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On Creating the TPNW Verification System

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Abstract

Upon entry into force, the Parties to the Treaty for the Prohibition of Nuclear Weapons will decide on the technical framework, scope, and the institutional architecture for the TPNW verification system. This Policy Brief is intended to facilitate those decisions.

Introduction

When the Treaty for the Prohibition of Nuclear Weapons (the TPNW) enters into force, agreeing on its verification system will be one of the first and perhaps the most consequential decisions the Parties will make. The greatest challenge facing the TPNW is to convince nuclear-armed states to become Parties to the Treaty, and then to engage in good-faith efforts aimed at peace, stability, and the eventual elimination of their nuclear weapons. Given the initial responses of the nuclear-armed states to the TPNW, the Parties must hope to create a different climate, in part by designing the TPNW verification system to satisfy all Parties, while providing value to the nuclear-armed states. The TPNW verification system will play a crucial role in decisions by nuclear-armed states to sign the Treaty, how they participate, and the steps they are prepared to accept leading eventually to the elimination of all of their nuclear weapons.

The TPNW requires each nuclear-armed State Party to:

1. eliminate its nuclear arsenal;
2. eliminate, or irreversibly convert its nuclear weapon facilities to peaceful use; and
3. commit to never again produce nuclear weapons.

North Korean leader Kim Jong Um is briefed by his experts on the details of their thermonuclear warhead.

The Treaty stipulates that these undertakings will be verified to confirm that nuclear-armed TPNW Parties honour their Article 4 obligations.

This Policy Brief is presented in three parts:[1]

Part A explores the anticipated role of the TPNW verification system in the emerging international nuclear disarmament regime, which will determine whether or not the Treaty will be successful in addressing the risks posed by nuclear weapons and in achieving progress on nuclear disarmament.

Part B argues in favour of creating a new verification authority responsible only to the TPNW Parties to address the elimination of the existing arsenals, complementing the verification missions assigned to the International Atomic Energy Agency (the IAEA) in the text of the Treaty.

Part C presents a possible framework, methods and techniques to meet the three verification requirements noted.

The most difficult challenges foreseen for TPNW verification will be:

a. Access to known locations (especially military installations) and access to clandestine locations within a nuclear-armed state or anywhere under its control where undeclared nuclear warheads may be hidden, where nuclear-weapon-related

[1] Much of what is included in this Policy Brief is drawn from my book, T. Shea (2019), *Verifying Nuclear Disarmament,* Routledge Press, London and New York.

activities may be underway, or where undeclared fissile material or other nuclear material might be held;

b. Reaching agreement on verifying items containing classified [2] forms of fissile material, including nuclear warheads, warhead fissile material components, and containers holding bulk forms of fissile material containing classified properties; and

c. Obtaining accurate estimates of the amounts of fissile material that each nuclear-armed state produced or otherwise acquired for its nuclear weapons, the identification number and history of each weapon, warhead, warhead primary and secondary component produced, and the disposition of the remaining fissile material.

This Policy Brief is intended to assist the Parties as they consider this task.

Part A: The TPNW Verification System and the Nuclear Disarmament Regime

By analogy, the Non-Proliferation Treaty and IAEA safeguards define the core of the non-proliferation regime, but that regime has grown to encompass nuclear supplier controls, the Proliferation Security Initiative, and special verification arrangements created under the authority of the United Nations Security Council, for example, in Iraq, North Korea and Iran. So, too, the TPNW and its verification system will grow to make continuing progress on disarmament likely and sustainable. As in the non-proliferation regime, sometimes mechanisms have been added to existing bodies, sometimes new entities have been created.

The principal difference between the two is that NPT states with nuclear weapons (Britain, China, France, Russia and the United States) (referred to as Nuclear Weapon States, or NWS in the NPT) and the great majority of NPT non-nuclear weapon states (NNWS) agree that proliferation is extremely dangerous. Proliferating states are historically outside the norms of national behaviour. As a result, the NNWSs have accepted demand after demand for less freedom and more intrusive inspections while the nine nuclear-armed states have managed to dismiss repeated calls for progress and the NWS have essentially ignored their NPT Article VI obligations for fifty years. [3]

Attracting the Nuclear-Armed States

The task for the Parties of creating the TPNW Verification System is all the more challenging given that no nuclear-armed state has signed the TPNW or voiced any positive views on its behalf. Up to now they have managed to avoid any commitments to begin a process of disarming and, regardless of the verification system adopted under the TPNW, they will

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[2] In this Brief, *classified forms* or *properties* means that knowledge of the shape, dimensions, physical form, chemical and/or isotopic composition of specific fissile material are restricted because that information would convey secret information on the design or manufacturing of nuclear weapons.

[3] See, for example, J. Carlson, V. Kuchinov and T. Shea, (2020), *The IAEA's Safeguards System as the Non-Proliferation Treaty's Verification Mechanism*, NTI Paper, https://media.nti.org/documents/NTI_Paper_Safeguards_FINAL_5-8-20.pdf.

probably not agree to participating in the TPNW – until they perceive that it could help their national security to do so, and when diplomatic pressure from the TPNW Parties convinces them—one after another—to sign on.

In creating the TPNW verification system, the Parties need to try to anticipate the national security requirements of the nuclear-armed states in order to attract them to the Treaty. The first reaction of those states rejecting the Treaty was no doubt a blanket wish to avoid any entanglement on this topic, continuing the tradition of the P5 to refuse any response to their commitments under NPT Article VI, with the certainty that India, Israel, North Korea and Pakistan would follow suit, knowing that any initial step would put them on a slippery slope where they would be pressed repeatedly to do more, then more, then more.

Once the TPNW verification system is fixed and is up and running, the nine nuclear-armed states might look more favourably at the costs and benefits of participating in the TPNW – especially and, taking into account its intention to work a broad scope of issues that they, together with the international community, might support.

The Scope of the TPNW Verification System

Hence, the TPNW Parties should consider broadening the scope of the TPNW Verification System to include additional measures to enrich the role of the TPNW in securing peace and stability, and to encourage the nuclear-armed states to participate.

The scope of the TPNW Verification System would begin with the three objectives defined in the TPNW as noted above. Recognising that there is no international mechanism for addressing the risks arising from nuclear arsenals and that all TPNW Parties are potential victims should those risks be manifested, should the TPNW Verification System specifically also address these risks associated with nuclear weapons, to manage threats associated with:

a. Tensions between nuclear adversaries possibly leading to nuclear war;
b. Steps taken by nuclear-armed states regarding the prevention of unauthorised use of their nuclear weapons;
c. Steps taken by nuclear-armed states to prevent sabotage or accidental detonations of their nuclear weapons;
d. Nuclear terrorism; and
e. Steps to make proliferation less attractive.

TPNW-Related Confidence-Building Measures

Not all nuclear-armed states threaten one another. Treaties and agreements between adversaries provide a common means for adversaries to move from confrontation to stability. The international nuclear disarmament regime should encourage bilateral or trilateral treaties between nuclear adversaries ideally within the framework of the TPNW Verification System. Under such an arrangement, while allowing TPNW inspectors to verify step-by-step progress in a state, under a bilateral or trilateral accord, the Parties could undertake their own verification of highly sensitive activities, including dismantling nuclear

warheads and subsequent processing to remove all classified properties from the recovered fissile material.

Every nuclear weapon which includes fusion energy will require deuterium, tritium and, for thermonuclear weapons, enriched lithium. Bilateral or trilateral controls on these materials could provide another mechanism to encourage and confirm progress towards disarmament, and another mechanism to detect cheating.

Bilateral or trilateral controls on warhead refurbishment and re-manufacturing would provide one mechanism for providing reciprocal transparency into an adversary's nuclear arsenal management.

Before nuclear-armed states are prepared to sign on to a treaty commitment that allows them no way out, it could be helpful if combined exercises could be held carried out by TPNW inspectors within each nuclear-armed state. The objective of such exercises would be to contribute to a realistic understanding of the steps each nuclear-armed state should expect, and to identify obstacles to implementation.

A commitment to disarmament must involve an irreversible process leading to the eventual elimination of their weapons and their production capabilities; however, it could be helpful to provide time-limited temporary arrangements under which a nuclear-armed state could submit weapons, warheads or warhead fissile material components to monitoring with the understanding that the state would maintain the right to withdraw such items if it so decided. Such a step might be helpful in convincing the adversary(ies) of a nuclear-armed state to take measured steps providing confidence in their *bona fides* and encouraging reciprocal commitments. Such steps should encourage full commitments to disarmament.

The Nuclear Suppliers Group and the Zangger Committee regulate commerce in materials, facilities, equipment and know-how within the non-proliferation regime. They control access to objects that could assist a state attempting to acquire nuclear weapons. As progress is made toward the elimination of existing nuclear weapons, it could be appropriate to introduce appropriate export/import controls as part of the nuclear disarmament regime.

Part B: TPNW Verification Authorities

Under Article 4.6 of the Treaty,

> "The States Parties shall designate a competent international authority or authorities to negotiate and verify the irreversible elimination of nuclear-weapons programmes, including the elimination or irreversible conversion of all nuclear-weapons-related facilities in accordance with paragraphs 1, 2 and 3 of this Article."

Based on my 24.5 years of service in the IAEA Safeguards Department, I can state categorically that the IAEA could—in principle—carry out any and all technical verification tasks foreseen in Article 4.6. But should it?

In favour of having the IAEA serve as the exclusive TPNW verification authority, consider the following:

- The IAEA exists and is highly regarded.
- It would be cheaper and faster for the IAEA to take on the Article 4.6 mission than to start up a new organisation for this purpose.
- Many of the existing capabilities and much of the IAEA's experience would be applicable to the Article 4.6 task.

However, in my opinion, based on the reasons cited below, the TPNW Parties should create a new organisation for this all-important responsibility:

1. Governance: The governing structure for the IAEA dates back to 1957. In addition to directions identified within the Agency itself, the IAEA accepts requests or mandates from the UN Security Council and normally adopts agreed recommendations from NPT Review Conferences. Its governance arrangements are well established and 'set in stone.' It would be difficult to allow TPNW parties to exercise control over the Article 4.6 disarmament verification role in addition to the roles already assigned. Moreover, both the Board of Governors and the General Conference include IAEA Member States who may choose to continue to remain outside the TPNW, complicating the ability of the TPNW parties to manage IAEA verification – especially in relation to Article 4.6.
2. Challenge Inspections: Pursuing indications of possible hidden nuclear weapons, warheads, or fissile material warhead components, or of undeclared nuclear activities or nuclear material, "challenge" inspections might be considered to be important. But there are no provisions for challenge inspections in the current IAEA safeguards system and introducing the necessary provisions would be difficult.
3. Competition for Attention: The IAEA is a multi-programme international organisation. If Article 4.6 verification is assigned to the IAEA, the verification requirements of Article 4.6 would need to compete with these other programmes, making it questionable whether the attention given to Article 4.6 verification would meet the intentions of the TPNW parties. In addition to its non-proliferation verification obligations under the NPT, the IAEA currently implements a host of voluntary programmes at the request of—and in support of—the needs and interests of IAEA Member States. Many are financed in whole or in part through voluntary extra-budgetary funds. These include nuclear power, nuclear safety and security, application of nuclear methods to health, agriculture and industry, and technical support in all of these fields to developing Member States.
4. Controversy: It would be difficult for the IAEA to be asked to consider related tasks – such as threat reduction measures to reduce the likelihood of nuclear conflict, or nuclear weapon safety and security. These are likely to be controversial and disruptive.
5. Non-proliferation Consensus: The non-proliferation mission of the IAEA functions on the basis of consensus, which has held remarkably well over the years. This

consensus reflects the positive role played by nuclear-armed states within the IAEA in support of its technical and financial requirements to implement safeguards in all of its capabilities.[4] Verification of Article 4.6 might undermine the non-proliferation consensus.

6. Requirements for Equipment Procurement & Use: The verification methods and procedures employed by the IAEA are developed and procured following agreed arrangements. The equipment used by the IAEA is accepted for common use in all relevant Member States. Verification equipment for Article 4.6 will have to be developed to meet the requirements of each nuclear-armed state, in order to provide the nuclear-armed state the protection it would demand against espionage. At the same time, it will have to provide the authenticity assurance that the verification authority would demand. Assigning verification of Article 4.6 to the IAEA would saddle it with additional demands that could impact its access to practical measures for use in relation to its non-proliferation role, or to the IAEA verification responsibilities explicitly called for in the TPNW.
7. Military Presence: Lastly, the IAEA functions via diplomacy and technology working in unison. Adding Article 4.6 to the IAEA missions would inevitably increase military participation in the day-to-day workings of the IAEA, which could undermine the success of the IAEA in meeting its other demands.

It is for these reasons that I believe that the TPNW Parties should create a new verification authority. The TPNW parties would then decide what to call it, how it should be created, where it should be headquartered, staffed, etc. Until then, the new authority might be referred to as the 'International Nuclear Disarmament Agency,' or 'INDA.'[5]

[4] J. Carlson, V. Kuchinov and T. Shea, op.cit.

[5] T. Shea, Op.Cit., Verifying Nuclear Disarmament, Chapters 1 and 2.

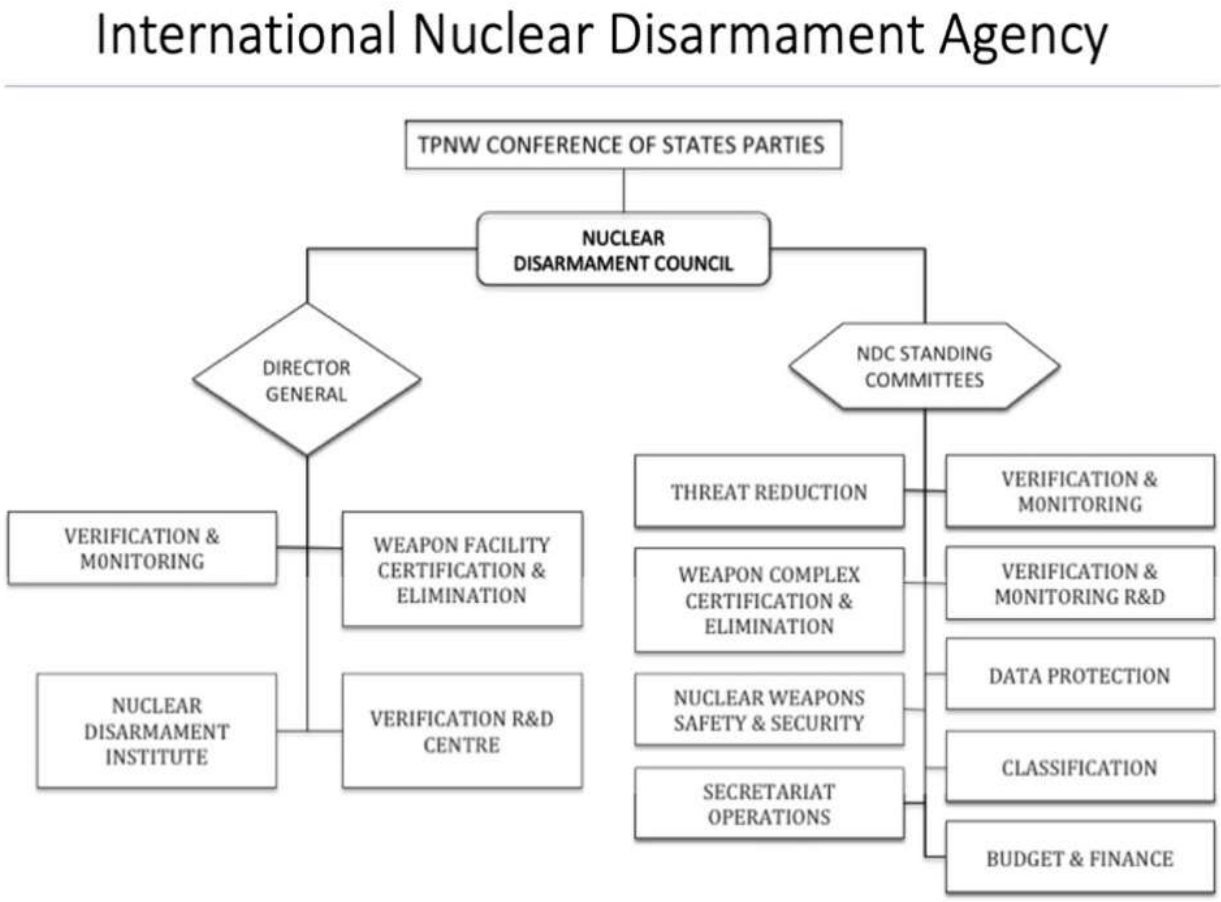

Figure 1. If the TPNW Parties decide on a new organisation, it might look like the hypothetical organigram in the figure.

If the Parties opt for INDA, the verification assignments for INDA and the IAEA might be settled as follows:

INDA	IAEA
1. Encourage nuclear-armed states to disarm	1. Disposition fissile material from disarmament
2. Verify arms reductions and fissile material controls at four levels	2. Detect diversion of declared stocks of nuclear material at declared facilities
3. Detect undeclared nuclear weapons, warheads or fissile material warhead components	3. Detect undeclared production, processing at declared facilities
4. Certify and eliminate mission-critical nuclear weapon facilities	4. Detect undeclared nuclear materials and undeclared nuclear activities
5. Verify non-explosive military uses of fissile material	5. Estimate and verify historical production of all plutonium, HEU, U-233, Np-237, and Am-241
6. Verify historical production of all nuclear weapons and their current whereabouts	-/-

Joint INDA/IAEA Tasks
Detect undeclared nuclear weapon production facilities
Convert mission-critical nuclear weapon facilities to peaceful use

Part C: Verification Methods and Procedures

When a nuclear-armed state becomes a Party to the TPNW, it will begin interacting with INDA and the IAEA. It will provide its official declaration on its nuclear weapons programme and the steps it commits to carrying out. A master verification dossier should be created by INDA and maintained for each nuclear-armed state, which would document all declarations made by it, all recommended steps for it to undertake, and all actions taken over time toward its full and complete disarmament. It would include all activities under the three objectives cited above and be the basis for reporting progress under the Treaty.

Certain aspects of the TPNW verification system will resemble current verification activities under the IAEA safeguards system in relation to the obligations of non-nuclear-weapon states parties to the NPT – especially in regard to objective 3, above. While the IAEA has no disarmament role at present, its assistance in relation to the TPNW will be invaluable, noting that the IAEA is obligated under Article III.B.1 of its Statute:

"B. In carrying out its functions, the Agency shall:

1. Conduct its activities in accordance with the purposes and principles of the United Nations to promote peace and international co-operation, and in conformity with policies of the United Nations furthering the establishment of safeguarded worldwide disarmament and in conformity with any international agreements entered into pursuant to such policies."[6]

Owing to the extreme security surrounding nuclear weapons, new methods and procedures will be necessary for the TPNW verification system – especially in regard to objectives 1 and 2 above, to provide clear indications of the disarmament activities undertaken by each nuclear-armed state.

1. Verifying the Elimination of a Nuclear Arsenal

The focus of TPNW verification is on the possession and use of fissile material,[7] in much the same manner as the principal NPT verification focus is on the possession and use of nuclear

[6] https://www.iaea.org/sites/default/files/statute.pdf

[7] For TPNW verification, *fissile material* means plutonium with 90% or more of the isotope Pu-239 or highly enriched uranium (HEU) containing more than 20% U-235. Other nuclear species could be used in lieu of plutonium or HEU, including plutonium containing lower amounts Pu-239, U-233, Np-237 and Am-241, but each has properties that make it less suitable than weapon-grade plutonium or HEU. *Nuclear materials* are broader in scope than *fissile material.* Whereas TPNW verification is focused primarily on *fissile materials* essential for nuclear weapons, NPT verification focuses on *nuclear materials* from which nuclear weapons could be produced. *Fissile material is nuclear material that* is ideally suited to nuclear weapon use.

material. TPNW verification may also include non-nuclear weapon components, and weapon support activities and facilities, to increase assurances that a nuclear-armed state is honouring its TPNW obligations. Verifying the elimination of a nuclear arsenal should include—where possible—verifying the physical destruction of each warhead after its fissile material components have been removed, verifying the warheads and warhead components to confirm their authenticity, then measuring the recovered fissile material and tracking it until it is transferred to an approved disposition process, under IAEA safeguards.

TPNW verification should assure that all fissile material in all forms associated with nuclear weapons be recovered, re-committed to an approved disposition process, and be subject to IAEA safeguards thereafter. (Note that verification of the destruction of a weapon delivery system could enhance the verification process, if agreed by the state and the verification authority.)

Figure 2 shows how fissile materials (plutonium and HEU) are used in a modern hypothetical thermonuclear warhead. The fission primary ignites or triggers the fusion secondary, which produces most of the explosive force. In the example shown, the explosive yield from fissioning plutonium in the primary is 'boosted' by fusing deuterium and tritium in gas form within the primary 'pit,' and the explosive yield of the secondary from fusing deuterium and tritium is increased by including HEU, causing additional fission energy to increase the overall explosive yield of a nuclear weapon.

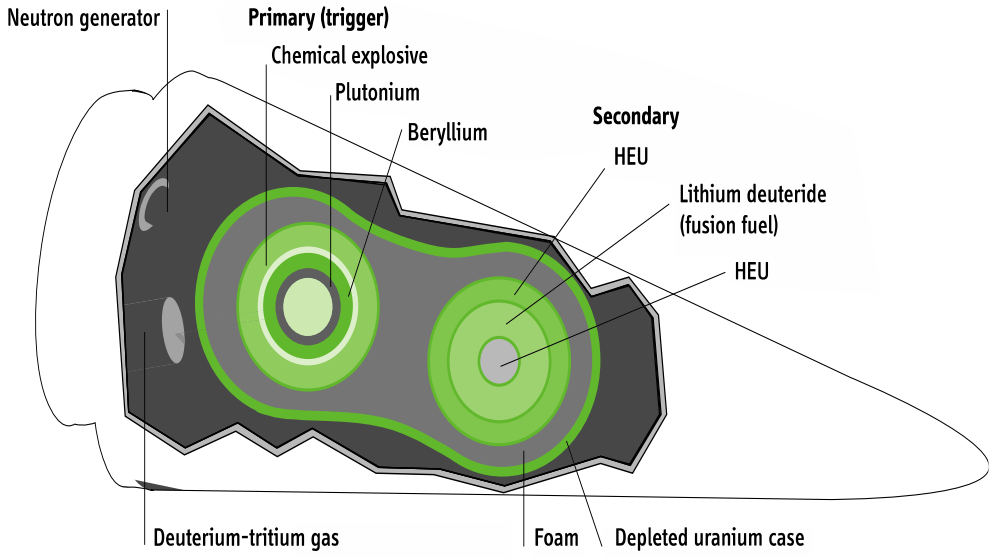

Figure 2. The Princeton cutaway diagram of a modern thermonuclear warhead.
Photo: International Panel on Fissile Materials, Princeton University

Grouping the disarmament steps into four levels will facilitate organisation of the required verification activities.

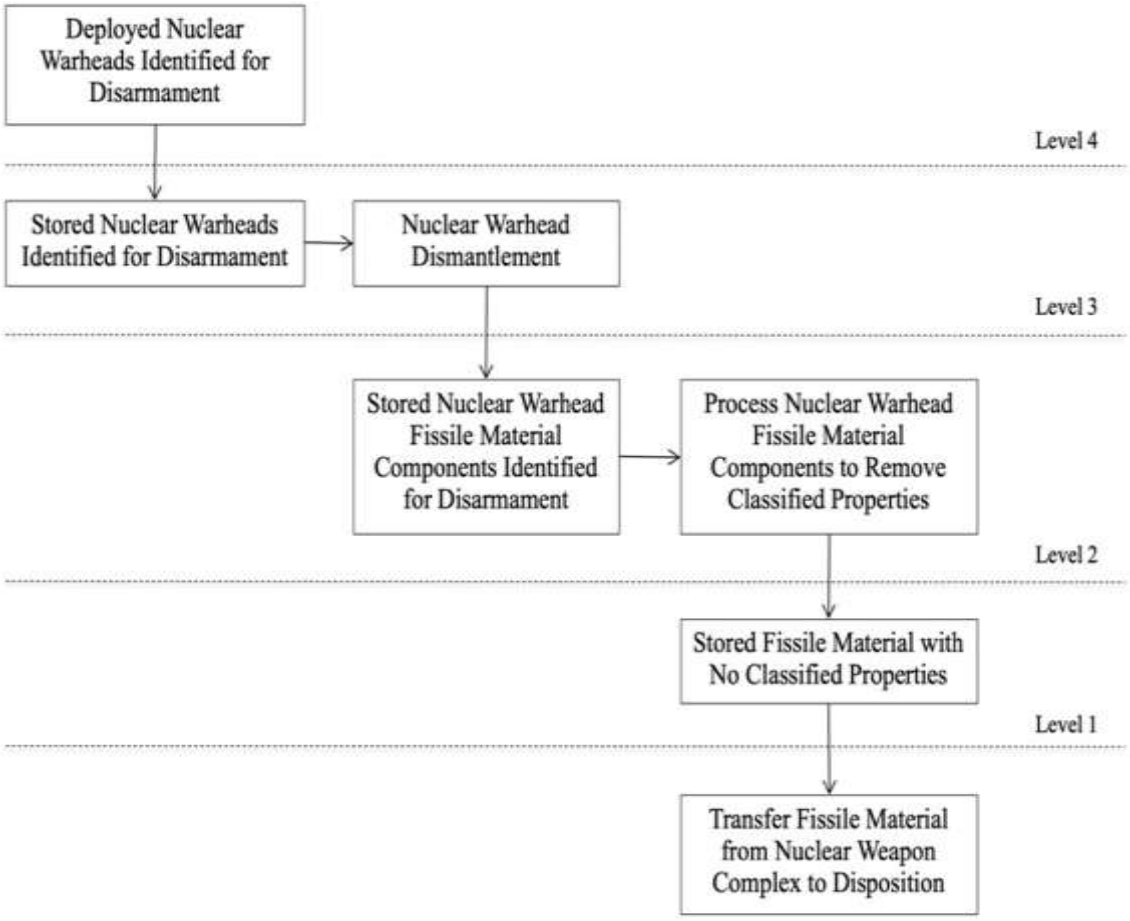

Figure 3. Fissile material will be removed from the nuclear weapon complex following the stages shown. Note that fissile material additional to that obtained by disarming a specific weapon may exist, and that fissile material could be introduced into the TPNW verification system at any level, corresponding to its properties.

Verification of the steps shown in Figure 3 could involve accepting declared objects into the verification process at any of the levels shown.

- If a nuclear-armed state and the verification authority are able to reach agreement on procedures that enable the authority to verify that an item declared to be a warhead is a true warhead, or if such verification were to be carried out under a bilateral or trilateral agreement between nuclear adversaries operating within the TPNW, then Level 4 verification could confirm that specific nuclear weapons have been disarmed and destroyed.
- At Level 3, the verification measures could confirm that specific warheads are destroyed and that the primaries and secondaries from each warhead will continue to be monitored.
- At Level 2, verification could confirm that the primaries and secondaries from specific warheads, or other primaries or secondaries, or other forms of fissile material are processed to remove all classified properties, noting that unclassified fissile material may be altered to block the verification authority from inferring the amounts of fissile

material or the isotopic compositions of actual warhead components or warheads when unrestricted verification measures are applied at Level 1.[8]

If the state and the authority do not agree on warhead verification, then the information derived will be less immediate and the assurances less direct. Using appropriate containment and surveillance devices to maintain continuity of knowledge through warhead dismantling and the processing operations for removing all classified properties, when allowed, unrestricted measurements of the recovered fissile material can be made using IAEA measurement systems, and the verification authority might reasonably conclude that the fissile material recovered had been used in nuclear weapons.

In any case, every nuclear-armed state will have detached warheads and have dismantled warheads before the TPNW comes into force. Hence, TPNW verification will differ in each nuclear-armed state and never be as clear or as credible as IAEA safeguards verification of non-nuclear weapon NPT states' commitments.

Verifying Classified Forms of Fissile Material

A nuclear-armed state will balance its TPNW obligations with protecting its national security from possible espionage under the guise of verification by preventing access to sensitive nuclear weapon design or manufacturing information that could enable a nuclear-armed adversary to gain a military advantage, or encourage or enable a state that does not have nuclear weapons to proliferate.

It would, in principle, be ideal for the purposes of verification to be able to determine that each warhead presented for verification is in fact a warhead, or that each primary or secondary is as declared. That would bring greater credibility to the verification process. In principle, it would be possible to measure the fissile material in situ, using nondestructive methods, together with the internal shapes and sizes of the inside of a warhead nose cone or a container, determining the types of fissile material that are present and how much of each is included, etc. But such measurements could clearly identify information that is considered to be sensitive to the design and/or manufacturing of a warhead or primary or secondary. Providing that sort of access could violate the nuclear-armed state's security laws and regulations, its NPT Article I prohibitions, and perhaps encourage proliferation, and hence TPNW verification must be restricted.

The IAEA has established competent methods for verifying unclassified forms of nuclear material which could be applied to verify all unclassified forms of fissile material. But the verification of nuclear weapons, warheads and warhead fissile material components poses a conundrum for each nuclear-armed state and the verification authority:

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[8] In 2000, the United States and the Russian Federation signed a Plutonium Management and Disposition Agreement under which each would convert 34 tonnes of plutonium from nuclear weapon use under IAEA safeguards. Under this Agreement, Russia would be allowed to blend this plutonium so as to conceal the isotopic concentration of the plutonium it uses in its nuclear weapons. This agreement never went into force and is now defunct. http://fissilematerials.org/library/PMDA2010.pdf

a. Whereas in NPT verification, the nuclear-armed states and the NPT non-nuclear weapon states share common interests and produce verification systems for the IAEA that are owned by and controlled by the IAEA, in disarmament verification, each nuclear-armed state is likely to be suspicious of other states and protect itself against the use of any equipment which might be capable of acquiring information in addition to its declared purpose. This concern will limit how much information the TPNW verification system is able to acquire, which physical methods are allowed to be used in the verification process, and how verification equipment will be produced and implemented. These restrictions will likely differ from state to state.

b. To be meaningful, verification of the TPNW must be independent, be based on sound scientific methods, and be implemented in such a manner as to provide confidence in the authenticity of the findings.

Both must be satisfied if the verification system will include steps to assure that warheads and warhead components declared by a nuclear-armed state are, in fact, as declared. A six-year Trilateral Initiative carried out by the United States, the Russian Federation and the IAEA demonstrated that acceptable arrangements for international verification of classified forms of fissile material are possible when the parties recognise the need to cooperate fully toward that purpose.[9]

Several research institutes are looking at possible ways to 'verify' nuclear warheads, without divulging classified information, and avoiding technologies that could be vulnerable to hacking, for example. Two concepts have been considered.

In one, the results of what would otherwise be revealing measurements are compared to unclassified **attributes** so that inspectors see only whether each comparison passes or fails. Under the Trilateral Initiative,[10] for example, the verification measurements on plutonium were to answer three questions about an item presented for verification:

> Is plutonium present? (Y/N)
>
> Is the ratio of Pu-240 to Pu-239 equal to 0.1 or less (as is typical for nuclear weapons)? (Y/N)
>
> Is the mass of plutonium above a value to be set for each facility where verification measurements will be made? (Y/N)

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[9] Shea, Thomas E and Rockwood, Laura, "IAEA Verification of Fissile Material in Support of Nuclear Disarmament." (Cambridge, Mass.: The Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard University, May 2015). Under the Trilateral Initiative, Russian experts informed their U.S. and IAEA counterparts that if the IAEA would bring its equipment to Russia to use for verifying classified forms of fissile material, Russian security experts would have to examine each item, that each examination could take up to 18 months, that if some problems were identified, the IAEA would be informed, but not of the specific problems, and the equipment would likely not be returned to the IAEA after the examinations. If the items were determined to be acceptable for the IAEA to use they would be returned to the IAEA, but the IAEA would not be allowed to open the equipment to confirm that the equipment had not been modified such that it would not function in the manner intended.

[10] T. Shea and L. Rockwood, op. cit.

This method could be extended to include other properties, if the state and the verification authority agree.

In the other concept, the properties of an item being verified are compared to the properties of a "known" reference, i.e., a **template** comparison, or to many other items declared to be "identical". When there are many "identical" items, then the numbers themselves may provide some assurance, especially when the verification authority has the authority to select specific warheads for dismantlement. If the items are to be stored for long periods before the fissile material can be fully verified, then calibrating the templates takes on additional importance.

Recalling the security conundrum noted, avoiding or coping with potential hacking will also be necessary.

As yet, no such methods have been accepted by any party for use, even hypothetically, although some may have been tested under realistic arrangements. An ongoing TPNW research and development effort will be needed.

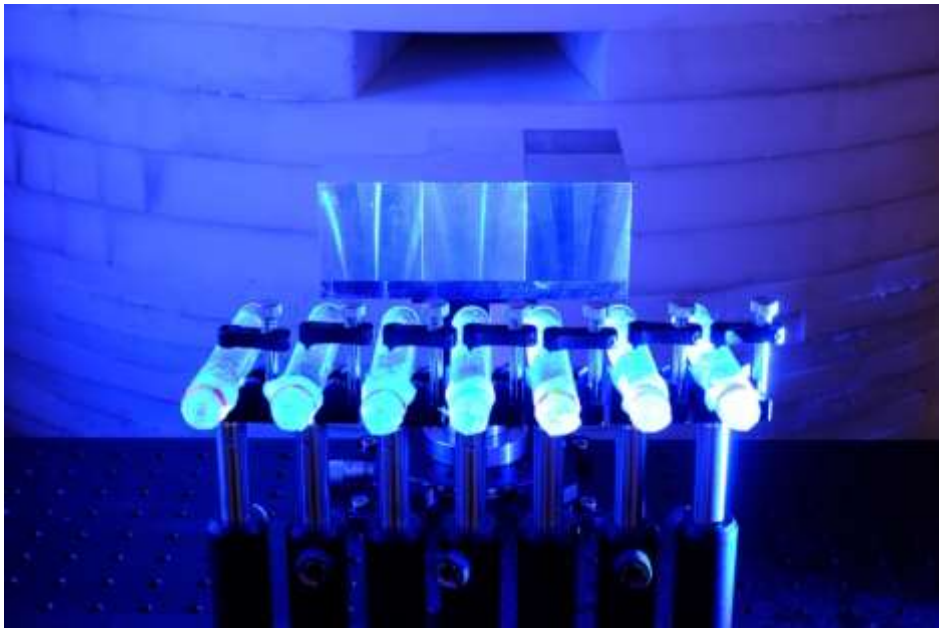

Figure 4. One promising concept for warhead verification involves an array of stand-alone bubble chamber detectors, avoiding the complications of having computers near warheads. After the warhead is irradiated with an accelerator, the bubble chambers are removed to another location for analysis. See: S. Philippe, R. J. Goldston, A. Glaser and F. d'Errico, (2016), *A Physical Zero-Knowledge Object-Comparison System for Nuclear Warhead Verification*, Nature Communications, 7:12890.

A Suggested Arsenal Elimination Verification Process

Each arsenal will be different. For example, a nuclear-armed state may have a single type of nuclear weapon, or it may have—or have had—different types of nuclear weapons, including nuclear warheads on ICBMs or shorter-range missiles, or in cruise missiles,

gravity bombs, torpedoes, sea or land mines, nuclear artillery, or man-deliverable nuclear weapons.

To verify the elimination of a nuclear-armed state's arsenal, the TPNW verification system will need to address each of the nine nuclear-armed states individually or as part of a sub-group of nuclear adversaries. Each would submit official declarations on its nuclear weapons programme and a schedule identifying the steps it intends to carry out within a specified period.

For each state, the TPNW verification system would organise verification methods and procedures for any deployed nuclear weapons included in the schedule, any detached nuclear warheads, fissile material nuclear weapon components, fissile material having classified warhead design or manufacturing properties that must not be shared with international inspectors, and all unclassified forms of fissile material remaining committed by a state to use in nuclear weapons.

Being able to determine that a "warhead" declared by a nuclear-armed state is in fact a real warhead and not a fake would give the verification system greater credibility and connect each to the process of disarmament. Recognising that it may take years to dismantle all warheads in an arsenal, such assurances would benefit the international community and a state's adversaries. If no such methods are approved, the ability of the TPNW verification system to identify and schedule individual warheads for dismantling would provide additional assurance.

The verification steps for the elimination of a state's arsenal should follow those shown in Annex 1. These steps pertain to verifying declared actions taken by a state. These steps do not address the possibility that a state may have hidden weapons or that it may have concealed its capability to manufacture new ones. Those concerns are addressed later in this Brief.

2. Verifying the Elimination or Irreversible Conversion of a State's Nuclear Weapons Production Complex

Every nuclear weapons programme will include a production chain for manufacturing nuclear warheads, warhead testing facilities, facilities for maintaining and repairing its warheads to assure that they remain reliable, plus dismantling facilities to retire warheads safely when they become obsolete or are no longer reliable. Each nuclear-armed state upon becoming a TPNW party, should, *inter alia*, provide a declaration of its nuclear weapon programme history and identify all required facilities as specified by the TPNW parties.

The nuclear weapon complexes in the nine nuclear-armed states differ significantly in terms of scale, redundancy, methods adopted to assure on-going functionality, and the ease with which a state can maintain, repair or replace its warheads over time. One may have a single complex of facilities to support its nuclear weapons programme, while others may have adopted redundant facilities for security purposes. Hence, the TPNW/VS will need to be tailored to each of the nine nuclear-armed states, just as IAEA safeguards are tailored to the specific circumstances of each state.

As provided in Article 4.2 of the TPNW,

> each State Party that owns, possesses or controls nuclear weapons or other nuclear explosive devices shall immediately remove them from operational status, and destroy them as soon as possible but not later than a deadline to be determined by the first meeting of States Parties, in accordance with a legally binding, time-bound plan for the verified and irreversible elimination of that State Party's nuclear-weapon programme, including the elimination or irreversible conversion of all nuclear-weapons-related facilities. (Underlining added for emphasis.)

The warhead production complex includes the fissile material acquisition element, plus the non-fissile material subsystems required for the warhead to function (such as the fuzing, firing, and neutron generator subsystems). The TPNW parties will need to define which of nuclear-weapons-related facilities are to be included under Article 4.2 verification, and also define the terms 'verified elimination' and 'irreversible conversion.'

For the facilities noted, verification should include confirming the location, functions and history of each facility identified. Inspectors from nuclear-armed states with expertise related to each function will be needed to undertake this activity in a competent manner. Verification could then proceed as suggested in the table shown in Annex Table 2, below.

Figure 5. The Pantex Plant is the primary U.S. facility for the final assembly, dismantlement and maintenance of nuclear weapons. Pantex has approximately 650 buildings and is one of six production facilities in the U.S. National Nuclear Security Administration's Nuclear Security Enterprise.
Photo: https://pantex.energy.gov

The parties to the TPNW should consult the IAEA on its nuclear weapon acquisition path analysis system before fixing the TPNW requirements.

3. Verifying the Absence of Undeclared Nuclear Warheads or New Production

The verification authority must assume that one or more of the nuclear-armed states Parties to the Treaty may intend to cheat. It must consider for each state what its most plausible means would be to hide existing warheads or make new ones and identify verification activities it could take to deter the state from proceeding, or to detect it if it did. Verifying the absence of undeclared nuclear warheads or new production would be carried out to prevent a nuclear-armed state from cheating on its TPNW obligations by intentionally omitting nuclear weapons, warheads, or fissile material warhead components from its declarations, or having undeclared weapon production capabilities that could be used by the state to produce new nuclear weapons to offset ones it dismantles.

This verification should encompass two concerns. The first would be to assure that all nuclear material declared by the state remains in peaceful use. This verification would—as specified in the TPNW—be undertaken by the IAEA, by adapting its existing methods. The IAEA is expected to detect the diversion of nuclear material committed to peaceful use to the manufacture of nuclear weapons or other nuclear explosives, or for unknown purposes, and to detect undeclared activities in facilities committed to peaceful use. While this would no doubt bring some new challenges to the IAEA, adapting existing practices should be relatively straightforward.[11]

Note that the IAEA might wish to introduce a new form of safeguards agreement for this mission, which could emphasise the disarmament nature of this undertaking and include the substance of the Additional Protocol as reflected in INFCIRC/540.

The second concern would require the TPNW verification system to gain knowledge of a nuclear-armed state's efforts to hide nuclear warheads and/or establish a clandestine warhead programme or the concealment apparatus to avoid its discovery. To address such threats, the TPNW verification system must allow for the introduction of so-called "third-party information" – including national intelligence information.[12]

The TPNW Parties should consider whether to include *challenge inspections* as part of the verification system, when it is deemed to be necessary.

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[11] J. Carlson, V. Kuchinov and T. Shea, op. cit.

[12] The IAEA Statute encourages Member States to provide such information as would, in the judgement of the Member, be helpful to the Agency. (Article VIII.A.). In relation to safeguards in Iran, at one point the Director General reported that more than 10 States had provided such information.

Annex 1: Inspection Activities for the Elimination of a State's Nuclear Arsenal

Category	Inspection Activities
Deployed nuclear weapons under military control designated for disarmament.	1. Visual examination of mounted warheads *in situ*; 2. Observation of de-mating the warhead; 3. Identification of warhead ID markings; 4. Application of seals and surveillance methods to establish and maintain a chain of custody;[13] 5. Use of allowed radiometric measurement systems to confirm agreed warhead characteristics, as allowed by state;[14] 6. Re-verification during transport & storage.
Complete nuclear warheads (see Figure 2) detached from delivery systems, under military control, as above, or additional warheads within the production complex, or on reserve, in maintenance or repair, under production, or in dismantlement.	1. Identification of warhead ID markings; 2. Application of seals and surveillance for establishing or confirming chain of custody; 3. Use of allowed radiometric measurement systems to confirm agreed warhead characteristics, as allowed by state; 4. Verification of warhead dismantlement by perimeter control, perhaps supplemented by bi- or trilaterial inspections; 5. Verification of fissile material warhead components inside of storage/shipping containers by use of ID confirmation, application of seals and surveillance to establish and maintain the chain of custody, and use of allowed radiometric measurement systems to confirm each item, according to protocols approved by the verification authority and by the state; 6. Re-verification of fissile material warhead components during transport & storage.
Fissile material components recovered from nuclear warheads (see Figure 2) during dismantling containing plutonium and/or highly enriched uranium, and any process, scrap or waste materials containing these fissile materials having classified properties.	1. Examine and record ID markings; 2. Application of methods establishing or confirming chain of custody; 3. Verification of fissile material warhead components by use of allowed radiometric measurement systems to confirm each item, as allowed by state; 4. Verification of processing of fissile material warhead components to remove all classified properties by perimeter control, perhaps supplemented by bi- or trilaterial inspections; 5. Use of existing IAEA-type radiometric assay systems to verify the elemental and isotopic content of all fissile material with no classified properties, use of seals and surveillance to establish and maintain the chain of custody on unclassified fissile material; 6. Re-verification fissile material during transport & storage.

[13] Note that as the warheads are to be dismantled, making permanent markings on the nose cone and base should be included in the scheme of containment and surveillance to facilitate tracking a warhead through transportation and interim storage until the dismantling operation can be carried out.

[14] Verification measurements will require that the State agrees that the information obtained and the access granted would not pose a risk of espionage, and that the verification authority is able to make use of methods based on sound science, under arrangements that ensure the results are authentic. Attribute verification and template matching are described in *Verifying Nuclear Disarmament*, including an Annex identifying promising methods.

Category	Inspection Activities
Fissile material committed by the state to use in nuclear weapons remaining within the nuclear weapon production complex, not containing any classified properties.	1. Identification of container ID markings; 2. Use of IAEA-type radiometric assay systems to verify the elemental and isotopic content of all fissile material having no classified properties; 3. Use of seals and surveillance to maintain the chain of custody on unclassified fissile material; 4. Re-verification fissile material during transport & storage until transfer to disposition under IAEA supervision.
Verification of the absence of any undeclared nuclear weapons or nuclear warheads or fissile material nuclear warhead components, once a NASP has declared that its entire arsenal has been eliminated.	1. Unannounced access to specific locations; 2. Visual examinations, perhaps under managed access arrangements; 3. Use of passive radiometric measurement systems to detect fissile material; 4. Use of neutron generators to stimulate fission from fissile material;

Annex 2: Inspection Activities for the Elimination of a State's Nuclear Weapon Capabilities, or Irreversible Conversion of Certain of a State's Nuclear Weapon Capabilities to Peaceful Use

Category	Inspection Activities
Verification of mission-critical nuclear weapon facilities.	1. Examination of information provided by the state to determine location, functions, historical record of operations, and current capabilities; 2. Visual examination of each facility, including essential equipment as required for the declared nuclear weapon support functions performed.
Verification of the destruction of each designated mission-critical nuclear weapon facilities following verification under step 1 above.	1. Review of plan for destruction and enabling actions; 2. Verification of disposition of sensitive equipment; 3. Verification of actual destruction; and 4. Ongoing verification of satellite imagery.
Verification of the irreversible conversion of designated mission-critical nuclear weapon facilities to peaceful use following verification under step 1 above.	1. Review proposed modification and submit plans to IAEA Board of Governors for approval; 2. Verify disposition of designated sensitive equipment identified under step 1 above; 3. Verify modifications; 4. Institute ongoing monitoring programme, as determined by IAEA Board of Governors.

The Author

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