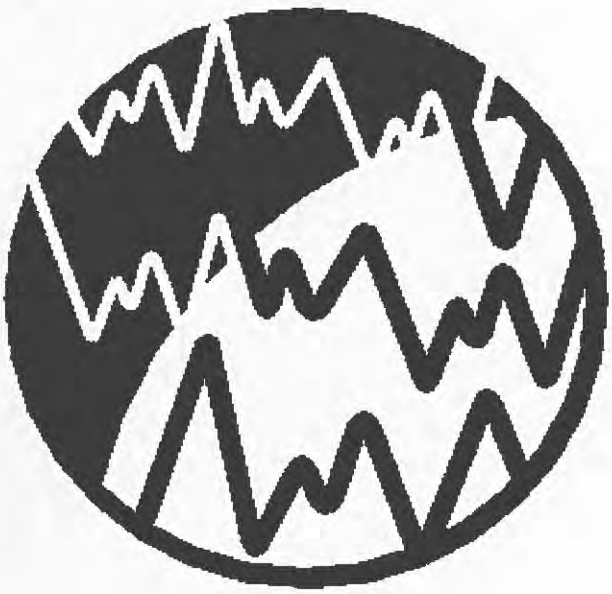
Laying the Foundations for Getting to Zero: Verifying the Transition to Low Levels of Nuclear Weapons



Patricia M. Lewis

VERTIC research report No1

Preface

In 1996 VERTIC launched a project funded by the W. Alton Jones Foundation and the Ploughshares Fund on Verification of the Transition to a Nuclear Weapon-Free World and Sustaining the Verification Regime for an Indefinite Period, otherwise known as the 'Getting to Zero' project.

The aim of the project is to investigate the verification challenges facing the transition to complete nuclear disarmament and how a verification regime might be sustained once the stage of zero nuclear weapons is achieved. Verification is the key to achieving nuclear disarmament, since without it the risk of 'breakout'—the illicit retention or production of nuclear weapons—would be high and the inclination to actually abolish nuclear weapons low. Verification of nuclear disarmament therefore needs to be highly intrusive and thorough, allowing for as little margin of error as possible. Given the extreme sensitivity of the nuclear weapon states about their security requirements, especially regarding their nuclear capability, this will be enormously difficult.

Many questions are pertinent: how should a verification regime be structured so that there is a high degree of confidence that no country or organisation could be hiding or manufacturing a stockpile? what technologies and techniques are most appropriate? how can one build on the precedents set by other nuclear agreements, such as the Intermediate-range Nuclear Forces Agreement and the Strategic Arms Reduction Treaties I and II, and non-nuclear agreements such as the Chemical Weapons Convention and the Biological Weapons Convention? how is the verification regime to be staged to match the gradual dismantling and destruction of nuclear arsenals? how should nuclear materials, nuclear laboratories and nuclear knowledge be dealt with? how is the verification regime to be implemented so that it builds trust and confidence? how are the de facto nuclear weapon states to be brought into the process and will the same verification provisions apply to them as to the declared nuclear weapon states? are nuclear and non-nuclear confidence-building measures required to supplement the verification regime? how can the regime cope with breakout should it occur?

Not only does the verification of nuclear disarmament have to be effective and efficient during the process of getting to a nuclear weapon-free world, it is also vital that there is confidence in the verification regime's ability to survive indefinitely. Questions here include: for how long should an intrusive verification regime last? 50 years? 100 years? could nuclear weapons be easily re-manufactured by a former nuclear weapon state or would they have to be essentially re-invented? what happens if the international situation seriously worsens? should the regime be implemented so that enthusiasm, expertise and funding is maintained? should the strictness of the regime be eased over time as a nuclear weapon-free world becomes the norm?

The research product of VERTIC's 'Getting to Zero' project comprises four reports dealing with:

1) verification of the transition to low levels of nuclear weapons, covering the period in which the nuclear weapon states would be expected to cut their nuclear warheads to below 1000 each;

2) verification of the transition to a nuclear weapon-free world, covering the period when complete nuclear disarmament is achieved and detailing the type of treaty and accompanying verification arrangements likely to be required;

3) management and verification of 'virtual' nuclear capabilities and 'virtual' nuclear deterrence, whereby residual nuclear capabilities (such as skilled personnel, fissionable materials and general industrial capacity) would give some states, especially former nuclear weapon states, the edge in any attempt to reconstitute nuclear weapons, thereby giving them a form of nuclear deterrence; and

4) how to sustain the verification system for a nuclear weapon-free world into the indefinite future.

On the question of the nuclear status of states, the four papers use the following terminology:

- **nuclear weapon state (NWS)**: a state which, as defined by Article VIII of the 1968 nuclear Non-Proliferation Treaty (NPT), had 'manufactured and exploded a nuclear weapon or other nuclear explosive device prior to January 1, 1967'; the NWS are thus China, France, Russia, the UK and the USA;
- **de facto nuclear weapon state (DFNWS)**: a state known to have nuclear weapons but which is not recognised by the NPT as being a nuclear weapon state; currently the DFNWS are considered to be India, Israel and Pakistan;
- **non-nuclear weapon state (NNWS)**: a state which is party to the NPT and legally recognised as not having nuclear weapons; there is in addition a tiny number of states not party to the NPT but which are also assumed not to have nuclear weapons, most notably Cuba.

This report, by Dr Patricia Lewis, former Executive Director of VERTIC and currently Director of the UN Institute for Disarmament Research (UNIDIR) in Geneva, is the first in the series.

VERTIC is grateful to the Ploughshares Fund of San Francisco and the W. Alton Jones Foundation of Charlottesville, Virginia for their financial support for the Getting to Zero project. VERTIC is also grateful to those individuals who have commented on draft manuscripts, offered advice and assistance and participated in VERTIC workshops as part of the project.

Trevor Findlay
Series Editor
September 1998

Executive Summary

- This paper discusses verification of the transition from the current levels of thousands of nuclear weapons to low levels, defined as being in the hundreds per nuclear weapon state (NWS). The establishment of effective and efficient verification for this transition will lay the foundations for the transition to zero nuclear weapons.

- Despite the obvious benefits of nuclear disarmament, the process of reducing nuclear forces dramatically and eventually eliminating them would involve some risk. Among the questions that need to be addressed before the process proceeds are the following: how sure can one be that all nuclear weapons have been accounted for and destroyed? how sure can one be that the verification system will be able to detect any clandestine nuclear weapons programme in time for it to be stopped? can verification give us the security required?

- There are risks whatever course of action is taken. Verification cannot provide 100 per cent certainty, but rather a system for reducing risks and deterring cheating.

- The process of reducing the large numbers of nuclear weapons that currently exist will rely on a system of verification that has as its cornerstone the verification regimes of the Intermediate-range Nuclear Forces (INF) Treaty and the Strategic Arms Reduction Treaties I and II (START I and II).

- For reductions to low levels, the verification regime need not be as stringent as going to zero. The verification regime established for the transition to low levels will, however, also serve as the foundation of the regime required for the transition to zero and beyond. Verification should thus be seen as an investment in the future.

- After several years of verifying the transition to low levels of nuclear weapons, a pattern of knowledge would be assembled, increasing confidence in the process. Further reductions to zero nuclear weapons, based on a high degree of confidence, would then be more likely.

Glossary

ABM	Anti-Ballistic Missile
ALCM	Air-Launched Cruise Missile
CD	Conference on Disarmament
CFE	Conventional Armed Forces in Europe
CIS	Commonwealth of Independent States
CTBT	Comprehensive Test Ban Treaty
CTBTO	Comprehensive Test Ban Treaty Organisation
CWC	Chemical Weapons Convention
DFNWS	De Facto Nuclear Weapon State
DPRK	Democratic Peoples' Republic of Korea (North Korea)
EMP	Electro-Magnetic Pulse
FMCT	Fissile Material Cut-Off
HEU	Highly-Enriched Uranium
HPTA	High-Performance Trace Analysis
IAEA	International Atomic Energy Agency
ICBM	Inter-Continental Ballistic Missile
IDC	International Data Centre
IMS	International Monitoring System
INF	Intermediate-range Nuclear Forces
LEU	Low-Enriched Uranium
MIRV	Multiple Independently-Targetable Re-entry Vehicle
MOX	Mixed-Oxide Fuel
MOU	Memorandum Of Understanding
Mt	Megaton
NNWS	Non-Nuclear Weapon State
NPT	Non-Proliferation Treaty
NTM	National Technical Means
NWS	Nuclear Weapon State
OSI	On-Site Inspection
SALT	Strategic Arms Limitation Treaties
SLBM	Submarine-Launched Ballistic Missile
SLCM	Sea-Launched Cruise Missile
SNDV	Strategic Nuclear Delivery Vehicle
SRAM	Short-Range Attack Missiles
START	Strategic Arms Reduction Treaty
TART	Tactical Arms Reduction Talks (Treaty)
TLI	Treaty-Limited Item
UK	United Kingdom of Great Britain and Northern Ireland
UN	United Nations
US or USA	United States of America

1. Introduction

Since the Intermediate-range Nuclear Forces (INF) Treaty was negotiated in 1987[1] there have been steady reductions in the numbers of nuclear weapons from their Cold War peaks, both through agreed and unilateral measures. The third stage of the Strategic Arms Reduction Talks process (START III), which aims to reduce US and Russian strategic arsenals to approximately 2,000-2,500 each, looks likely to commence in a couple of years.

Since the indefinite extension of the nuclear Non-Proliferation Treaty (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. Most notable was the Canberra Commission on the Elimination of Nuclear Weapons which produced its report in August 1996. It 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'[2]. The Commission proposed 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 undertakings of no-first use and non-use against non-nuclear weapon states.[3]

However, there is a great deal of institutional reluctance 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 to the fear of change and the risks that nuclear disarmament would entail.[4] In addition, while there is great opposition to nuclear weapons in the military, there are also institutional forces within it that are against deep cuts in the nuclear arsenal.[5]

There are risks whatever course of action is decided. To leave nuclear forces at high levels leaves the risk of accidental launches and explosions high. Such inaction may increase the risk of proliferation in the long run because non-nuclear weapon states (NNWS) may conclude that the nuclear weapon states (NWS) view nuclear weapons as essential for their security whatever the political circumstances. Indefinite retention of nuclear weapons by the NWS would also erode trust between them and the NNWS because the former would be continuing to fail to meet their obligations under the NPT. Deciding not to reduce nuclear weapons dramatically and thus not to eventually

---

[1] Treaty between the United States of America and the Union of the Soviet Socialist Republics on the Elimination of their Intermediate-Range and Shorter-range Missiles, December 1987.

[2] *Report of the Canberra Commission on the Elimination of Nuclear Weapons*, Executive Summary, Australian Department of Foreign Affairs and Trade, Canberra, Aug. 1996, p. 9.

[3] One of the Commission members, General George Lee Butler, called for the abolition of nuclear weapons at the US National Press Club in December 1997. His stance was supported by other generals and admirals from around the world. See George Lee Butler, 'Time to End the Age of Nukes', *Bulletin of the Atomic Scientists*, vol. 53 no. 2, Mar./Apr. 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.

[4] See for example, Robert G. Sulak Jr., 'The Case in Favor of US Nuclear Weapons', *Parameters*, spring 1997, pp. 106-118.

[5] 'Military Can Meet Threat With 2,000 Nukes, But Not Less', *Inside the Air Force*, 28 March, 1997.

eliminate them, begs the question of how long those who advocate such inaction think that nuclear weapons will be needed? Do they ever see a time when the elimination of nuclear weapons could be possible, or do they see the current state of affairs as being indefinite, perhaps until some new and even more destructive technology supplants nuclear weapons? Why is it that many who advocate nuclear deterrence believe it is possible to eliminate chemical and biological weapons but not nuclear weapons?

Clearly, reducing nuclear forces dramatically and eventually eliminating them also carries risks. The most important is the possibility of 'breakout'. How can one be sure that all nuclear weapons have been accounted for and destroyed? How can one be sure that the verification system will be able to detect any clandestine nuclear weapons programme in time for it to be stopped? Can a verification regime provide the security required? Or will other arrangements such as a UN nuclear force, 'virtual nuclear arsenals',[6] missile defence systems[7] or other 'counter-proliferation measures' be viewed as necessary? Will the norm against nuclear weapons be strong enough to make the preferred response to a rogue state or organisation which attempts nuclear blackmail in an (otherwise) nuclear weapon-free world, be a conventional one? Would the elimination of nuclear weapons so dramatically alter the power relations between the NWS that the international system would become unstable?

There cannot be 100 per cent certainty when verifying the elimination of nuclear weapons. Verification reduces risk and deters cheating. If established carefully and painstakingly, a verification system can provide a very high level of confidence that states are abiding by their commitments.

All states in possession of nuclear weapons, together with those without them, must decide whether the elimination of nuclear weapons is worth the risks and whether these are more acceptable than those posed by retaining them. Governments must also decide to what extent they are prepared to accept highly intrusive inspections and how much funding and resources they are prepared to provide for a high-confidence verification regime. To advocate nuclear disarmament without being prepared to accept intrusive and expensive verification is irresponsible.

---

[6] Michael J. Mazarr, 'Virtual Nuclear Arsenals', *Survival*, autumn 1995, pp. 7-26.

[7] In *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 established a realistic hedge against cheating, Schell did not believe that verification of complete nuclear disarmament could be adequate.

2. An Approach to Deep Cuts

Although the START process between the United States and Soviet Union (now Russia) has made considerable headway in nuclear reductions, it will need at some stage in the future to include China, France and the UK. China and the UK have stated that not until US-Russian forces are reduced to near their levels will they consider joining reduction negotiations. The UK position may well change, but China's is unlikely to in the near future.

None of the NWS will consider joining a nuclear disarmament process aimed at zero nuclear weapons unless several criteria are fulfilled:

1) all the NWS are involved;

2) the de facto nuclear weapon states are also involved;[8]

3) the security environment is conducive to strategic change;

4) transparency and verification regimes provide assurance that the process can be effectively verified;

5) there is a strategy to deal with fissile materials that is clear, environmentally sound and renders the material invulnerable to theft or diversion;

6) the Chemical Weapons Convention (CWC) and Biological Weapons Convention (BWC) are adhered to by all significant states and that assured compliance increases;

7) measures are in place to counter the possibility of break-out;

8) verification measures are in place for the long term so that defence planning can proceed with sufficient confidence that nuclear weapons will never be a feature of international relations again.

This process of disarmament will likely take decades—if not due to politics then due to practicalities. START I and II have already demonstrated the enormous effort that will have to go into dismantling nuclear weapons, storage of materials and verification. The addition of more parties with different infrastructures and nuclear histories will slow the process. Also, politics will likely determine—even if there is agreement that the ultimate goal is elimination—a staged approach, permitting the negotiators at each stage to assess how confident they feel about proceeding to the next.[9] That confidence will depend to a large extent on verification and the trust built up between the parties.

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

---

[8] The DFNWS have variously been referred to as the 'threshold states', the 'hold-out states' or the 'undeclared nuclear weapon states'. India and Pakistan, as a result of their nuclear tests and declarations are no longer threshold or undeclared, although they remain hold-outs from the NPT. By the end of a deep-cuts process the DFNWS may be fewer or greater in number.

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

Knowing the nuclear history[10] of a country is crucial for preparing for a transition to low levels of nuclear weapons with a view to going to zero. For example, when South Africa declared in March 1993 that it had destroyed its small nuclear arsenal in 1990, the only means that the International Atomic Energy Agency (IAEA) had to verify this were the original, hand-written, operating records of the uranium enrichment plant at Valindaba.[11] Although there are few who doubt that all South Africa's nuclear weapons were dismantled, the experience illustrated how difficult verifying a declaration can be years after the event, especially when little of a civil nuclear programme has been independently monitored beforehand.

In the period of reducing to very low levels, it is vital, therefore, to build a databank of knowledge on the nuclear weapon programmes of each NWS and, eventually, of the de facto nuclear weapon states.

If we assume that the START III process will get underway very soon (following the ratification of START II in the Russian Duma), and that the US and Russia reduce their strategic arsenals to 2,000 or 2,500 each by 2007, then follow-on negotiations between Russia and the US could bring numbers of strategic weapons down to about 1,000 each. There are also thousands of tactical weapons still to be considered. It is estimated that in Russia alone there are between 5,000 and 12,000 tactical warheads to be retired.[12]

As a result of START III or even without such a formal treaty, the US and Russia could make deeper cuts in their nuclear arsenals (strategic and tactical), which could then lead to very substantial cuts in the nuclear weapons of all NWS. There have been numerous proposals[13] for phased reductions in nuclear weapons based on a recognition that after the end of the Cold War there is no remaining justification for such large arsenals. Although many analysts believe 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 the position of possessing just hundreds of nuclear weapons each, 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 degree of confidence that they have in the verification regime and judge the status of the de facto nuclear weapon states. Such states may have already dismantled their weapon programmes after the fashion of South Africa. Even if they have only previously participated in a transparency process they may be prepared to join in the reduction process. Or they may need further persuasion that the process is genuine and in their security interests.

One possible scheme for deep cuts is outlined on the following page. The steps need not be sequential but can run in parallel or overlap.

---

[10] Steve Fetter, 'Nuclear Archaeology: Verifying Declarations of Fissile Material', *Science and Global Security*, vol. 3, nos. 3-4, 1993.

[11] Steve Fetter, 'Verifying Nuclear Disarmament', *Occasional Paper*, no. 29, Henry L. Stimson Center, Washington DC, Oct. 1996.

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

[13] See for example: Frank von Hippel, 'Paring Down the Arsenal', *Bulletin of the Atomic Scientists*, vol. 53, no. 3, May/June 1997, pp. 33-40; 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 Mar./Apr. 1996; Jack Mendelsohn, 'START II and Beyond', *Arms Control Today*, vol. 26, no. 8, Oct. 1996.

A Possible Scheme for Deep Cuts

START III

- A reduction to 2,000-2,500 strategic warheads by 2007 by Russia and the US.
- Nuclear forces taken off alert.

Tactical Arms Reduction Treaties (TARTs)

- 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).

NWS transparency and confidence-building

- Either before or after START III 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[14] and on-site inspections (OSIs) to check declarations.

NWS proportional or gradual reductions

- Having established a framework for transparency the NWS could then embark on reductions—either 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 by amounts to be agreed at each stage of negotiations or percentage reductions at specified time intervals.[15]

Multilateral transparency and confidence-building

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

Very low levels

- At the end of the reduction process the NWS should be left with very low levels of nuclear weapons. They should also be participating with the de facto nuclear weapon states in a transparency regime. At this point the decision to go on to the final elimination of nuclear weapons will be made.

---

[14] Harald Mueller, 'Transparency in Nuclear Arms: Towards a Nuclear Weapons Register', *Arms Control Today*, vol. 24, no. 8, Oct. 1994, pp. 3-7.

[15] See Singer.

3. A Verification Scheme for Deep Cuts

The success of any agreement depends on building an atmosphere of trust between the parties. This trust can only be maintained if all sides are confident that violations are likely to be detected. Verification is a process that establishes whether all parties are complying with their obligations.[16]

However 100 per cent certainty in verification is impossible. The role of verification is to ensure that a party contemplating violation of a treaty runs a substantial risk of being detected. The consequences of being detected need to be seen as unacceptable by potential violators. This is called 'verification deterrence'. The design of a verification regime determines whether the likelihood of detecting significant cheating is high or low.

Verification includes the collection of information relevant to obligations under the agreement, analysis of the information and the making of judgements as to whether the specific terms of the agreement are being met.[17]

On the following page is the outline of a possible verification scheme for deep cuts. The steps outlined need not necessarily be taken in the order indicated.

[16] For further general discussion of verification see Patricia M. Lewis, 'Verification as Security', *VERTIC Matters*, no. 8, VERTIC, London, 1995.

[17] '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.

Outline of a Verification Scheme for Deep Cuts

START III (US and Russia only)

- data exchange and transparency
- on-site inspections
- information from satellite and aircraft
- verification of missile reductions
- warhead dismantlement monitoring
- nuclear materials safeguards
- verification of a halt to fissile material production

NWS transparency and confidence-building measures

- begin process before any reductions
- data exchange and transparency
- on-site inspections (carried out by inspectors from the NWS but monitored by the IAEA)[18]
- information from satellites and aircraft
- nuclear materials safeguards (not necessarily full-scope)
- verification of a halt of fissile material production
- agreement on nuclear propulsion

NWS proportional or gradual reductions

- data exchange and transparency
- on-site inspections
- information from satellite and aircraft
- verification of missile reductions
- warhead dismantlement monitoring
- nuclear materials safeguards
- verification of a halt of fissile material production

Further NWS transparency and confidence-building measures

- begin process before any reductions
- multilateral data exchange and transparency
- multilateral on-site inspections
- information from satellites and aircraft
- nuclear materials safeguards
- continued verification of the halt of fissile material production

NWS reductions to very low levels

(not necessarily equal across the five states, e.g. US and Russia might retain more than the other three)

- agreement on missile defences
- data exchange and transparency
- on-site inspections
- information from satellite and aircraft
- verification of missile reductions
- warhead dismantlement monitoring
- nuclear materials safeguards.

---

[18] Richard Guthrie, 'The Transition to a Nuclear Weapon Free World: A New Model for the Verification Framework', *Verification Matters* Briefing paper 97/1, Apr. 1997, VERTIC, London.

4. Verification Techniques and Technologies[19]

Transparency and data exchanges

It is important for the process of confidence-building that as much information 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 their delivery vehicle;
- aggregate amounts and locations of weapons-grade fissile material in active warheads, stored warheads, dismantling facilities, production facilities, nuclear propulsion fuel, stored pits, scrap, waste;
- 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 and transferred for space launches;
- location, purpose and layout of facilities that produce nuclear weapon components such as fissile materials, fusion materials, high explosives, fusing and firing assemblies.

These data can be checked and confirmed by on-site inspection and national technical means (NTM), originally 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 to prepare for 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. The agency would not carry out the inspections itself, but would attempt to satisfy itself that inspections had been conducted correctly.[20]

Nuclear history[21]

As a complement to verifying data exchanges, and as an adjunct to the data the NNWS will supply under the new safeguards agreements with the IAEA to be concluded as part of the IAEA's Programme to Strengthen the Effectiveness and Improve the Efficiency of Safeguards,[22] it would be useful if the NWS, and eventually the DFNWS were to make available a complete nuclear history of their arsenals. Data could include the history of

---

[19] For an excellent summary of the wide range of technologies and methods applicable to nuclear disarmament see the following in *Background Papers to the Canberra Commission on the Elimination of Nuclear Weapons* (Department of Foreign Affairs and Trade: Canberra, August 1996): Christopher E. Paine, Thomas B. Cochran, Robert S. Norris, 'Techniques and Procedures for Verifying Nuclear Weapons Elimination'; Christopher E. Paine, Thomas B. Cochran, Robert S. Norris, 'Technical Realities Confronting Transition to a Nuclear Weapon-Free World'; 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'.

[20] See Guthrie.

[21] Fetter, *'Nuclear Archaeology'*, pp. 237-259.

[22] Suzanna van Moyland, 'The IAEA' s Programme 93+2', *Verification Matters*, no. 10, VERTIC, London, Jan. 1997.

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 used to confirm activities such as plutonium production at certain facilities. It is expected, however, that the records will be far from complete and may not permit a full accounting.

De-alerting missiles

Despite the end of the Cold War, nuclear forces are still operating in alert mode. There have been a number of proposals recommending that strategic weapons systems be taken off such alert status.[23]

In 1994 there were statements from the US, Russia, UK and China that strategic nuclear missiles on alert were no longer targeted at each other.[24] Although these statements did help build confidence between the NWS, they are not sufficient to significantly reduce the possibility of accidental launches: there is no way of verifying them and in any case it would take minutes to place nuclear forces back on alert. In May 1997 President Yeltsin made a further, confusing, statement about taking missiles off alert which the President's staff later clarified as being intended to reassure the NATO countries that they were no longer the targets of Russia's missiles.

There have been some practical actions. The US removed bombers from 15-minute alert so that they no longer stand fully armed at the end of runways. Russia reduced the number of SSBN patrols and decommissioned some submarines earlier than planned.[25] There are other technical measures that could be carried out. The following are examples, although they will not be applicable across the board (indeed the UK would find it hard to adopt many de-alerting measures simply because since the end of March 1998 it has had only one type of nuclear weapon, based at sea):

- 'safeing' silo-based missiles so that the ignition system is physically blocked (e.g. by a special pin as used in 1991 for 450 US Minuteman II missiles);[26]
- decoupling warheads from missiles and placing them in separate locations;
- removing weapons from heavy bombers;
- reducing strategic submarines and eliminating or reducing the frequency of operational patrols;
- physically separating guidance equipment from missiles;
- removing warhead covers; and
- physically separating missiles from their engines.

Each of these steps could be subject to inspection, either by on-site inspectors or satellites. Surveillance cameras could be installed to monitor potential re-loading at

---

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

[24] Marco De Andreis and Francesco Calogero, 'The Soviet Nuclear Weapon Legacy', *SIPRI Research Report, no. 10*, Oxford University Press, Oxford, 1995, p. 67.

[25] Alexei Arbatov, 'De-alerting Nuclear Forces: A Substitute or Supplement to Disarmament?', *Background Papers to the Canberra Commission on the Elimination of Nuclear Weapons*, Canberra, Aug. 1996, p. 303.

[26] Christopher E. Paine, Thomas B. Cochran, Robert S. Norris, 'Practical Interim Steps Toward Nuclear Weapons Elimination and a Fissile Material Control Régime for Nuclear Weapon States,' *Background Papers to the Canberra Commission on the Elimination of Nuclear Weapons*, Canberra, Aug. 1996, p. 102.

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 subject to verification.

Missile monitoring

Because nuclear warheads alone, without some means of delivery, were not perceived as the main threat during the Cold War, the INF Treaty and START I and II focused on reducing the numbers of launchers, missiles and bombers. Although START III and beyond will address the destruction of warheads, control of the means of delivery will remain just as important.

Verification measures which could reveal how many nuclear weapons were on board ships and submarines and what type, would play an important role. Before START I 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 follow the missile as it was carried to a disassembly facility.[27] There are a number of procedures to permit verification of numbers 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. There could also be spot check inspections at other ports to check that facilities for handling nuclear weapons are not available for clandestine deployment. In the case of Trident submarines this could be aided by monitoring the activity schedule of the two special cranes needed for loading and unloading D5 missiles.

The issue of dual capability is difficult to resolve. Because some missiles can carry both nuclear and conventional warheads and because the difference between them is not easy to discern externally,[28] it could be relatively easy to substitute nuclear missiles for the declared conventional. Portable nuclear radiation detectors measuring radiation emanating from a nuclear warhead, as described below would be used to distinguish between them (care being taken to eliminate the effects of radiation from the naval reactor).

As the NWS reduce to low levels of nuclear missiles the reduction process is vulnerable to the possibility that a small clandestine store of extra nuclear weapons might be retained. For example, if the numbers agreed 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. The discovery of such subterfuge could wreck any moves to make further reductions and achieve eventual elimination. It is imperative, therefore, that the verification of these low levels be extremely stringent.

One way to increase confidence in the verification regime would be to close all but a few missile sites and platforms in each NWS. Although this could increase the sense of vulnerability to nuclear strikes, these sites could be carefully monitored. Any missile found elsewhere than the allowed sites or platforms would be an obvious violation (this

[27] *Trust & Verify*, no. 13, Aug./Sept. 1990, VERTIC, London.

[28] V. Thomas, 'Verification of Limits in Sea-launched Cruise Missiles' in F. von Hippel and R. Sagdeev (eds), *Reversing the Arms race: How to Achieve and Verify Deep Reductions in the Nuclear Arsenals* (Gordon and Breach Science Publishers: New York 1990), pp. 147-172.

implies the inspection of undeclared sites). Tags would greatly help in such a verification process. If only tagged weapons were allowed, any untagged weapon or wrongly tagged weapon found would be in contravention of the treaty. Inspectors would then only have to check tags on weapons and check that all weapons had valid tags. Sampling of missile tags is then possible, rather than having to account for each 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 deployed or stored is a critical part of laying the foundations for a comprehensive verification regime. If there is little faith in the accuracy of the accounting procedures, it will be hard for 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.

Visual inspection by removing the nose cone shroud, moreover, 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 (not all nuclear weapons have shrouds however).

During on-site inspections, including baseline inventory inspections, warheads would be monitored 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,[29] thus recording a unique signature or 'fingerprint'. These measurements could be taken automatically and encoded so that 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 large enough to contain nuclear warheads may also be subject to radiation detectors, both active and passive.

Passive radiation detectors simply measure the radiation from nuclear material. Active nuclear detectors use the transmission of 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 a container can be compiled from the measurements. Neutron activation analysis can yield detailed information on the composition of the materials inside. Such detection equipment is now portable and used routinely in industry and 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 were transported for dismantlement.

[29] Steve Fetter, '*Verifying Nuclear Disarmament*', pp. 10-11.

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.

US and Russian Missiles Destroyed Since 1987		
Treaty	US Missiles destroyed	Russian/USSR missiles destroyed
1987 INF Treaty	832 by 1 June 1991	1,846 by 1 June 1991
1991 START 1*	507 by mid 1997	688 by mid 1997

** Figures calculated by comparing data in the 1990 US/USSR Memorandum of Understanding (MOU) and the latest published figures in January 1998 culled from the MOU exchange in July 1997. Sources: Arms Control Association, Washington DC and US Arms Control and Disarmament Agency, Washington DC.*

Excess missiles can be destroyed in a variety of ways. All of the methods used for the INF Treaty and START process can be employed in a future disarmament process. such Destruction methods include slow burning, controlled explosions and transfer, under strict controls, to the civil sector for use 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 an increasing percentage of the whole.

Warhead dismantling

Although verification of warhead dismantling was not part of the INF Treaty or START I and II, substantial work has been done on the techniques and technologies required for this next step,[30] including work by the US government as early as 1969.[31]

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 warheads coming in and out and carry out periodic inventories on the site.[32] Such a process is called portal-perimeter monitoring and there is a great deal of experience in such techniques from the INF Treaty and START I. Their identifying tags would be read on arrival and any untagged warheads fingerprinted and tagged. If there were any doubt as to whether an item contained a nuclear explosive device, active radiation measurements could be made (see below) to detect radiation shielding.

[30] 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*, vol. 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*, vol. 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*, vol. 1, nos. 3-4, 1990, pp. 328-333.

[31] Frank von Hippel, 'The 1969 ACDA Study on Warhead Dismantlement', *Science and Global Security*, vol. 2, no. 1, 1990, pp. 103-108.

[32] Steve Fetter, *'Verifying Nuclear Disarmament'*, pp. 12-13.

A major problem when monitoring the destruction of warheads is the protection of sensitive information relating to the warhead design. Inspectors need to be certain that the warheads have been destroyed without, at the same time, gaining highly classified information on warhead design. This is necessary to avoid the spread of information about how nuclear weapons are made to those who do not have such knowledge. Avoiding the proliferation of knowledge can be achieved by a series of simple steps:[33]

1. The warheads would be brought to a warhead dismantling facility after being tracked throughout transit. Tamper-resistant locks which sealed the warhead containers when they were removed from their deployment sites would be checked and the warheads 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 experts from the NWS that owns the warheads and split into nuclear and non-nuclear components.

3. All of the parts would then be shown to the other NWS inspectors and checked against the record taken in step 1. Parts could be crushed, fissile and fissile material put under safeguards and taken to interim storage awaiting disposal. Inspectors would witness the removal of all the parts and, due to portal perimeter monitoring and periodic whole-site inventory checks, would be certain that materials not could have been substituted.

Tagging technologies[34]

Tags are in common use for internal accounting purposes, as for example, in vehicle registration numbers, engine serial numbers and bar codes in supermarkets. While missiles and warhead components have identification markings for internal accounting purposes, there would be no proof that on inspection the identification numbers were genuine. It may be possible to have one set of registration numbers for inspectors and a completely different set for internal accounts. It could thus 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 it was possible to fool inspectors by duplicating US Army equipment numbers.[35]

Tags would aid detection of violations and verification of limits on numbers, allowing 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 detected would be a clear treaty violation.

---

[33] For more details of such procedures see Theodore B. Taylor, 'Warhead Dismantlement and Fissile-material Disposal' in F. von Hippel and R. Sagdeev (eds), *Reversing the Arms Race—How to Achieve and Verify Deep Reductions in the Nuclear Arsenals* (Gordon and Breach Science Publishers: New York, 1990), pp. 91-115.

[34] Adapted from Patricia M. Lewis, 'Verification of Nuclear Weapon Elimination' in Regina Cowan Carp (ed.), *Security Without Nuclear weapons?*, (Oxford University Press for SIPRI, Oxford, 1992), pp. 128-152.

[35] Patricia M. Lewis, 'Verification Experiments in the 1960s: From CLOUD GAP to Exercise "FIRST LOOK" in Richard Kokolski and Sergey Koulik (eds), *Verification of Conventional Arms Control in Europe: Technological Constraints and Opportunities* (Westview Press for SIPRI: Boulder, CO, 1990), p. 264.

Tags also simplify sampling procedures for inspections. The problem of data collection is then simply one of data verification. That is, missiles and warheads can be checked on an inventory checklist, allowing 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 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 needed for verification purposes and not interfere with the tagged item's function.

Tags fall into two main categories:

1. Active
These provide their own identification, i.e. they are electronic and provide digital information. They can be attached to an item for inspection with a specified code which will automatically void if tampered with.

2. Passive
These require comparison with a record for their identification. They are based on the techniques of pattern recognition. and include, for example, a 'fingerprint' of a surface—a photographic image or an acetone print of a part of the missile surface.

Fissile materials

Even though the INF Treaty and START I do not directly require nuclear warheads to be dismantled, the dismantling of strategic and tactical warheads has been carried out as a direct result of these agreements and unilateral withdrawals of tactical nuclear weapons. Further nuclear weapon reductions will produce more plutonium (Pu) and highly enriched uranium (HEU) for disposal. As the nuclear disarmament process continues these materials will come from warheads of NWS other than the US and Russia.

Stocks of military HEU and weapons-grade plutonium are hard to gauge. The most recent estimates are listed in the following tables.

Estimated Stocks of Military HEU and Weapons-Grade Plutonium (in tonnes), 31 December 1994

Country	Weapon-grade HEU equivalent	Weapon-grade plutonium
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*

** this is unlikely to remain the case.*
Source: David Albright, Frans Berkhout and William Walker, Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies (Oxford University Press for SIPRI, Oxford, 1997), pp. 399-402.

Estimated Civil and Military Inventories of Plutonium and HEU World-Wide (in tonnes), 31 December 1994			
	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 (Oxford University Press for SIPRI, Oxford, 1997, pp. 397.			

In addition, whether or not a treaty banning the production of fissile materials for weapons purposes is negotiated, and whether or not that treaty covers stocks of fissile materials, the issue of fissile material production and stocks will have to be addressed before the transition to very low levels of nuclear weapons. The verification systems in place for monitoring fissile materials are carried out by the IAEA (see Appendix 1). In many respects the monitoring of fissile material stocks and production will be similar, if not identical, to the monitoring of fissile materials under the NPT in non-nuclear weapon states. The difference will lie in the extent to which, during the transition to low levels, nuclear weapons secrecy can be maintained using such practices. The issue of stocks will assume increasing importance as the numbers of nuclear weapons decrease, as will the issue of the levels of stocks held by the de facto nuclear weapon states.

There are a number of ways to deal with weapons-grade fissile material.[36] In the case of 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 be used for making nuclear weapons without costly re-enrichment of the uranium so that it contains the requisite amount of U^{235}. (Since all the isotopes of uranium are chemically essentially the same, chemical separation is not possible. The separation process is thus complex and relies on the small differences in charges and masses of the isotopes).

For electromagnetic separation the effort is proportional to the square of the enrichment. Therefore availability of LEU would be a significant cost saving.[37] Once LEU has been placed under safeguards, it has effectively been removed from the military uranium cycle to the civil sector. So long as safeguards and physical security are fully maintained, the uranium no longer poses a proliferation threat.

HEU is a large proliferation threat. This increases the need for placing all former warhead fissile material under safeguards. In many respects it is easier to make a crude, reliable bomb out of HEU than out of plutonium and it may well be less physically secure in places than weapons-grade plutonium. Market considerations work against the rapid disposal of HEU, but the proliferation risks far outweigh such obstacles.[38]

---

[36] 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* (Oxford University Press for SIPRI: Oxford, 1997), pp. 416-458; John P. Holdren, 'Management of Surplus Nuclear Materials', *Background Papers to the Canberra Commission on the Elimination of Nuclear Weapons*, p. 241.

[37] R. Joern S. Harry, private communication.

[38] Albright, Berkhout and Walker, p. 445-446.

Plutonium, however, is altogether different. All plutonium isotopes can be used as an explosive if a critical mass is formed,[39] although not all are very useful for maximal bomb design. In addition, while blending plutonium with U^{238}(a non-fissionable isotope of uranium) forms a mixed oxide (MOX) fuel for use in MOX-fuel reactors, this does not present a permanent solution, because plutonium and uranium can be easily separated chemically. As a result, a great deal of attention has been given in recent years to procedures for disposing of weapons-grade plutonium. The US National Academy of Sciences[40] has devised a 'spent fuel standard' which demands that whatever method of plutonium disposal is used, the fuel should be at least as inaccessible as the stock of plutonium in civilian spent fuel.

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,[41] the second is to blend it with high-level radioactive wastes and then vitrify it for long-term storage,[42] and the third is to store it in deep bore-holes. While awaiting disposal in one of these forms, plutonium pits are currently being stored in secure environments under the supervision of the owners. Implementation of agreements concluded in 1995 between the US and Russia, requiring exchange of information on nuclear stockpiles and materials and reciprocal monitoring of nuclear material storage facilities,[43] has been prevented by delays over an agreement on co-operation 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 was due to report in mid-1997. In December 1996, the US Department of Energy announced a 'dual-track' strategy[44] for disposal of up to 50 tonnes of plutonium: conversion into MOX and mixing it with high level wastes, then vitrification.[45]

While it is currently unlikely that fissile material from storage sites would be squirreled away, since there is an excess of the material (this does not imply that there is no risk of theft), nonetheless as a confidence-building measure it is important that the US, Russia and the IAEA implement transparency measures soon for the accounting and storage of

---

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

[40] National Academy of Sciences, Management and Disposition of Excess Weapons Plutonium.

[41] John P. Holdren, 'Work with Russia', *Bulletin of the Atomic Scientists*, vol. 53, no. 2, Mar./Apr. 1997, p. 42; Edwin S. Lyman and Paul Leventhal, 'Bury the Stuff', *Bulletin of the Atomic Scientists*, vol. 53, no. 2, Mar./Apr. 1997, p. 45.

[42] There are also proposals for irradiating the plutonium 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: Cambridge, Mass.), 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).

[43] 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.

[44] 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, Nov./Dec. 1996, p. 3.

[45] Mike Moore, 'Plutonium: The Disposal Decision', *Bulletin of the Atomic Scientists*, vol. 53, no. 2, Mar./Apr. 1997, p. 41.

surplus fissile material. Future confidence in deep cuts and eventual elimination will be greatly enhanced if transparency measures are established in advance.

At the 1997 Helsinki Summit between US President Clinton and Russian President Yeltsin, the proposed negotiations for START III 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 issues related to transparency in nuclear materials. This will clearly 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, a great deal of the necessary measures could already be in place. Albright, Berkhout and Walker[46] have proposed four guiding principles for an international strategy for the disposal of nuclear materials:

1. **Universality:** all fissile materials in all countries should be subject to the same verification standards.

2. **Transparency:** summaries of inventories should be prepared by all states and followed by the preparation of detailed inventories for verification purposes.

3. **Minimisation:** no new production should be permitted unless for well-founded commercial or other reasons. Excess fissile material should be eliminated.

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

Infrastructure monitoring

In addition to monitoring the destruction of delivery vehicles, warheads, launchers, fissile materials residual levels and stocks of those items, the issue of the infrastructure of nuclear weapons production, storage, maintenance and deployment would have to be addressed in the transition to very low levels—particularly if the decision to achieve a nuclear weapon-free world is then made.

The organisation of nuclear weapons infrastructure varies among the nuclear weapon states. The production of nuclear weapons begins with the design, computer modelling, laboratory experiments and nuclear test explosions. This is an iterative process, each stage being tested and checked and the results fed back into the process. Rarely did the results of nuclear tests match expectations. The results were used to modify designs and eventually another test explosion was carried out. This process continued through several cycles (the number depending on the results, the quality of computer modelling and the amount and quality of laboratory experimentation) until the designers and potential users were satisfied with the outcome and a final proof test was carried out.

Despite the negotiation of the CTBT, the NWS have, for the most part, retained their nuclear testing infrastructure. This has caused consternation among observers, especially when sub-critical, non-explosive experiments have taken place at the test sites in the full knowledge that it would not be technically possible to discriminate between an allowed sub-critical experiment and a prohibited very low yield or hydronuclear test. For this

[46] Albright, Berkhout and Walker, *Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies*, p. 458.

reason there have been calls to close down the test sites as a confidence-building measure and an aid to the CTBT verification regime. The NWS, with the exception of France, have chosen to keep open their nuclear test sites in order to use them for design purposes now or in the future.

Other aspects of nuclear weapon infrastructure, such as the design laboratories, production lines, fissile material production facilities, missile production facilities, storage, maintenance, dismantling and deployment facilities tend to be complex and multi-purpose. In the transition to low levels, as part of a process to eventually eliminate nuclear weapons, thought would have to be given to the confidence-undermining potential of leaving these facilities intact.

It is easy to see how deployment, maintenance, dismantling and storage facilities could be closed down and monitored as the weapons were removed from them—this has been the pattern in the INF and START agreements. Production facilities too could be monitored in a similar manner to these bilateral treaties and fissile material production may well be being monitored under a Fissile Material Cut-off Treaty (FMCT).

Testing grounds and design facilities will be the trickiest aspects of infrastructure. Even prior to the end of the Cold War, the nuclear weapons laboratories were beginning to diversify, taking on both other military and non-military design tasks. This trend has accelerated. Decoupling design work on nuclear weapons from design work on, say, medical equipment, when the same individuals are taking part in both may prove impossible and nigh on impossible to verify. If the laboratories were turned into places for purely civilian research, an 'open labs' policy could operate. If, however, legitimate non-nuclear defence-related work were taking place at certain installations, the NWS and DFNWS would be unlikely to countenance turning them into non-military research laboratories.

From the verification point of view, it would then be too intrusive and costly to ascertain if the laboratories were carrying out any form of nuclear weapons design work unless the laboratories were free to participate in a citizen's verification programme. Under such a programme, employees could report to an international authority any illegal activities at the research centre free from fear of prosecution and job loss. In practice, however, it would be hard to convince people that they would be truly protected and in some countries such an approach could not work for political, cultural and other reasons. On the other hand, there are many instances of people risking their jobs and even lives to 'blow the whistle' on illegal activities and any potential violator would have to factor that into calculations about whether to violate the treaty.

5. Organisational Aspects

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

First, 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, some multilateral arrangement between the NWS will be instituted for inspections, data exchange and the provision of information from NTM. A consultative body is also likely to be established to deal with compliance problems and for arranging on-site inspections. As the five NWS carry out reductions in their arsenals, these transparency and data verification arrangements could 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 to the rest of the international community.

This whole process will be complex, time consuming and costly. The better the organisational structure, the more efficient it will be. The NWS and the NNWS have now a large degree of experience in how to handle the verification of arms control and disarmament treaties. The DFNWS, on the other hand have very little experience of such procedures and there are countries which, for cultural reasons, find the concept of transparency and intrusive inspection difficult to understand and accept.

As the NWS approach the end of their deep reduction process, and if the decision is made to fully eliminate nuclear weapons, the extant de facto nuclear weapon states could be brought into the process of transparency and verification to prepare them for dismantling their nuclear weapon programmes along with those of the five declared NWS. Having made the decision to go to zero, many more technologies and procedures (such as high performance trace analysis (HPTA) for environmental monitoring) will be incorporated into the verification regime. It may be that the IAEA would be the appropriate body to carry out such tasks. Alternatively, a UN body could be established to monitor the transition to zero nuclear weapons and the resulting nuclear weapon-free world. One proposal is for a United Nations Disarmament Organisation (UNDO).[47]

Once the NWS have been NNWS for some time it would be most efficient to verify the status of a nuclear weapon-free world under the auspices of the IAEA or some amalgamated body which incorporates the IAEA. How to organise such a process for the long term is the subject of the fourth paper in this series.

---

47 Christopher E. Paine, Thomas B. Cochran, Robert S. Norris, 'International Arrangements for the Transition to a Nuclear Weapon Free World', *Background Papers to the Canberra Commission on the Elimination of Nuclear Weapons*, p. 141.

6. Conclusion

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

If the intended endpoint of this process is to remain at low levels (and it is beyond the scope of this paper to discuss whether such a situation could be stable), the verification regime for the five NWS need not be significantly more stringent than those for INF and START. It will depend on how many nuclear weapons remain—the larger that number the less important any accounting errors 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, the verification regime established in this period will be the foundation of the verification regime required for the transition to zero and beyond. Consequently, it will need to be more ambitious and stringent.

Verification must provide the nuclear weapon states and the de facto nuclear weapon states with the confidence they would need to take the final steps to eliminate nuclear weapons. Verification cannot provide 100 per cent certainty, but after several years' experience in verifying the transition to low levels of nuclear weapons, a pattern of knowledge would be assembled. 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.

Appendix 1

Existing Nuclear Arms Control and Disarmament Treaties

There are a number of treaties which have relevance for the elimination of nuclear weapons. The treaties outlined below are those which would affect the transition to low-levels. The obligations and verification procedures for the INF Treaty, START I and II and the CTBT will have helped lay the foundations for verifying a transition to low levels of nuclear weapons by all the NWS.

The Non-Proliferation Treaty (NPT)

The nuclear Non-Proliferation Treaty, negotiated between 1965 and 1968, entered into force on 5 March 1970 and now has 186 states parties. The significant outsiders are Israel, India and Pakistan.

Responsibility for the verification of compliance with the safeguards obligations of the treaty falls to the IAEA in Vienna through safeguards agreements between the agency and the treaty parties. However, IAEA membership is not the same as NPT membership.

In the early 1990s confidence in the treaty was undermined by the discovery of Iraq's clandestine nuclear weapon programme and suspicions about the capabilities and intentions of North Korea (DPRK) and its long-standing refusal to fulfil its safeguards obligations.

Iraq's situation demonstrated serious shortcomings in the IAEA safeguards system: a lack of resources; inspection criteria based on quantities and types of nuclear materials, leading to numerous inspections of installations in Germany, Japan and Canada and a only a handful in Iraq; and the failure of the international community to promote the use of special or challenge inspections.

North Korea's agreement with the US on the freezing of its nuclear weapons programme and the substitution of its existing reactor programme with light water reactor technology has eased the situation. However, the issue of on-site inspections of undeclared sites is likely to cause problems in a few years when these inspections are to occur.

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. Of course the situation for the NWS is far greater and much more complex than for South Africa. In particular, South Africa's records of its nuclear material production were very detailed. This is unlikely to be the case in all of the NWS.

Since the Iraq and North Korea episodes the IAEA has strengthened its safeguards programme. In 1993 the agency embarked on a two-year programme (previously called '93+2') to evaluate the technical, financial and legal aspects of a wide set of measures to strengthen the safeguards regime. These measures ensure greater access to information about a state party's nuclear activities and to nuclear sites and locations to verify that information.

The programme was divided into two parts. Measures contained in Part 1 fell within the existing legal authority conferred on the IAEA by the comprehensive safeguards agreements. Part 2 measures required additional legal authority. Part 1 measures, now being implemented, include seeking further information than hitherto about a state's nuclear activities and intentions through an Expanded Declaration from the state; unannounced inspections in specific circumstances; and the use of environmental sampling wherever and whenever the agency has a right of access to conduct inspections or design information visits. Part 2 measures include seeking information from states about activities which might be relevant to nuclear activities; seeking more information than hitherto about the domestic manufacture of nuclear equipment and materials; increased inspector access to nuclear-related sites and locations; simplified procedures for the designation of safeguards inspectors and provision of long-term multiple visas for inspectors.

By early 1996 it became apparent that the passage of Part 2 measures would not be smooth. A number of states (especially Germany and Japan) expressed concern 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. Concern was also expressed about the increased reporting and inspection burden on states, which, because of their substantive nuclear industries, are already subject to a large number of inspections. It was also pointed out that the nuclear weapon states, because they are not subject to such mandatory safeguards, would be at a commercial advantage with fewer reporting requirements and inspections. To this end in mid-1996, an open-ended Committee of the IAEA Board of Governors was established to negotiate an Additional Protocol embodying the Part 2 measures. On 3 April 1997 the Committee agreed on a draft Model Protocol for submission to the Board of Governors. On 15 May 1997 the text of the Model Additional Protocol was approved by the Board.

The initial increased costs of a strengthened safeguards system should in due course be partly offset by a reduction in the frequency of on-site inspections under certain conditions and by the provision of information by states. There will, however, be a large increase in efficiency and cost-effectiveness, thus ensuring that the money spent on safeguards is better spent than in the past.

1995 NPT Review and Extension Conference

At the NPT Review and Extension Conference in 1995 it was decided to extend the treaty indefinitely. The NPT already commits 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, and on a treaty on general and complete disarmament under strict and effective international control.' The decision to indefinitely extend the NPT was a result of a package deal in which states parties committed themselves to the eventual elimination of nuclear weapons.

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

1995 Principles and Objectives

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 IAEA in verifying compliance with the NPT. It specifically states that IAEA safeguards should be regularly assessed and evaluated, although 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 ability to detect undeclared nuclear activities increased. Significantly, the document recommends that fissile material, when transferred from military to peaceful uses, be placed under safeguards in the framework of voluntary agreements by 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 co-operation among all interested states parties. Specific reference was 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 conference, the review process is now strengthened 'with a view to assuring that the purposes of the Preamble and the provisions of the Treaty are being realised'. A Review Conference will continue to be held every five years but, from 1997 its Preparatory Committee (PrepCom) will meet in each of the three years prior to the conference. Unlike previously, the purpose of these enhanced PrepComs is to consider principles, objectives and ways, in order to promote the full implementation of the treaty and to make recommendations to the Review Conference. The first of these meetings took place in April 1997 in New York and the second in May 1998 in Geneva.

The Intermediate-range Nuclear Forces (INF) Treaty

The 1987 Intermediate-range Nuclear Forces Treaty between the US and USSR (Russia) which eliminated an entire 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 laid the foundations for the START agreements. The treaty eliminated ground-launched missiles over three years. On-site verification has been in operation ever since. Earlier in the negotiations it looked likely that the treaty would allow for 100 INF missiles to be retained by each side. Verification would have had to have been even more stringent for the same level of certainty. In 1987, however, it was agreed that the treaty would eliminate all INF weapons and consequently, because the INF infrastructure would be shut down, verification could be relaxed. The example of the INF Treaty demonstrates the difference between the 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 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 START I and II 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 future. They are therefore worth outlining in some detail.

First, the data exchanged between two sides was verified 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. Bases from which all assigned missiles had been removed were closed under observation. Warheads were not affected by the treaty and are assumed to have been returned to the national stockpiles for re-use. Active bases were visited at short notice by inspectors to check the numbers of deployed missiles. These were located in several countries, including, after the collapse of the Soviet Union, some of its successor states. Separate memoranda were signed with those countries to allow inspections to proceed. From mid-1988 to mid-1991, 20 challenge inspections were allowed per annum per party, for the following five years 15 and for the final three years 10. On the production side 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 verify that legal SS-25 production facility at Votkinsk was not hiding the production of banned SS-20s, the US installed a portal perimeter monitoring system[48] manned by 25-30 personnel, an infra-red profiler, an X-ray cargo scanner[49] and computers to drive, monitor and analyse the system.

The treaty pays significant attention to the role of National Technical Means. In particular a co-operative measure 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 12 hours. Each side is allowed six such requests per annum. This article (Article XII) contains an interesting reference to strategic arms

---

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

[49] The installation of the X-ray cargo scanner has been fraught with difficulties. See *Arms Control Reporter*, 21 Nov. 1988, 403.B.713, 11 Jan. 1989, 403.B.727, 9 Feb. 1990, 403.B.743 and 11 Mar. 1990, 403.B.745 and *Trust & Verify*, no. 8, Mar. 1990.

reductions, linking the INF Treaty to a future START Treaty. The open display provision was to remain in effect until either START I entered into force or for no more than three years after the INF Treaty became effective (START I did not enter into force until 1994). The article also prohibits interference with NTM by either party.

There have been a few problems[50] with the INF Treaty, but the verification regime and particularly the close collaboration between the parties needed to operate it has enabled these to be sorted out amicably.

The Strategic Arms Reduction Treaty I (START I)

START I, signed in 1991, was the beginning of a second 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 of 1979.

START I actually reduces, in addition to setting upper limits on, the number of deployed nuclear weapons by limiting missiles and warheads rather than limiting launchers. Both missiles 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: [51]

- 1600 SNDVs (inter-continental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs) or nuclear-armed 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 I specifies how many warheads are counted for each type of missile or launcher (counting rules). They are set out in the chart below.

[50] For example, in 1990 Czechoslovakia reported that SS-23 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 German Democratic Republic and Bulgaria) and certainly never spotted by US intelligence satellites (*Trust & Verify*, nos. 9, Apr. 1990 and 13, Aug./Sep. 1990). This caused grave concern, particularly with the fuss that the USSR made over the German Pershing 1As before the signing of the treaty.

[51] 'Watching START Take Off: The Verification of a Complex Arms Control Treaty', *Verification Matters*, no. 4, VERTIC, London, July 1990.

START I Warhead Attributions per Missile Type			
Soviet Union (Russia)		US	
SS-11	1	MX/Peacekeeper	10
SS-13	1	Minuteman II	1
SS-17	4	Minuteman III	3
SS-18	10	Trident I	8
SS-19	6	Trident II	8
SS-24	10	Poseidon	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 START I. The basing of road-mobile missiles is confined to an area of 25 square kilometres and their deployment to a 125 square-kilometre area. In a time of national emergency these restrictions will not apply. Rail-mobile missiles will be confined to a rail garrison, but have an unlimited deployment area. However, there are limits on the number of rail-mobile missiles which can be housed in sheds and garages; there is thus 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 (SLCMs) 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, US President Bush announced the withdrawal of all US nuclear Tomahawk cruise missiles from US ships and submarines and nuclear bombs aboard aircraft carriers.[52]

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 I a bomber is considered an air-launched cruise missile (ALCM) carrier if it holds nuclear ALCMs with a range greater than 600 kilometres. The first 150 US ALCM carriers (B-1 or B-52) count as having 10 warheads. The first 210 Soviet ALCM carriers (Bear and Blackjack bombers) count as having 8. 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. Two hundred and ten Soviet ALCM carriers may not carry more than 12 ALCMs. Although unlimited

[52] President George Bush, 'Nuclear Initiative Speech', 27 September 1991, reproduced in J.B. Poole and R. Guthrie (eds), *Verification Report 1992: Yearbook on Arms Control and Environmental Agreements* (Apex Press for VERTIC: London, 1992), pp. 295-296.

numbers of ALCMs can be produced, they cannot be stored near bomber bases. Non-nuclear heavy bombers and the Russian Backfire bomber are not limited by START I.

Modernisation 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 a 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 modernisation, such as improved accuracy, fuel efficiency or warheads, are not 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 I verification regime includes:

- data exchanges in which each side provides the other with numbers and locations of treaty-limited items (TLIs);
- baseline inspections—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 (NTM);
- co-operative measures to enhance NTM (a continuation from the INF Treaty).

While some parts of the START I verification regime were unprecedented, others had originated in the INF Treaty.

There are several types of on-site inspections in START I, including:

- short-notice OSI of declared facilities;
- suspect-site inspections:
  —challenges to undeclared facilities (with right of refusal) and
  —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; and
- inspection of missile exhibitions.

START I entered into force at the end of 1994. Instruments of ratification by Russia, Ukraine, Belarus, Kazakhstan (all members of the Commonwealth of Independent States (CIS)) and the US were exchanged in Budapest on 5 December 1994.

Despite the delayed entry into force, both sides had been reducing their weapons. 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 had carried out 24 inspections on US sites. Russia had not taken up its right to continuously monitor the MX final assembly plant in Promontory, Utah. In the second and third years of implementation, by the end of 1997, the US had carried out 64 START on-site inspections in CIS states and the US received a total of 53 on-site inspections.

START I: Aggregate Numbers Of Strategic Nuclear Weapons, 1 January, 1998*

Category of data	Belarus	Kazakhstan	Russia	Ukraine	Total Former USSR Parties	USA
ICBMs, SLBMs & deployed heavy bombers	0	0	1484	110	1594	1486
Warheads attributed to above categories	0	0	6680	932	7612	7986
Warheads attributed to ICBMs & SLBMs	0	0	6110	580	6690	6205
Throw-weight ICBMs & SLBMs (Mt)	0	0	4047.50	273.30	4320.80	1965.95

** Most recent aggregate MOU data exchanged by the Parties to START I (deployed systems only) published January, 1998, obtained from the US Arms Control and Disarmament Agency (ACDA), Washington DC.*

The START inspection process has been hailed as a great success so far, as has the rate at which the weapons have been dismantled. By late November 1996, with the final nuclear weapon transported from Belarus to Russia, all nuclear warheads had been withdrawn from Kazakhstan, Ukraine and Belarus, making them nuclear-free and eligible to join the NPT as NNWS.[53]

The Strategic Arms Reduction Treaty II (START II)

START II has been more difficult to implement than START I. Although it was signed at the beginning of 1993, by mid-1998 it had yet to enter into force. START II incorporates two phases of elimination, the first running concurrently with START I 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 had yet to ratify it.

[53] *Arms Control Reporter*, 611.B.897, Sept. 1996, and 611.B.905, Dec. 1996. Although Ukraine has transferred all of the warheads on its territory 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 been removed to Russia.

START II 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-limits are shown below.

START II Warhead Sub-limits		
Weapon type	Phase 1	Phase 2
MIRVed ICBMs	1,200	0
SLBMs	2,160	1,750
Heavy ICBMs	650	0

Verification of START II is a direct follow-on from verification of START I, with some additions such as observation of SS-18 silo conversion and exhibitions and inspection of heavy bombers. Although START II limits the number of warheads, there are no verification provisions for warhead dismantlement, a defect likely to be rectified by START III.

At the March 1997 Helsinki Summit, US President Clinton and Russian 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 III (see below).

Perhaps the main concern for Russia is the inequality in US and Russian status following the achievement of START II limits. There is a strong sense in the Duma that the treaty was badly negotiated from Russia's point of view. For example, there are concerns over the ability of the US to quickly upload Minuteman IIIs and 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; the costs of disarmament and dismantlement; the linkage to NATO enlargement; Anti-Ballistic Missile (ABM) Treaty demarcation negotiations; and the lack of political focus. In February 1996 the Duma established a special commission on START II ratification (set up by the committees on international affairs, defence, security and geopolitics). Many analysts believe that because of Russia's ageing missiles and lack of finance to replace them, its strategic forces may well shrink to START II levels or lower over the next few years. If this proves to be the case legislators may decide that it would be better to ratify START II so that the US is similarly forced to down-size.

The Strategic Arms Reduction Talks III (START III)

Proposals for a START III have been seen as a possible way out of the impasse. At their March 1997 Summit, Presidents Yeltsin and Clinton agreed that START III negotiations would begin immediately after START II was ratified by Russia. They also agreed that START III negotiations would cap the number of strategic warheads at 2,000 to 2,500 each and that reduction would be completed by 2007 (the new date for START II reduction completion).

In addition, they agreed that START III will be the first strategic arms control 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 the two sides will consider issues related to transparency in nuclear materials.

Finally, they 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 III negotiations.

The Comprehensive Test Ban Treaty (CTBT)

The Comprehensive Test Ban Treaty, signed in 1996, commits each state party not to carry 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 its verification regime, the CTBT Organisation (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 will be members of the CTBTO. The Executive Council will consist 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.[54] 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. Improvement of the verification regime is permitted, 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 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.

The question of On-site inspections (OSI) and how to decide whether to carry one out was controversial during the negotiations. The treaty allows an on-site inspection to be triggered by any relevant information 'consistent with generally recognised principles of

---

[54] For a detailed explanation of hydroacoustic detection see Ruth Weinberg, 'Hydroacoustic Monitoring of the World's Oceans', *Test Ban Verification Matters*, no. 8, VERTIC, London, Jan. 1995.

international law', including National Technical Means (NTM) but excluding, by implication, espionage. The Executive 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 must be stopped.

A decision on undertaking an OSI must be taken by the Executive Council within 96 hours of receiving a request and an inspection team must arrive within 6 days of the receipt of request. The time-frame for an inspection is 60 days, with the possibility of extension 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 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 referral 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 IMS monitoring stations. 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 it 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 listed in the April 1996 edition of the IAEA's 'Nuclear Power Reactors in the World' or the December 1995 edition of 'Nuclear Research Reactors in the World'. This list includes both the nuclear weapons states and the de facto nuclear weapon states (Israel, India and Pakistan). Since India and Pakistan conducted nuclear tests in May 1998 the prospects for the entry into force of the CTBT are widely believed to have diminished.

Appendix 2

Principles and Objectives of the Final Document of the 1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons

The Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons,

Reaffirming the preamble and articles of the Treaty on the Non-Proliferation of Nuclear Weapons,

Welcoming the end of the cold war, the ensuing easing of international tension and the strengthening of trust between States,

Desiring a set of principles and objectives in accordance with which nuclear non-proliferation, nuclear disarmament and international co-operation in the peaceful uses of nuclear energy should be vigorously pursued and progress, achievements and shortcomings evaluated periodically within the review process provided for in article VIII, paragraph 3, of the Treaty, the enhancement and strengthening of which is welcomed,

Reiterating the ultimate goals of the complete elimination of nuclear weapons and a treaty on general and complete disarmament under strict and effective international control,

The Conference affirms the need to continue to move with determination towards the full realisation and effective implementation of the provisions of the Treaty, and accordingly adopts the following principles and objectives:

Universality

1. Universal adherence to the Treaty on the Non-Proliferation of Nuclear Weapons is an urgent priority. All States not yet party to the Treaty are called upon to accede to the Treaty at the earliest date, particularly those States that operate unsafeguarded nuclear facilities. Every effort should be made by all States parties to achieve this objective.

Non-proliferation

2. The proliferation of nuclear weapons would seriously increase the danger of nuclear war. The Treaty on the Non-Proliferation of Nuclear Weapons has a vital role to play in preventing the proliferation of nuclear weapons. Every effort should be made to implement the Treaty in all its aspects to prevent the proliferation of nuclear weapons and other nuclear explosive devices, without hampering the peaceful uses of nuclear energy by States parties to the Treaty.

Nuclear disarmament

3. Nuclear disarmament is substantially facilitated by the easing of international tension and the strengthening of trust between States which have prevailed following the end of the cold war. The undertakings with regard to nuclear disarmament as set out in the Treaty on the Non-Proliferation of Nuclear Weapons should thus be fulfilled with determination. In this regard, the nuclear-weapon States reaffirm their commitment, as stated in article VI, to pursue in good faith negotiations on effective measures relating to nuclear disarmament.

4. The achievement of the following measures is important in the full realisation and effective implementation of article VI, including the programme of action as reflected below:

(a) The completion by the Conference on Disarmament of the negotiations on a universal and internationally and effectively verifiable Comprehensive Nuclear-Test-Ban Treaty no later than 1996. Pending the entry into force of a Comprehensive Test-Ban Treaty, the nuclear-weapon States should exercise utmost restraint;

(b) The immediate commencement and early conclusion of negotiations on a non-discriminatory and universally applicable convention banning the production of fissile material for nuclear weapons or other nuclear explosive devices, in accordance with the statement of the Special Coordinator of the Conference on Disarmament and the mandate contained therein;

(c) The determined pursuit by the nuclear-weapon States of systematic and progressive efforts to reduce nuclear weapons globally, with the ultimate goal of eliminating those weapons, and by all States of general and complete disarmament under strict and effective international control.

Nuclear-weapon-free zones

5. The conviction that the establishment of internationally recognised nuclear-weapon-free zones, on the basis of arrangements freely arrived at among the States of the region concerned, enhances global and regional peace and security is reaffirmed.

6. The development of nuclear-weapon-free zones, especially in regions of tension, such as in the Middle East, as well as the establishment of zones free of all weapons of mass destruction, should be encouraged as a matter of priority, taking into account the specific characteristics of each region. The establishment of additional nuclear-weapon-free zones by the time of the Review Conference in the year 2000 would be welcome.

7. The co-operation of all the nuclear-weapon States and their respect and support for the relevant protocols is necessary for the maximum effectiveness of such nuclear-weapon-free zones and the relevant protocols.

Security assurances

8. Noting United Nations Security Council resolution 984 (1995), which was adopted unanimously on 11 April 1995, as well as the declarations of the nuclear-weapon States concerning both negative and positive security assurances, further steps should be considered to assure non-nuclear-weapon States party to the Treaty against the use or

threat of use of nuclear weapons. These steps could take the form of an internationally legally binding instrument.

Safeguards

9. The International Atomic Energy Agency is the competent authority responsible to verify and assure, in accordance with the statute of the Agency and the Agency's safeguards system, compliance with its safeguards agreements with States parties undertaken in fulfilment of their obligations under article III, paragraph 1, of the Treaty, with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices. Nothing should be done to undermine the authority of the International Atomic Energy Agency in this regard. States parties that have concerns regarding non-compliance with the safeguard agreements of the Treaty by the States parties should direct such concerns, along with supporting evidence and information, to the Agency to consider, investigate, draw conclusions and decide on necessary actions in accordance with its mandate.

10. All States parties required by article III of the Treaty to sign and bring into force comprehensive safeguards agreements and which have not yet done so should do so without delay.

11. International Atomic Energy Agency safeguards should be regularly assessed and evaluated. Decisions adopted by its Board of Governors aimed at further strengthening the effectiveness of Agency safeguards should be supported and implemented and the Agency's capability to detect undeclared nuclear activities should be increased. Also, States not party to the Treaty on the Non-Proliferation of Nuclear Weapons should be urged to enter into comprehensive safeguards agreements with the Agency.

12. New supply arrangements for the transfer of source or special fissionable material or equipment or material especially designed or prepared for the processing, use or production of special fissionable material to non-nuclear-weapon States should require, as a necessary precondition, acceptance of the Agency's full-scope safeguards and internationally legally binding commitments not to acquire nuclear weapons or other nuclear explosive devices.

13. Nuclear fissile material transferred from military use to peaceful nuclear activities should, as soon as practicable, be placed under Agency safeguards in the framework of the voluntary safeguards agreements in place with the nuclear-weapon States. Safeguards should be universally applied once the complete elimination of nuclear weapons has been achieved.

Peaceful uses of nuclear energy

14. Particular importance should be attached to ensuring the exercise of the inalienable right of all the parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with articles I, II as well as III of the Treaty.

15. Undertakings to facilitate participation in the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy should be fully implemented.

16. In all activities designed to promote the peaceful uses of nuclear energy, preferential treatment should be given to the non-nuclear-weapon States party to the Treaty, taking the needs of developing countries particularly into account.

17. Transparency in nuclear-related export controls should be promoted within the framework of dialogue and co-operation among all interested States party to the Treaty.

18. All States should, through rigorous national measures and international co-operation, maintain the highest practicable levels of nuclear safety, including in waste management, and observe standards and guidelines in nuclear materials accounting, physical protection and transport of nuclear materials.

19. Every effort should be made to ensure that the International Atomic Energy Agency has the financial and human resources necessary to meet effectively its responsibilities in the areas of technical co-operation, safeguards and nuclear safety. The Agency should also be encouraged to intensify its efforts aimed at finding ways and means for funding technical assistance through predictable and assured resources.

20. Attacks or threats of attack on nuclear facilities devoted to peaceful purposes jeopardise nuclear safety and raise serious concerns regarding the application of international law on the use of force in such cases, which could warrant appropriate action in accordance with the provisions of the Charter of the United Nations.

The Conference requests that the President of the Conference bring the present decision, the decision on strengthening the review process for the Treaty and the decision on the extension of the Treaty on the Non-Proliferation of Nuclear Weapons, to the attention of the heads of State or Government of all States and seek their full co-operation on these documents and in the furtherance of the goals of the Treaty.

About the Author

Dr Patricia Lewis is the Director of the United Nations Institute for Disarmament Research (UNIDIR) in Geneva. She graduated in Physics from the University of Manchester in 1978 and received her PhD from the University of Birmingham in 1981. While working in India and New Zealand from 1982-6, Dr Lewis became interested in the application of physics to arms control and disarmament. On her return to Britain in 1986, she took up the post of senior research analyst at the newly-established Verification Technology Information Centre (VERTIC). She was VERTIC's Executive Director from 19891997.

Dr Lewis is the author of several academic papers and publications. For the duration of the 1988-90 Conventional Forces in Europe (CFE) treaty negotiations she was a consultant to the UK Foreign and Commonwealth Office on the verification of conventional force reductions in Europe. She was appointed British governmental expert to the 1989-90 United Nations study on 'The Role of the UN in Verification'. From 1990-92, Dr Lewis was a visiting lecturer at Imperial College London and was the Elizabeth Poppleton Fellow at the Australian National University from 1992-3. In 1995, Dr Lewis was a witness to the UK Parliamentary Foreign Affairs Committee study on 'UK Policy on Weapons Proliferation and Arms Control in the Post-Cold War Era' and in 1995 to the European Parliamentary Joint Committee Hearings on France's Nuclear Testing.

About VERTIC

The Verification Technology Information Centre (VERTIC) is an independent, non-profit, non-governmental organisation. Its mission is to promote effective and efficient verification as a means of ensuring confidence in the implementation of treaties or other agreements which have international or national security implications. Along with verification, VERTIC also concerns itself with the negotiation, monitoring and implementation of such agreements and the establishment of confidence-building measures to bolster them.

VERTIC aims to achieve its mission by means of:

- research
- training
- dissemination of information, and
- interaction with relevant political, diplomatic, technical and scientific communities.

VERTIC's 'clients' are policy-makers, the media, legislators, academics, students and others needing reliable information on and analysis of verification and monitoring issues.

What are VERTIC's research priorities?

While maintaining a watching brief on all aspects of verification and related issues, VERTIC specialises in the following three broad areas.

Peace and Security

Verification and monitoring of international and intra-national peace accords by means of peacekeeping operations and their strengthening through civilian confidence-building measures.

VERTIC's current project in this area is on verification of the decommissioning of weapons in Northern Ireland.

Arms Control and Disarmament

Verification and monitoring of international conventions on nuclear non-proliferation, nuclear disarmament, nuclear testing, chemical and biological weapons and conventional weapons.

VERTIC's current projects in this area are on:

- the implementation and verification of the Comprehensive Test Ban Treaty (CTBT)
- the strengthening of nuclear safeguards
- verification of the transition to a nuclear weapon-free world ('Getting to Zero')
- verification of the Chemical Weapons Convention (CWC).

The Environment

Verification and monitoring of international environmental agreements.

VERTIC's current project in this area is on the implementation and verification of the Climate Change Convention and its Kyoto Protocol.

How does VERTIC operate?

VERTIC is based in central London, governed by a Board of Directors and advised by a Verification Consultants Network.

VERTIC is mostly funded by philanthropic trusts and foundations, currently the Ford Foundation, the John Merck Fund, the Ploughshares Fund, the Rockefeller Family Philanthropic Offices, the Joseph Rowntree Charitable Trust and the W. Alton Jones Foundation. VERTIC also accepts commissions from governments and other organisations.

What are some of VERTIC's activities?

VERTIC holds its own seminars, workshops and conferences and participates in those organised by other organisations.

VERTIC's staff publish widely in the general and specialist press, academic journals and books.

VERTIC has its own publications: a newsletter called *Trust & Verify*; a *Verification Yearbook*; a *Verification Organisations Directory*; and VERTIC *Research Reports* and *Briefing Papers*.

VERTIC is often the first port of call for media representatives seeking information on and analysis of verification issues.

VERTIC also has an intern programme.

VERTIC co-operates closely with United Nations bodies, other international organisations, universities, research centres, governments and non-governmental organisations. It has consultative (roster) status with the UN's Economic and Social Council (ECOSOC).

What are the details of VERTIC's publications?

Trust and Verify

Published six times a year, providing analysis and news of verification developments and information on VERTIC's activities. Annual subscriptions for a paper copy are £15 (individual) or £20 (organisation). *Trust & Verify* can also be received via email on request. It can also be found on VERTIC's website.

Verification Yearbook

Beginning with 1991, each edition surveys the preceding year's developments in verification and related areas; identifies problems still in need of solution; and draws attention to under-explored possibilities. The 1997 *Yearbook* and copies of most previous editions are available from VERTIC.

VERTIC *Research Reports* and *Briefing Papers*

These are published on an *ad hoc* basis and cover a range of verification issues.

Verification Organisations Directory

VERTIC will publish in late 1998 a directory of all organisations involved in verifying or monitoring arms control and disarmament agreements or which conduct research into verification and monitoring. International, regional, national and non-governmental organisations will be included. Initially the Directory, which will be published annually, will contain contact details and an indication of the particular field of specialisation of each organisation.

For a full list of VERTIC's publications see below.

VERTIC Personnel

Dr Trevor Findlay, *Executive Director*
Suzanna van Moyland, *Arms Control and Disarmament Researcher*
Nicola Elborn, *Administrator*

VERTIC's Board of Directors

VERTIC Publications

Verification Organisations Directory

£12

VERTIC Research Reports

£10 each

- Patricia M. Lewis, **Laying the Foundations for Getting to Zero: Verifying the Transition to Low Levels of Nuclear Weapons,** *Research Report* no. 1
- Tom Milne and Henrietta Wilson, **Verifying the Transition for Low Levels of Nuclear Weapons to Zero,** *Research Report* no. 2 (forthcoming)
- George Paloczi-Horvath, **Virtual Nuclear Capabilities and Deterrence in a World Without Nuclear Weapons,** *Research Report* no. 3
- Suzanna van Moyland, **Sustaining a Verification Regime in a Nuclear Weapon-Free World,** *Research Report* no. 4
- Joseph McGrath and David Robertson, **Monitoring the Landmine Convention: Ratification and National Implementation Legislation,** *Research Report* no. 5 (forthcoming)

VERTIC Briefing Papers

£10

- Clare Tenner, **Meeting of the Subsidiary Bodies to the Convention on Climate Change, Bonn, June 1999,** *Briefing Paper,* 99/1, May 1999

VERTIC Yearbooks

1991-1996: reduced price of £20 each or the 4 in-print volumes for £50

- R. Guthrie (ed.), ***Verification 1997: The VERTIC Yearbook*** (£30)
- J.B. Poole & R. Guthrie (eds), ***Verification 1996: Arms Control, Peacekeeping and the Environment***
- J.B. Poole & R. Guthrie (eds), ***Verification 1993: Peacekeeping, Arms Control, and the Environment***
- J.B. Poole & R. Guthrie (eds), ***Verification Report 1992: Yearbook on Arms Control and Environmental Agreements***
- J. B. Poole (ed.), ***Verification Report 1991: Yearbook on Arms Control and Environmental Agreements***

Trust & Verify

Annual subscriptions for a paper copy are £15 (individual) or £20 (organisation). *Trust & Verify* can also be received via email on request. It can also be found on VERTIC's website.

The following publications have been discontinued and only limited copies are available.
Please email info@vertic.org for information

Verification Matters

- Dr P. M. Lewis, **Verification as Security,** July 1995 (£5)
- Reynold Chung, **The Road to a New CFE Treaty,** *Briefing Paper* 97/3, September 1997 (£2)
- Suzanna van Moyland, **The International Atomic Energy Agency's Additional Protocol,** *Briefing Paper* 97/2, July 1997
- Suzanna van Moyland, **The IAEA's Programme '93+2',** *Verification Matters no. 10,* January 1997
- Ruth Weinberg, **Hydroacoustic Monitoring of the World's Oceans,** Test Ban Verification Matters no. 8, January 1995
- Kim Tay, **Entry Into Force,** Test Ban Verification Matters no. 6, September 1994

- **The Verification of a Global Comprehensive Test Ban Treaty**: Briefing Paper for the Partial Test Ban Amendment Conference, 7-18 January 1991, *Verification Matters* no 3., Jan. 1991
- **Scientific and Technical Aspects of the Verification of a Comprehensive Test Ban Treaty,** *Verification Matters* no. 1, January 1990

Implementation Matters

£2 each or £20 for the set

- John Lanchbery, **Briefing paper for the subsidiary bodies to the Convention on Climate Change, June 1998,** *Implementation Matters* 98/1, June 1998
- John Lanchbery, **Briefing paper for COP-3 Kyoto, December 1997: practical considerations for a protocol,** *Implementation Matters,* 97/6, Novemeber 1997
- John Lanchbery, **Briefing paper for the eighth session of the AGBM: some practical considerations for a protocol,** *Implementation Matters* 97/5, October 1997
- John Lanchbery, **Briefing paper for the seventh session of the AGBM: some practical considerations,** *Implementation Matters* 97/4, July 1997
- John Lanchbery, **Briefing paper for the fifth session of AG 13, 28 to 30 July 1997: a possible text for a multilateral Consultative Process,** *Implementation Matters* 97/3, July 1997
- John Lanchbery, **Briefing paper for the UN GA Special Session June 1997: some practical considerations for the Convention on Climate Change,** *Implementation Matters* 97/2, May 1997
- John Lanchbery, **Negotiating a protocol (or another legal instrument) : some practical considerations, A Briefing Paper for AGMB 5,** *Implementation Matters* 96/3, Novemeber 1996
- John Lanchbery, **Whither a protocol (or another legal instrument): How to make one work,** *Implementation Matters Briefing Paper* 96/1, June 1996
- John Lanchbery, **Protocols to the Climate Convention: Prospects, Problems and Proposals. A Briefing Document for the eleventh meeting of the INC on the Climate Convention, New York 6-17 February 1995,** *Implementation Matters* no. 4, January 1995
- John Lanchbery, **Note on Elaboration of Article 13 of the Climate Convention: A Briefing Paper for the INC Delegates and Secretariat,** *Implementation Matters* no. 3, August 1994
- John Lanchbery, **Verifying the Climate Change Convention: A briefing document for sixth meeting of the Intergovernmental Negotiating Committee Meeting on Climate Change, Geneva, 7-10 December,** December 1992

Greenhouse Gas Inventory Series

£3 each

Case studies of national reporting processes and implementation review mechanisms in Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Sweden, UK. Published by Forschungszentrum Jülich GmbH (KFA), LABEIN Technological Research Centre, University of Bradford Department of Peace Studies, VERTIC, Russian Academy of Sciences, Moscow and Russian Academy of Transport, Moscow.

Confidence-Building Matters

£2 each

- Dennis Sammut & Nikola Cvetkovski, **The Georgia-South Ossetia Conflict,** *Confidence Building Matters* no. 6, March 1996
- Walter Kemp & Dennis Sammut, **Rethinking the OSCE: European Security after Budapest,** *Confidence Building Matters* no. 5, March 1995
- Owen Greene & Dennis Sammut, **The CSCE and the Process of Confidence Building,** *Confidence Building Matters* no. 2, September 1994

For a complete list of VERTIC publications see VERTIC's website:www.fhit.org/vertic