nuclear Disarmament", Op Cit. note 24, pp. 12-13.*

44 *For more details of such procedures see Theodore B. Taylor, "Warhead Dismantlement and Fissile-material Disposal" in Reversing the Arms Race - How to Achieve and Verify Deep Reductions in the Nuclear Arsenals, Eds F. von Hippel and R. Sagdeev, Gordon and Breach Science Publishers 1990, p91 - 115.*

site inventory checks, they would be sure that there was no possible way in which the materials could have been substituted.

Tagging technologies[45]

Tags are in common usage for internal accounting purposes. They are, for example, vehicle registration numbers, engine serial numbers, bar codes in supermarkets etc. Missiles and warhead components possess identification for internal accounting purposes. However, there is no proof that on inspection the identification numbers are genuine. It may be possible to have one set of say, registration numbers, for the inspectors and a completely different set for the internal accounts. In this way it could be possible to keep substantially more missiles or warheads than allowed by moving registration numbers around. During experimental inspections in the 1960s under the CLOUD GAP programme, the US military showed that it was possible to fool inspectors by duplicating[46] the US Army numbers of equipment.

Tags simplify the problems of violations and verification of limits on numbers. In a sense tags allow verification of low levels of nuclear weapons to be as simple as the zero-zero option in the INF treaty: following the baseline inventory, any untagged missile or warhead is a clear treaty violation.

Tags also simplify the sampling procedures for inspections. The problem of data collection is then the simple one of data verification, that is missiles and warheads can be checked on an inventory checklist, this allows sampling procedures to be more accurate than if the inspectors were counting the number of missiles or warheads seen at the site, particularly if the numbers observed do not match up with the numbers notified.

In order to be effective, tags have to be copy resistant, tamper resistant, tamper indicating, be no more observable than the item itself, display no more information than is needed for verification purposes and not interfere with the tagged item's function.

Tags fall into two main categories:

i. Those which provide their own identification — i.e. they are electronic tags and provide digital information. These are usually called active tags. They can be attached to an item for inspection with a specified code which will automatically void if tampered with.

ii. Those which require comparison with a record for their identification. These are based on the techniques of pattern recognition. They are usually called passive tags. These include, for example, a "fingerprint" of a surface — taking a photographic image or taking a acetone print of a part of the surface of a missile.

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45 *Adapted from Patricia M. Lewis, "Verfication of Nuclear Weapon Elimination" in Security Without Nuclear weapons?, Ed. Regina Cowan Carp, SPIRI, Oxford University Press, 1992, pp.128-152.*

46. *Patricia M. Lewis, "Verification Experiments in the 1960s: from CLOUD GAP to Exercise "FIRST LOOK"", Verification of Conventional Arms Control in Europe: Technological Constraints and Opportunities, SIPRI, Westview Press, September 1990, p 264.*

Nuclear materials disposal

Even though START 1 does not directly require nuclear warheads to be dismantled, the process of dismantling strategic and tactical warheads has been carried out as a direct result of the INF and START agreements and unilateral withdrawals of tactical nuclear weapons. Further nuclear weapons reductions will result in more special materials needing to be disposed of and, as the process continues, these materials will be coming from warheads of NWS other than the US and Russia.

There are a number of ways to deal with weapons-grade fissile material[47].

In the case of Highly Enriched Uranium (HEU), mixing it with natural, depleted or slightly enriched uranium will convert it into low-enriched uranium (LEU) for use in nuclear power reactors or for storage. LEU cannot in itself be used for making nuclear weapons without the costly business of enriching the uranium once more so that it contains the requisite amount of ^{235}U (because all the isotopes of uranium are chemically essentially the same a chemical separation is not possible, and so this process is complex and relies on the small differences in charges and masses of the isotopes). Once the LEU has been placed under safeguards (particularly under the new safeguards arrangements (see above)), then the material has been taken out of the military uranium cycle into the civil sector. So long as safeguards and physical security are fully implemented, the uranium no longer poses a proliferation threat. It is important that this process be carried out as soon as practical. HEU is a large proliferation threat. In many respects it is easier to make a crude, reliable bomb out of HEU than it is out of plutonium and it may well be less physically secure in places than weapons-grade plutonium. There are market considerations that work against the rapid disposal of HEU, but the proliferation risks far outweigh such obstacles[48].

Plutonium, however, is all together different. All plutonium isotopes can be used as explosives, if the critical mass is formed[49]. In addition, blending plutonium with ^{238}U (a non-fissionable isotope of uranium), thus forming the more expensive mixed oxide (MOX) fuel for use in MOX-fuel reactors, whilst diluting the plutonium, does not present a permanent solution, because plutonium and uranium can be easily chemically separated. As a result, a great deal of attention has been placed in recent years on procedures for disposing of weapons-grade plutonium. The US National Academy of Sciences[50] devised what is called the "spent fuel standard" which demands that whatever method of plutonium disposal is used, it should be at least as inaccessible as the stock of plutonium in civilian spent fuel.

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[47] *For a more complete discussion of these options see:*

National Academy of Sciences, Committee on International Security and Arms Control, "Management and Disposition of Excess Weapons Plutonium", National Academy Press, Washington DC, 1994;

David Albright, Frans Berkhout and William Walker, "Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies, SIPRI, Oxford University Press, 1997, pp416-458;

John P. Holdren, "Management of Surplus Nuclear Materials", Background Papers to the Canberra Commission of Nuclear Weapons, Government of Australia, August 1996, p 241

[48] *Op Cit. note 47, Albright, Berkhout and Walker, p 445-446.*

[49] *J. Carson Mark, "Explosive Properties of Reactor-Grade Plutonium" Science and Global Security, Volume 4, 1993, pp. 111 - 128.*

[50] *Op Cit. note 47, National Academy of Sciences.*

Three approaches have been proposed to achieve this "spent fuel standard". One is to burn the plutonium as part of MOX fuel in power reactors[51], the second is to blend it with high-level radioactive wastes and then vitrify it for long-term storage[52], and the third is to store it in deep bore-holes. Whilst awaiting disposal in one of these forms, the plutonium pits are currently being stored in secure environments under the supervision of the owners. 1995 agreements between the US and Russia, requiring the exchange of information on nuclear stockpiles and materials and reciprocal monitoring of nuclear material storage facilities[53], suffered a delay in implementation because of delays over an agreement on cooperation and confidentiality. The IAEA, the US and Russia have agreed to begin discussions in a joint working group on the verification of surplus weapons fissile materials. The group is due to report in mid-1997. In December 1996, the US Department of Energy announced a "dual-track" strategy[54] for disposal of up to 50 tonnes of plutonium: conversion into MOX and mixing it with high level wastes then vitrification[55].

Whilst it is currently unlikely that material from the storage sites will be squirreled away by the owners because there is an excess of the material (this does not however imply that there is no risk of theft), none-the-less as a confidence-building process, it is important that the US, Russia and the IAEA, soon implement transparency measures for the accounting and storage of surplus fissile material. Future confidence in deep cuts and eventual elimination will be greatly enhanced if transparency measures are set up in advance. At the 1997 Helsinki Summit, the proposed negotiations for START 3 specifically included the monitoring of warhead dismantlement and measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads. The presidents also agreed that both sides will consider the issues related to transparency in nuclear materials. This is clearly going to be a critical process in nuclear arms reductions. Once other NWS and *de facto* nuclear weapon states join in, it will easier be to expand this to an international transparency regime. If a convention on fissile materials is negotiated, then a great deal of the necessary measures could already be in place. Albright, Berkhout and Walker[56] have stated four

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[51] *John P. Holdren, "Work with Russia", The Bulletin of the Atomic Scientists, Vol. 53 No. 2, March/April 1997, p 42;*

Edwin S. Lyman and Paul Leventhal, "Bury the Stuff", The Bulletin of the Atomic Scientists, Vol. 53 No. 2, March/April 1997, p 45.

[52] *There are also proposals for irradiating the plutonium in order to transmute it into non-fissionable isotopes and for launching it into the sun. For a comprehensive survey of these options see:*

International Physicians for the Prevention of Nuclear War and the Institute for Energy and Environmental Research, "Plutonium: Deadly Gold of the Nuclear Age", International Physicians Press, USA, 1992, pp. 126 - 138

Arjun Makhijani and Annie Makhijani "Fissile Materials, in a Glass, Darkly: technical and policy aspects of the disposition of plutonium and highly enriched uranium", Institute for Energy and Environmental Research Press, Washington DC, 1995.

[53] *Joint Statement on the Transparency and Irreversibility of the Process of Reducing Nuclear Weapons, The President of The United States of America and the President of the Russian Federation, 10 May 1995, Moscow.*

[54] *John P. Holdren, John F. Ahearne, Richard L. Garwin, Wolfgang K. H. Panofsky, John J. Taylor and Matthew Bunn, "Excess Weapons Plutonium: How to reduce a clear and present danger", Arms Control Today, Vol. 26, No. 9, November/December 1996, p. 3.*

[55] *Mike Moore, "Plutonium: The disposal decision", The Bulletin of the Atomic Scientists, Vol. 53, No. 2, March/April 1997, p 41.*

[56] *op Cit. 47, Albright, Berkhout and Walker, p. 458.*

guiding principles for an international strategy for the disposal of nuclear materials. They are summarized below:

1. *Universality* — all fissile materials in all countries subject to same verification standards.

2. *Transparency* — summaries of inventories by all states, and detailed inventories for verification.

3. *Minimization* — no production unless for well-founded commercial or other reasons. Excess fissile material to be eliminated.

4. *Access* — inspection agencies to have greater access to facilities and information in all states.

The amounts of military HEU and weapons-grade plutonium are hard to gauge. Most recent estimates for 31 December 1994 are as follows:

Country	HEU — weapon-grade equivalent in tonnes	Weapon-grade plutonium in tonnes
FSU	1,050 ± 30%	131 ± 25%
USA	645 ± 10%	85 ± 3%
France	24 ± 20%	5 ± 30%
China	20 ± 25%	4 ± 50%
UK	8 ± 25%	3.1 ± 20%
Israel	unknown	0.44
India	negligible	0.3
Pakistan	0.21	negligible

Source: David Albright, Frans Berkhout and William Walker, "Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies", SIPRI, Oxford University Press, 1997, pp399-402.

Estimates for civil and military inventories of plutonium and HEU world-wide for 31 December 1994 are reported as:

Figures are in tonnes	Civil inventory	Military inventory	Total
Plutonium	914	249	1,160
HEU	20	1,750	1,770

Source: David Albright, Frans Berkhout and William Walker, "Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies, SIPRI, Oxford University Press, 1997, pp397

Organizational Aspects

The institutional arrangements for substantial reductions in nuclear weapons need to be considered with an eye to further reductions and eventual elimination.

In the first place, the US and Russia will continue the bilateral verification arrangements under the START process. If all five NWS participate in a transparency regime such as that outlined above then some multilateral arrangement between the P5 will be instituted for inspections, data exchange, the role of information from NTM and some consultative body for ironing out problems and for arranging on-site inspections so as to avoid clashes and overload and so on.

As the five NWS go on to carry out reductions in their arsenals, these transparency and data verification arrangements can be extended to take account of more stringent requirements for accountancy, warhead and missile destruction and long-term monitoring and disposal of nuclear materials. The IAEA could then check that this verification had been carried out to its satisfaction and report in that to the rest of the world.

As the NWS approach the end point of the deep reduction process, the *de facto* nuclear weapon states, as they exist at that time, could be brought into the process of transparency and verification with a view to dismantling their nuclear weapons programme along with the five declared NWS if the decision is made to fully eliminate nuclear weapons.

Having made the decision to go to zero nuclear weapons, many more technologies and procedures (such as high performance trace analysis for environmental monitoring) will be brought into the verification regime. It maybe that the IAEA would be the appropriate body to carry out such tasks, or it may be a subsidiary UN body specifically tasked to monitor the transition to zero nuclear weapons and a nuclear-weapon-free world that results (one proposal is for UNDO — the United Nations Disarmament Organization[57].

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[57] *Christopher E. Paine, Thomas B. Cochran, Robert S. Norris, "International Arrangements for the Transition to a Nuclear Weapons Free World", Background Papers to the Canberra Commission on the Elimination of Nuclear Weapons, Canberra, August 1996, p.141*

Conclusion

The process of reducing the large numbers of nuclear weapons that still exist in the world will rely on a system of verification that has its cornerstone in the verification regimes of the INF Treaty, and START 1 and 2.

If the intended endpoint of this process is to remain at low-levels (and it is not in the scope of this paper to discuss whether such a situation could be stable), the verification regime for the five NWS could be fairly relaxed, depending on how many nuclear weapons were to remain under their control — the larger that number, the less important errors in accounting would be.

However, if the transition to low levels of nuclear weapons is intended to be a step on the way to eventual elimination of nuclear weapons, then the verification regime established in this period will be the foundations of the verification regime required for the transition to zero and beyond. Consequently, it will need to be comprehensive and stringent in its measures.

Verification could provide the NWS and the *de facto* nuclear weapon states with the confidence they would need to take the final steps and eliminate nuclear weapons. Verification cannot provide 100 per cent certainty, nothing can, but after a period of several years of the NWS carrying out monitoring and inspections for the transition to low-levels of nuclear weapons, a pattern of knowledge would be built-up, so that confidence in the process would be high. Once that process includes the *de facto* nuclear weapon states, then further reductions to zero nuclear weapons with a high degree of confidence would be possible.

Glossary

ABM Treaty	Anti -Ballistic Missiles Treaty
ALCM	Air-Launched Cruise Missile
CD	Conference on Disarmament (Geneva)
CFE Treaty	Conventional Forces in Europe Treaty
CTBT	Comprehensive Test Ban Treaty
CTBTO	Comprehensive Test Ban Treaty Organization
CWC	Chemical Weapons Convention
DPRK	Democratic Peoples' Republic of Korea (North Korea)
EMP	Electro-Magnetic Pulse
HEU	Highly-Enriched Uranium
HPTA	High-Performance Trace Analysis (for environmental sampling)
ICBM	Inter-Continental Ballistic Missile
IDC	International Data Centre
IMS	International Monitoring System
INF Treaty	Intermediate-range Nuclear Forces Treaty
KEDO	Korean Peninsular Energy and Development Organization
LEU	Low-Enriched Uranium
MOX	Mixed-Oxide fuel
NTM	National Technical Means
MTM	Multinational Technical Means
NNWS	Non-Nuclear-Weapon State
NPT	Non-Proliferation Treaty
NWS	Nuclear-Weapon State (declared)
OSI	On-Site Inspection
P5	Five permanent members of the UN Security Council
R&D	Research and Development
SALT	Strategic Arms Limitation Treaties
SLCM	Sea-Launched Cruise Missile
SNDV	Strategic Nuclear Delivery Vehicle
SRAM	Short-Range Attack Missiles
START	Strategic Arms Reduction Treaties
TART	Tactical Arms Reduction Talks (Treaty)
UK	United Kingdom of Great Britain and Northern Ireland
UN	United Nations
UNGA	United Nations General Assembly
USA or US	United States of America

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CARRARA HOUSE 20 EMBANKMENT PLACE
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Tel +44 171 925 0867 Fax +44 171 925 0861
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