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B R I E F

Verification of a nuclear weapon-free world

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Introduction

The verification and compliance regime for a nuclear weapon-free world will need to be more effective than any disarmament arrangement hitherto envisaged. One hundred per cent verification of compliance with any international arms agreement is highly improbable. In the case of nuclear disarmament, however, the security stakes will be so high that states will not agree to disarm and to disavow future acquisition of nuclear weapons unless verification reduces to a minimum the risk of non-compliance.

Similarly, the compliance mechanism must be as compelling as possible, providing a high degree of assurance that any violation will be dealt with firmly and effectively. Both the verification and compliance systems must be able to cope with the most feared threat to complete nuclear disarmament: 'breakout'. This is when a state party is suddenly revealed to have a previously hidden nuclear arsenal or to have produced new weapons.

Meeting these requirements is a tall order, but not an inconceivable one. For a start, a verification and compliance regime for total nuclear disarmament will not be constructed from scratch. It will build on practical experience of the disarmament process as it moves towards zero and will draw on yet unforeseen developments in the information and technological revolutions.

An array of procedures, techniques and technologies that would be used to verify complete nuclear disarmament has been identified, researched and evaluated. In some cases they have already been implemented, especially in relation to Russia–US bilateral nuclear arms limitations, the nuclear test ban and nuclear safeguards. Continuing research is needed to ensure that the latest technological advances are incorporated into verification and that promising avenues are explored. The long-term aim should be to preclude verification from becoming a negotiating obstacle once the political will to achieve nuclear disarmament emerges.

Moreover, the same conjunction of good relationships between major states that will permit the negotiation of a nuclear disarmament treaty will overcome many of the obstacles, which today seem insurmountable, to the construction of an appropriate verification and compliance system.

Verification tasks for a nuclear weapon-free world

This paper starts with the assumption that, by the time the transition to complete nuclear disarmament is imminent, Russia and the US will have reduced their arsenals to below 1,000 warheads each through a continuing strategic nuclear disarmament process, non-strategic reductions and limitations and/or unilateral measures. Their remaining weapons are all likely to be considered strategic: tactical weapons, those for short-range or battlefield use, will have to have been prohibited and the ban subject to verification (itself a highly challenging undertaking that will set precedents for verification of a nuclear weapon-free world).[1]

Depending on the size of the remaining Russian and US arsenals, the lesser nuclear weapon states (China, France, India, Israel, Pakistan and the UK), all of them by this stage declared, will either have joined in the process or will be ready to. Naturally, those nations under suspicion of having secretly produced nuclear weapons, such as Iraq and North Korea, will either have been verifiably denuclearised or will be willing to become so. The remaining nuclear weapons retained by any state, as zero draws near, will no longer be on alert status or deployed on missiles or aircraft. These steps will be subject to verification, including on-site inspection. Such verification measures will set precedents and provide experience for those charged with designing and implementing the much more complicated verification regime to come.

1. For some states, such as India, Israel and Pakistan, whose likely intended targets are relatively close, warheads designed for short-range systems would be considered 'strategic' for arms control purposes.

If this is the scenario, as the world approaches complete nuclear disarmament, the following five verification tasks become clear:

- verification of the dismantlement and destruction of existing declared nuclear weapons and nuclear weapon facilities;
- verification that no undeclared nuclear weapons or facilities remain;
- verification of restrictions or bans on delivery systems;
- verification of non-diversion of fissionable materials to new nuclear weapon production; and
- timely detection of research, development and manufacture of new nuclear weapons.

Verification of the dismantlement and destruction of declared weapons and nuclear weapon facilities

The first task of any verification system for a totally nuclear weapon-free world will be to verify the dismantlement and destruction of all remaining declared weapons and weapon production and maintenance facilities. This is the easiest part of nuclear disarmament verification.

It would begin with each possessor state submitting to an international verification organisation (the nature of which remains to be determined) a declaration giving a detailed inventory of its remaining weapons and weapons-grade fissionable material and their location. The weapons and materials would be placed, if this had not already been done, in sealed containers with a unique tamper-proof tag and seal affixed to each warhead and container. Any untagged items subsequently discovered would constitute a treaty violation. The containers would be stored in secure identifiable locations, sometimes referred to as 'bonded stores', well away from any potential delivery systems.[2] After declarations had been made, international and national on-site inspectors could monitor these sites permanently, supplemented by a range of sensors directly linked by satellite to the national and international verification organisation. Such a system would be the starting point for verifying the dismantlement and destruction of the weapons. (Some experts have suggested pooling all remaining weapons into a single site under international auspices, although this may be considered a step too far by some nuclear weapon states and too tempting a target for a country with a secret cache of remaining weapons).

Before destruction could begin, the contents of the bonded stores would require authentication to prove that they were not fake. This would have to be done without revealing sensitive design information, particularly to international inspectors from non-nuclear weapon states. Research is underway in the UK[3] and the US into infallible authentication techniques based on measurement of radiation emissions and other characteristic signatures.[4] 'Fingerprinting techniques' can be used to determine that weapons purportedly of the same type are in fact identical in composition and manufacture.[5]

After authentication, chain-of-custody procedures, like those developed for missile reductions under the 1987 Intermediate-range Nuclear Forces (INF) Treaty and the first and second Strategic Arms Reduction Treaties (START) of 1991 and 1993 would be implemented. (Unfortunately, the new Strategic Offensive Reductions Treaty (SORT), signed by Russia and the US in Moscow on 24 May 2002, provides no new verification models, since it leaves the method and timetable for achieving reductions entirely to the discretion of each party.) In the case of complete nuclear disarmament, chain-of-custody procedures would be used not just for missiles but also for nuclear weapons themselves:

- to monitor the transport of the items to destruction/disposition sites;
- to verify the dismantling and destruction of weapon components; and
- to ensure that weapons-grade fissionable material is placed under international safeguards.

2. The following is adapted from Tom Milne and Henrietta Wilson, 'Verifying the transition from low levels of nuclear weapons to a nuclear weapon-free world', *VERTIC Research Report*, no. 2, June 1999, p. 17 ff.
3. For information on the nuclear verification research programme of the UK's Atomic Weapons Establishment at Aldermaston, see Gary George and Martin Ley, 'Nuclear warhead arms control research at the AWE', *Verification Yearbook 2001*, VERTIC, London, 2001.
4. See Oleg Bukharin and Kenneth Luongo, 'US-Russian warhead disarmantlement transparency: the status, problems, and proposals', Princeton University/Center for Energy and Environmental Studies (PU/CEES) report no. 314, April 1999.
5. Theodore B. Taylor and Lev P. Feoktistov, 'Verified elimination of nuclear warheads and disposition of contained nuclear materials', in Francesco Calogero, Marvin L. Goldberger and Sergei P. Kapitsa (eds), *Verification: Monitoring Disarmament*, Westview Press, Boulder, CO, 1991.

"Increased transparency, active co-operation between scientists and 'managed-access' inspections could help to ensure compliance"

Dismantling facilities could be built with one entrance and one exit. Warheads would be monitored entering the facility and correlated with the warhead 'pits' (reformed into shapes that have no security classification) and other components and materials as they came out through the exit. The pits would be placed under international safeguards and removed to internationally monitored storage facilities to await final disposition.[6] International inspectors would have no access to the inside of the facility, where national personnel would carry out the dismantlement.

Verification would also be necessary to ensure the dismantling and decommissioning of nuclear weapon design, production and maintenance facilities. Ideally, they should be razed to the ground. Satellite monitoring could verify this process. The complete closure of nuclear research laboratories is likely to be resisted because peaceful nuclear research will continue in a nuclear weapon-free world. But increased transparency, active co-operation between scientists and 'managed-access' inspections could help to ensure compliance.

Verification that no undeclared weapons or facilities remain

While there will ideally be a great deal of trust between states that their declarations of remaining nuclear weapons are complete and correct—significant preparatory work and experience will serve to reinforce such trust—there may still be lingering suspicions. These will need to be dealt with sooner rather than later. A challenge inspection system will, therefore, need to be in place from the outset to permit the conduct of intrusive on-site inspections. Using technologies like ground-penetrating radar, environmental sampling and overhead imagery, such inspections should be able to determine that at least identifiable sites of concern are free of nuclear weapons or materials. Provision will need to be made for remote monitoring of such sites if that is felt necessary. Such 'challenge' activities will need to be handled carefully to avoid creating mistrust and suspicion. According each former nuclear weapon state the right to conduct a quota of such inspections in the first few years of a total ban entering into force—regardless of any actual suspicions or compelling evidence of non-compliance—could achieve this. Random, unannounced inspections could also be used. On-going verification to ensure that no new weapons or facilities are constructed will obviously need to be carried out thereafter.

Verification of restrictions or bans on delivery systems

For the transition to zero to occur there will need to be limitations or outright bans on different types of delivery systems, notably strategic bombers, ballistic and cruise missiles and nuclear-armed submarines. If outright bans are impossible to negotiate, specific numbers of delivery systems may be permitted for conventional weapon delivery purposes, or, in the case of ballistic missiles, for space launch purposes, although such exceptions would make verification more difficult.

A great deal of experience has been and will be further accumulated with regard to verifying numbers of deployed strategic bombers and ballistic missiles. As a result, universal restrictions or bans on these items could be verified with a high degree of confidence. Satellites and aircraft overflights, along the lines of the 1992 Open Skies Treaty (which has now entered into force) will be used for such purposes. Banned strategic bombers, ballistic missiles and missile silos will have to be destroyed and any suspected ballistic missile deployment sites subject to 'anytime, anywhere' on-site inspections. Missile manufacturing plants will be subject to the type of inspections seen in the INF treaty to ensure that only missiles of the permitted type and range are being built. If range restrictions are imposed, the type

6. Milne and Wilson, p. 21.

of tests conducted in Iraq by the United Nations Monitoring, Verification and Inspection Commission (UNMOVIC) could verify them. Missile test ranges could be verified from the air. Space programmes and space launches will need to be monitored intrusively to ensure that they are not used to mask missile development programmes and to ensure that space launches are for peaceful purposes. The development and deployment of anti-ballistic missile (ABM) systems will also need to be monitored to ensure that they cannot be used for offensive purposes. Alternatives would be to ban ABM systems completely or to ensure that a global ABM system was collectively owned and operated.

Verifying that other delivery systems are not armed with nuclear weapons would be more problematic. In the case of submarines, intrusive on-site inspections in port could guarantee that they were no longer nuclear-armed, but overhead imagery would be needed to ensure that nuclear weapons were not placed onboard by other means, such as from ships at sea. Non-strategic aircraft can be used to deliver nuclear weapons and verification in this case would be impossible. Likewise, any cruise or short-range missiles permitted for conventional purposes in a nuclear weapon-free world could be relatively easily converted for nuclear use. Similarly, non-conventional means of delivering nuclear weapons (for example, in a suitcase or in the hold of a ship) would be as impossible to control and verify, as they are today. Such difficulties with controlling delivery systems make it even more essential that there be an effective global verification system for detecting illicit nuclear warheads and the diversion of weapons-usable nuclear material to nuclear weapons.

Verification of non-diversion of fissionable materials to new nuclear weapon production

Since it is highly unlikely that all use of nuclear materials will be banned in a nuclear weapon-free world, there will continue to be a need for nuclear safeguards to prevent the diversion of nuclear materials from peaceful employment to weapons. Such a system would be based on, but be even more stringent than, the strengthened safeguards system currently being implemented by the International Atomic Energy Agency (IAEA).

A safeguards system in a nuclear weapon-free world would need to cover all nuclear material worldwide, including all weapons-usable nuclear material, whether in reactors, stockpiles or extracted from dismantled weapons. Consequently, all of the nuclear material holdings of the nuclear weapon states would come under safeguards and the distinction between nuclear and non-nuclear weapon states would disappear. The amount of material and number of facilities requiring safeguards would thus increase substantially, compared with today. If weapons-usable materials—plutonium and highly-enriched uranium (HEU)—continued to be permitted for peaceful purposes, primarily in nuclear power and research reactors, the verification task would be much greater than if nuclear reactors were permitted to use only low-enriched uranium (LEU).

In addition, if HEU continued to be used in naval propulsion, special arrangements would need to be made to bring such material under nuclear safeguards. Safeguards should also be extended to uranium mining and milling to ensure that all sources of new fissionable material are accounted for.[7]

Other ways in which safeguards would have to be further strengthened include increasing the intrusiveness of inspections, lowering the quantities and increasing the types of nuclear materials requiring declaration and inspection, and boosting the intelligence and data-handling capacities of the international verification organisation.[8] Some of the most important measures are outlined below.

- The current 'significant quantity' of weapons-usable material considered necessary

7. Currently they only begin when uranium is converted to 'yellowcake', a form suitable for fuel fabrication or enrichment.
8. Adapted from Steve Fetter, 'Verifying nuclear disarmament', *Occasional Paper*, no. 29, Henry L. Stimson Center, Washington, DC, October 1996.

for producing a nuclear weapon (eight kilogrammes of plutonium or 25kgs of HEU) would have to be lowered to provide greater reassurance.
- Other nuclear materials recently identified as weapons-usable would have to be accorded their own standards.
- The standard for 'timely detection' would also have to be revised downward from months to weeks, since former nuclear weapon states could convert diverted material into a fabricated weapon more quickly than non-nuclear weapon states to which the current standard applies.
- All remaining nuclear facilities, whether operating or decommissioned, would have to be monitored continuously and data transmitted in real-time to the verification headquarters by satellite link.
- Intelligence information of the highest quality would have to be available to the international verification organisation.
- Permanent environmental monitoring, especially around nuclear and nuclear-related facilities, would have to be undertaken, to detect normal as well as accidental releases into the environment.
- Import–export regimes will need to be strengthened and universalised.

Finally, the international verification organisation charged with ensuring a nuclear weapon-free world would need to have the right to conduct virtually no-notice anytime, anywhere inspections of any suspect site, an even more intrusive system than that envisaged for the Organization for the Prohibition of Chemical Weapons (OPCW) under the 1993 Chemical Weapons Convention (CWC) and much closer to that operated by UNMOVIC in Iraq.

Timely detection of research, development and manufacture of new nuclear weapons

This will be one of the most difficult verification tasks in a nuclear weapon-free world, since the facilities required for these activities, unlike those for the illicit production or diversion of fissionable materials, are comparatively small and may be relatively easily hidden. Illicit new production is unlikely to take place at old facilities, which will be closely and comprehensively monitored, but, rather, at new, specially designed underground facilities or at remote locations.

Random and challenge on-site inspections, aerial monitoring through a cooperative open skies inspection regime, and satellite imagery (from an internationally-controlled satellite system) may reduce the risks and increase the costs of such activities to an actual or potential violator. Yet it is difficult to conceive of systematic verification techniques to guarantee completely the detection of such violations.

The possibility of detection may, however, be enhanced through three variables that are external to the formal verification system. One is 'national technical means' (NTM), which refers to verification and monitoring capabilities under individual state control and which include satellite monitoring, electronic eavesdropping, information-gathering and espionage. These will all continue and perhaps intensify in a nuclear weapon-free world. Many states will require the additional assurance that national systems can provide before ratifying a nuclear disarmament convention. While data from such systems may be manipulated and used in a self-serving fashion or be misused politically within the state concerned, such possibilities would be attenuated in a nuclear weapon-free world by the existence of a strong multilateral system with its own independent data collection and analysis capabilities.

The second complement to the official verification system is 'societal verification', which employs civil society, including non-governmental organisations (NGOs), professional bodies and individuals (such as academics, scientists and engineers), to monitor the activities of governments and if necessary to 'blow-the-whistle'.[9] A nuclear weapons convention should make specific

9. See Dieter Deiseroth, 'Societal verification: wave of the future?', *Verification Yearbook 2000,* VERTIC, London, 2000.

mention of, and provision for, societal verification. While one could not rely completely on such methods, they certainly add to the complexity of the task facing any would-be violator. Organised societal verification is most feasible in open societies, but even closed societies or open ones with secretive programmes have difficulty in preventing defectors and others from leaking national security information. The cases of Mordechai Vanunu in regard to the Israeli nuclear arsenal, Kamal Hussein in relation to Iraq's biological weapons programme and various Russian defectors and 'whistle-blowers' are instructive. Cheap and ready access to satellite imagery[10] and the instantaneous capabilities of modern communications greatly increase the possibilities for NGOs to participate in verification activities.

A third means of supplementing formal verification is so-called cooperative threat reduction programmes. The model here is the Cooperative Threat Reduction Program between Russia and the US. Ensuring that large parts of the former Soviet nuclear complex are safely dismantled, that fissionable material from dismantled nuclear weapons is accounted for and disposed of, and that former nuclear scientists and facilities are gainfully and peacefully employed has greatly increased transparency and confidence between the two states.[11] One can imagine a similar process involving all of the nuclear possessor states and those that have come close to a nuclear weapon capability.

Institutional components of a verification and compliance regime

The international verification capabilities for a nuclear weapon-free world will likely be organised and managed by a dedicated verification and compliance regime established by and for a nuclear disarmament convention. A Model Convention on the Prohibition of the Development, Testing, Production, Stockpiling, Transfer, Use and Threat of Use of Nuclear Weapons and on their Elimination has already been drafted, one version of which was submitted by Costa Rica to the United Nations (UN) General Assembly in 1997.[12] The regime will be elaborate, intrusive and expensive (compared with current multilateral disarmament agreements, but not compared with the cost of maintaining nuclear arsenals). While the specifics of such a regime are necessarily speculative, standard verification and compliance models for international disarmament agreements are likely to be emulated. The following outline is based on an assumption that there would be a single, universal nuclear disarmament convention that would supersede the 1968 Nuclear Non-Proliferation Treaty (NPT), the 1996 Comprehensive Nuclear Test Ban Treaty (CTBT), the various nuclear weapon-free zone treaties and other nuclear-related treaties.[13]

A Conference of States Parties

This would comprise representatives of all states parties. Given the importance of nuclear disarmament to all states and the security nightmare that a rapid breakout from a nuclear disarmament regime would entail, membership will have to be universal. The conference would be the treaty's ultimate decision-making body, responsible for its overall effectiveness, including compliance by all states parties. It would be able to recommend amendments to the treaty, which in this case would have to be binding on all parties. It would be impossible to envisage a nuclear disarmament treaty with selective adherence to amendments by states parties.

Executive Council

This would be a standing body, comprising a representative selection of states parties, which would be responsible for day-to-day decision-making on the operation of the treaty, particularly its verification and com-

10. See Bhupendra Jasani, 'Remote monitoring from space: the resolution revolution', *Verification Yearbook 2000,* VERTIC, London, 2000.
11. See Rose Gottemoeller, 'Beyond arms control: how to deal with nuclear weapons', *Policy Brief,* no. 23, Carnegie Endowment for International Peace, Washington, DC, February 2003, and Nancy Gallagher, 'Verification and advanced co-operative security', *Verification Yearbook 2002,* VERTIC, London, 2002.
12. See UN document A/C 1/52/7 and Draft Convention in Merav Datan and Alyn Ware, *Security and Survival: the Case for a Nuclear Weapons Convention,* International Physicians for the Prevention of Nuclear War, Washington, DC, May 1999.
13. This would naturally have to be done without damaging these existing treaties (as the CWC was negotiated without damaging the 1925 Geneva Protocol).

pliance mechanisms. Constantly alert to potential non-compliance with the accord, it would receive a steady stream of virtually real-time reports from the treaty secretariat based on information from the treaty's verification and monitoring system. This would permit it to make judgements about compliance and non-compliance. The council would also have the power to demand clarification from any state party and an immediate on-site inspection anywhere on the territory of any state party. The council would ultimately have the power to recommend action in the case of non-compliance, including by referring the matter to the UN Security Council. Finally, the Executive Council could order that improvements or adjustments be made to the verification system.

All of the current nuclear weapon states (declared and non-declared) would need to be permanent members of the Executive Council, as presumably would all states with a significant 'virtual' nuclear weapons capability—that is, the ability to manufacture a nuclear device within a short period by virtue of their industrial and non-military nuclear capabilities and assets.[14] All of these states would need to be closely involved and have a strong sense of 'ownership' of the regime, since, unlike other disarmament agreements, the existence of only one treaty 'holdout' would completely defeat the purpose of the agreement. Hence, the council would be a large body, perhaps needing a small executive sub-organ to make routine decision-making more efficient.

An Organisation for the Prohibition of Nuclear Weapons (OPNW)?

Some such body would be required to establish, administer and operate the treaty's international verification and monitoring system. It would be staffed by international civil servants and scientific and technical experts and would be headed by the equivalent of a director-general. It would presumably include a large technical secretariat, which would manage the verification system, and an international inspectorate that would be responsible for on-site inspections. A scientific advisory board would also be indispensable. As well as a headquarters, the organisation would presumably need regional offices and offices in all of the former nuclear weapon states and virtual nuclear weapon states in order to liaise closely with national authorities responsible both for compliance with the treaty and for peaceful nuclear activities permitted by it. The organisation would supersede and subsume the IAEA and its nuclear safeguards system; alternatively, the IAEA itself would become the organisation responsible for verifying complete nuclear disarmament. This organisation would also absorb the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO), along with its International Monitoring System (IMS) and International Data Centre (IDC), since the detection of clandestine nuclear tests would also be an integral part of its verification task.

Arrangements between former nuclear weapon states

In addition to international arrangements, there are also likely to be arrangements between pairs and groups of former nuclear weapon states, established to give them additional reassurance as the nuclear disarmament process proceeded towards zero. These could have been designed to endure indefinitely or only until the multilateral system proved its effectiveness. Such arrangements would include those for the Russia–US nuclear reduction treaties from START I onwards and any similar arrangements between, for example, China and the US, China and India, India and Pakistan and Israel and its neighbours.

A strengthened Security Council

As the likely final arbiter in any compliance dispute (as in the case of other multilateral disarmament agreements), and, therefore, a vital component of any compliance system

14. For a comprehensive discussion of virtual nuclear capabilities, see George Paloczi-Horvath, 'Virtual nuclear capabilities and deterrence in a world without nuclear weapons', *VERTIC Research Report*, no. 3, October 1998.

for a nuclear weapon-free world, the UN Security Council would need to be reformed. It is inconceivable that the current permanent five member states, which are all nuclear weapon possessors, could be permitted to veto action against themselves or any other country that violated a nuclear weapon ban. Furthermore, all of the current nuclear weapon states, declared and non-declared, and all of the other major powers, most of which are also capable of acquiring nuclear weapons, would have to be represented permanently on the council. Consequently, a mixture of nuclear and non-nuclear great powers would comprise the permanent members of the council, helping to de-legitimise nuclear weapons, although continuing to reflect the actual distribution of power in a non-egalitarian international system.[15]

The 'breakout' problem

While all of the verification techniques and institutional arrangements described above would aim to prevent and/or deter breakout, it could, nonetheless, occur. While in the abstract such an event might seem cataclysmic, in reality, its impact would depend on the particular circumstances:

- whether the violator used or simply threatened to use a nuclear weapon (or weapons) and for what purpose;
- the state of readiness and deliverability of the weapons or purported weapons;
- the existence of defences against whatever delivery system the violator might try to use;
- the relative conventional military strength of the violator and the rest of the international community combined; and
- the international community's willingness to respond.

Since achievement of nuclear disarmament would require consensus among the great powers that their relationships had improved so much as to obviate the need for nuclear weapons, the main threat to a nuclear weapon-free world would be a 'rogue state' that had not previously produced nuclear weapons. The most worrying scenario would be a 'bolt-from-the-blue' pre-emptive strike by the proverbial madman—a nuclear Hitler. There are, in this case, likely to be warning signs of the true nature of such a regime and its nuclear intentions, which would probably trigger intensified scrutiny by the verification system in a denuclearised world. Any weapon(s) produced would be untested, could not be deployed until the last minute, could probably not be delivered by conventional means, and overt training for use would have been impossible. Such a scenario is, of course, possible today, and, in some respects, is more likely given the relative weakness of existing verification regimes in the absence of a total nuclear weapons ban. In the current nuclearised world such an attack is deterred by the certainty of a nuclear counter-attack. In a nuclear-free world it would have to be deterred by a devastating and increasingly accurate and powerful conventional assault, the credibility of which would be enhanced by mutual guarantees by the great powers to come to any state's assistance were it to be threatened or attacked with nuclear weapons.

The possibility of an illicit nuclear weapon being suddenly revealed and used to alter the course of a major conventional war would be presaged by the outbreak of such a war. Efforts would have to be made, therefore, to prevent any nuclear-capable state being forced into such a corner.

If a previously hidden nuclear weapon or weapons were to be used for political purposes, presumably blackmail, the existence of the arsenal would have to be revealed, or at least alluded to, thereby alerting the international community to a major treaty violation. A 'demonstration shot' would have the same effect (and, humiliatingly, might fail). Potential responses to such breakout scenarios encompass political, economic and

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15. In addition to the current permanent five one could imagine adding, for instance, Brazil, Canada, Germany, Japan, India, Indonesia, Nigeria and South Africa.

military sanctions, including the use of conventional force. Missile defences against ballistic missiles and aircraft could decrease the threat of nuclear blackmail and actual attack.

One element of deterrence would be the residual ability of some states to reconstitute quickly a nuclear device or arsenal. For the former nuclear weapon states, depending on how long a nuclear weapon-free world had existed, this might amount to only a month or two. While an obviously impending threat could be countered in this way, it would be at the risk of reigniting a nuclear arms race. An alternative suggested by some observers is a small deterrent arsenal under international control, although this would raise command-and-control difficulties and would be incompatible with total nuclear disarmament.

"One element of deterrence would be the residual ability of some states to reconstitute quickly a nuclear device or arsenal"

These hypothetical scenarios notwithstanding, neither the technology of verification nor the broader verification and compliance system can solve the breakout problem alone. Verification can never provide complete assurance that a small clandestine nuclear arsenal or hidden cache of plutonium will be discovered. What verification can do is to reduce significantly, albeit unquantifiably, the likelihood of breakout occurring. It does so through a combination of deterrence and enhanced warning time through early detection.

Necessary precursors for effectively verifying a nuclear weapon-free world

Such a dramatic expansion in the scope and intrusiveness of verification as envisaged above will probably require an incremental, 'learning-by-doing' process of increasing transparency and confidence-building over many years. In addition to deep cuts by the two largest nuclear weapon states, Russia and the US, all of the other nuclear weapon states will need to be drawn into the process of putting in place the essential precursors for a verifiable total nuclear disarmament treaty. The following are among the most important.

Nuclear transparency

The sooner transparency can be achieved in relation to numbers, types and deployments of nuclear weapons, delivery systems and holdings of special nuclear materials, the earlier and deeper can confidence be established. Openness about past production of fissionable materials will be particularly challenging, since, even with the best intentions, it will be virtually impossible for any nuclear weapon state to give a completely accurate account. The IAEA's experience in verifying South Africa's account of its past production, even with a high degree of cooperation from the South African authorities, is salutary. The documentation of past production ('nuclear archaeology') must begin now, while any glaring discrepancies discovered are not strategically significant and potentially destabilising.

Confidence-building measures

These should include exchanges by the nuclear weapon possessors on the acceptability of various intrusive verification techniques and growing familiarity with each other's nuclear establishments and facilities through exchange visits and cooperative monitoring ventures. This process is likely to begin with France, Russia, the UK and the US, but needs to be quickly extended to China, India, Israel and Pakistan.

Deepening experience of nuclear and other verification regimes

A key precursor of a verification system for nuclear disarmament will be American and Russian experience of verifying deep cuts, building on their already extensive bilateral experience in verifying the INF and the

START I and II treaties. The lessons need to be shared with all nuclear weapon states. Multilateral experience in verifying the CWC, the 1972 Biological Weapons Convention (BWC) and the CTBT will also be germane, particularly in regard to on-site inspections and the operation of global multilateral monitoring networks. Valuable lessons have already been learned, including that on-site inspections can be managed in a way that does not reveal security or commercial proprietary information and that some of the concerns that states have prior to negotiating intrusive regimes fall away once implementation begins and experience grows.

Research and development

Currently, the vast bulk of research into verification procedures, techniques and technologies is conducted in the US.[16] Other nuclear weapon states need to establish their own programmes, not only because they need to be convinced of the capability of various standard verification techniques, but also because they could develop innovative techniques and technologies themselves. The non-nuclear weapon states should also be encouraged to conduct such research, as they did in the lead-up to and during negotiations on the CWC and the CTBT.

Conclusion

An impressive and reliable verification system can, even on the basis of current knowledge, be constructed to verify with high, although not exactly quantifiable, certainty that all parties to a universal nuclear disarmament treaty are complying with their obligations. Verification can increase the risks of detection and consequent political costs to any potential violator, extend the warning time to permit responses to be mounted, and foster mutual trust and confidence among the parties.

Such a world, clearly different from our own, but not impracticably idealistic, is likely to be arrived at gradually, through increasing transparency, confidence-building, an evolving attitude towards the utility of nuclear weapons, growing experience of verifiable interim steps towards nuclear disarmament, and the progressive involvement of all of the nuclear weapon states—declared and undeclared.

Yet there can be no foolproof guarantee against unexpected breakout through the retention of hidden stocks or the manufacture of new ones. This scenario must, however, be seen not just in the context of the verification and compliance systems established specifically for a nuclear disarmament treaty, but also in the evolution of the international system between now and then. States will have to have made significant changes in their attitudes to the limits of sovereignty, the rule of international law and governance of the international system, particularly in regard to enforcement, for nuclear disarmament to be negotiated.

The attainment of a nuclear weapon-free world is so dependent on such changes that we will only be able to judge fully and accurately its verifiability as we become seriously engaged in moving towards that world. In doing so, we need to ponder whether a world with seven declared, one undeclared and numerous potential nuclear weapon states is safer than a denuclearised world with a strong international verification system and a remote chance of nuclear breakout.[17]

16. See Tom Milne, 'Global spending on nuclear disarmament verification work', Verification Matters, no. 3, VERTIC, London, April 2002.

17. For further information see VERTIC's four 'Getting to Zero' reports: Patricia Lewis, 'Laying the foundations for getting to zero: verifying the transition to low levels of nuclear weapons', *VERTIC Research Report,* no. 1, September 1998; Tom Milne and Henrietta Wilson, 'Verifying the transition from low levels of nuclear weapons to a nuclear weapon-free world', *VERTIC Research Report*, no. 2, June 1999; George Paloczi-Horvath, 'Virtual nuclear capabilities and deterrence in a world without nuclear weapons', VERTIC *Research Report,* no. 3, October 1998; Suzanna van Moyland, 'Sustaining a verification regime in a nuclear weapon-free world', *VERTIC Research Report,* no. 4, June 1999.

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About this paper

In this first VERTIC Brief, Trevor Findlay considers the requirements for verifying complete nuclear disarmament. He describes the verification tasks that will need to be accomplished while 'getting to zero', including those related to nuclear weapons, nuclear research and development and manufacturing capabilities, nuclear-capable delivery systems and fissionable material.

The Brief also considers the institutional components of the verification and compliance regime that are likely to be required, ranging from a substantial technical secretariat to a strengthened United Nations Security Council. Special attention is paid to the 'breakout' problem—the sudden re-emergence of a nuclear weapon state in a denuclearised world—and the possible responses.

Finally, the paper considers what it terms the 'necessary precursors' for building an effective verification system for a nuclear weapon-free world, all of which exist in embryonic form at present but which must be greatly developed and enhanced if 'getting to zero' is to succeed.

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