UNIDIR

Nuclear Disarmament Verification

Survey of Verification Mechanisms

UNIDIR RESOURCES

Acknowledgements

UNIDIR is grateful to the Government of New Zealand for its support in funding this project.

About the author

Tim Caughley is a Senior Research Fellow at UNIDIR. He was assisted by Mapril Pocas Da Silva, a graduate student Mastering in European Studies at the Global Studies Institute, University of Geneva, and an intern at UNIDIR.

UNIDIR and verification

Research projects evaluating the verification procedures and practices in arms limitation and disarmament agreements have been a regular part of UNIDIR's work over the years. Major publications include *Verification of Current Disarmament and Arms Limitation Agreements, Ways, Means and Practices* (edited by Professor Serge Sur), 1991; *Sensors for Peace: Applications, Systems and Legal Requirements for Monitoring in Peace Operations*, 1998; and *Coming to Terms with Security: A Lexicon for Arms Control, Disarmament and Confidence-Building* (Chapter 10) (Steve Tulliu and Thomas Schmalberger), 2001 (revised in 2004) and its companion piece, *Coming to Terms with Security: A Handbook on Verification and Compliance*, which was published jointly with VERTIC in 2003. In addition, a full issue of *Disarmament Forum* was devoted to 'Arms control verification' in 2010 (volume 3 of that year). UNIDIR's latest survey does not attempt to update or replicate those earlier publications: instead it seeks to outline sources relevant to the growing debate about the kinds of measures that will be needed for the elimination of nuclear weapons.

About UNIDIR

The United Nations Institute for Disarmament Research (UNIDIR)—an autonomous institute within the United Nations—conducts research on disarmament and security. UNIDIR is based in Geneva, Switzerland, the centre for bilateral and multilateral disarmament and non-proliferation negotiations, and home of the Conference on Disarmament. The Institute explores current issues pertaining to the variety of existing and future armaments, as well as global diplomacy and local tensions and conflicts. Working with researchers, diplomats, government officials, NGOs and other institutions since 1980, UNIDIR acts as a bridge between the research community and governments. UNIDIR's activities are funded by contributions from governments and donor foundations.

Note

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. The views expressed in this publication are the sole responsibility of the individual authors. They do not necessarily reflect the views or opinions of the United Nations, UNIDIR, its staff members or sponsors.

www.unidir.org

Table of Contents

Executive summary 3

1. The multilateral context: 'Taking forward nuclear disarmament' 4

1.1. Summary 4
1.2. Introduction 4

2. Explaining verification 6

2.1. Summary 6
2.2. Verification 6
2.3. Role of verification 6
2.4. Forms and methods of verification 8
2.5. Other relevant terms 10
2.5.1. Baseline declarations 10
2.5.2. Challenge inspections 10
2.5.3. Fissile material 10
2.5.4. Nuclear disarmament 10
2.5.5. Safeguards 10

3. Verification mechanisms overview 11

3.1. Summary 11
3.2. Recent projects, proposals, international meetings and other collaborations 11
3.2.1. United Kingdom-Norway Initiative (UK-NI) 11
3.2.2. The International Partnership for Nuclear Disarmament Verification (IPNDV) 12
3.2.3. Nuclear Threat Initiative's Verification Pilot Project (NTI Project) 14
3.2.4. United Kingdom-United States Technical Cooperation Programme 14
3.2.5. Trilateral Initiative 15
3.2.6. Fissile Material Prohibition Treaty (FMT)/(FM(C)T) 16
3.3. Legally binding treaties and other relevant arrangements and initiatives 17
3.3.1. Summary 17
3.3.2. Bacteriological and Toxin Weapons Convention (BTWC) 17
3.3.3. Chemical Weapons Convention (CWC) 19
3.3.4. Comprehensive Nuclear-Test-Ban Treaty (CTBT) 19
3.3.5. Non-Proliferation Treaty (NPT) 20
3.3.6. IAEA safeguards 22
3.3.7. Nuclear-weapon-free zones (NWFZs) 23
3.3.8. United-States–Russian Federation bilateral collaboration 24
3.3.9. Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) 25

3.3.10. European Atomic Energy Community (EURATOM) 26
3.3.11. Conventional Forces in Europe (CFE) Treaty 27
3.3.12. Intermediate-Range Nuclear Forces (INF) Treaty 27
3.3.13. Joint Comprehensive Plan of Action (JCPOA): Islamic Republic of Iran ... 28
3.4. The United Nations and verification Issues 29
3.4.1. Security Council 29
3.4.2. General Assembly 30
3.4.3. Secretary-General 31
3.4.4. Open-Ended Working Group (OEWG) 2016 31
3.4.5. Draft Model Convention on Nuclear Weapons 32
3.4.6. Fissile Material Group of Government Experts 33

4. Key verification challenges and analogies 33
4.1. Summary 33
4.2. General 33
4.3. Pre-negotiation bodies 34
4.4. Confidence-building 34
4.5. Transparency 34
4.6. Baseline declarations 35
4.7. Intrusiveness: maintaining confidentiality 35
4.8. Technical feasibility 36
4.9. Experience and expertise 36
4.10. Scope: nuclear lifecycle 36
4.11. Collaboration between nuclear-weapon States and non-nuclear-weapon States 36
4.12. Collaboration among nuclear-weapon States 37
4.13. Collaboration among non-nuclear-weapon States 37
4.14. Considerations of equity 37
4.15. Costs 37
4.16. Choice of institution: existing or new? 38
4.17. Time 38

5. Conclusion 39

6. Bibliography 40

Nuclear Disarmament Verification: Survey of Verification Mechanisms

Executive summary

The objective of this survey is to provide a general overview of past and present verification activities and proposals relevant to the elimination of nuclear weapons. We look beyond the current debate on nuclear disarmament towards the development of the mechanisms required to provide assurances that a nuclear-weapon-free world can be achieved and maintained. Reaching these objectives will be challenging, but, as our paper shows, feasible.

Possible measures and processes for making progress on nuclear disarmament are receiving increasing attention in multilateral diplomacy, notably in the 2016 Open-ended Working Group.[1] Irrespective of *how* nuclear disarmament progress is made (views on which lie outside this survey's remit) one thing is universally recognized. Along the path to eliminating nuclear weapons, nuclear-weapon possessors and non-possessors will have to develop and agree on various mechanisms to verify the destruction of nuclear armaments and prohibit their future existence and the fissile material that they contain.[2]

This survey explains what is meant by 'verification' and outlines the role that verification mechanisms are intended to play in ensuring that international obligations are fulfilled. By way of possible analogy with the verification of the destruction of nuclear weapons, we summarize existing verification commitments of relevance, including those contained in treaties covering the two other categories of weapons of mass destruction (biological

1 The Open-ended Working Group was established by General Assembly resolution A/RES/70/33, 11 December 2015, for the purpose of 'taking forward multilateral nuclear disarmament negotiations'.

2 See, for example, OEWG working paper, *Proposal by the Community of Latin American and Caribbean States (CELAC) on effective legal measures to attain and maintain a world without nuclear weapons*, UN document A/AC.286/WP.15, 12 April 2016, paragraph 14.

and chemical weapons). The part played by international organizations in promoting States' adherence to these obligations, and in trying to hold them to account if they fail to do so, is also covered.

In addition, this overview identifies a range of initiatives by States, civil society, and academic institutions that can be seen as preparing the ground for future negotiations on verification mechanisms for nuclear disarmament. The survey does not, however, delve into technical aspects of verification or what the Stockholm International Peace Research Institute has characterized as 'nuclear forensic analysis'.[3]

The survey draws on these analogies and initiatives to highlight key political and legal challenges to be overcome by the international community in order to provide assurance that obligations to remove nuclear weapons from military arsenals can be verified in practice.

The complexity and nature of political and military sensitivities around nuclear disarmament verification should not be underestimated. Nevertheless, as surveyed here, serious efforts are already being made to understand and overcome them at a practical level. The experience of existing verification organizations can also be drawn upon. Ultimately, however, the effectiveness of mechanisms that verify the elimination of nuclear weapons will depend on the collective will of the international community to achieve a world without nuclear weapons.

1. The multilateral context: 'Taking forward nuclear disarmament'

1.1. Summary

Based on the current multilateral debate, this section identifies key processes or pathways by which the international community might make progress on nuclear disarmament.

1.2. Introduction

The period of the five-year review cycle of the Nuclear Non-proliferation Treaty (NPT) between 2010 and 2015 saw the emergence of a new impetus for nuclear disarmament. This found expression in three conferences on humanitarian impacts in 2013 and 2014[4] and in the setting up by the United Nations General Assembly of Open-ended Working Groups in 2013 and 2015[5] with mandates for 'taking forward multilateral nuclear disarmament negotiations'.

---

3 See Vitaly Fedchenko (ed.), *The New Nuclear Forensics: Analysis of Nuclear Materials for Security Purposes*, Oxford University Press, 2015.

4 Oslo, Norway, March 2013; Nuevo Vallarta, Mexico, February 2014; and Vienna, Austria, December 2014.

5 United Nations General Assembly, *Taking forward multilateral nuclear disarmament negotiations*, United Nations document A/RES/67/56, 4 January 2013, and General Assembly, *Comprehensive Nuclear-Test-Ban Treaty*, UN document A/RES/70/33, 11 December 2015, respectively. See also

During that period, three essential approaches[6] to legally binding multilateral nuclear disarmament became more clearly delineated, in contrast with an existing fourth approach of an organizational kind:

1. A comprehensive nuclear weapons convention or treaty (where prohibition, elimination and verification would be provided for in a single, stand-alone legal instrument);
2. A stand-alone prohibition or ban treaty (where, as currently conceived by proponents of this notion, prohibition would precede elimination and verification, although it could also be negotiated after nuclear armaments have been eliminated); and
3. A framework agreement under which various prohibitions and other obligations, including elimination and verification, would be foreshadowed, pursued coherently within the same broad legal framing and integrated perhaps as protocols or other formal agreements.

Like the two types of stand-alone approach, a framework agreement and its components would be legally binding on its parties. This is not the case with the fourth approach, which is a framework of an organizational nature, rather than a legal construct:

4. A step-by-step or building block approach (where elimination and verification would precede prohibition).[7] This approach foreshadows the negotiation of a number of legally binding instruments, but it has not to date been articulated in a prescriptive way. It might be seen as a form of framework or agenda, but as currently conceived is not one with legal effect.[8]

Irrespective of the approach or process—or mix thereof—described above that States decide to pursue for taking nuclear disarmament forward, mechanisms will at some point be required to be agreed among nuclear-weapon possessors and non-possessors to verify the destruction of nuclear armaments and their components. It goes without saying that nuclear-armed States cannot simply be dispossessed of their nuclear armaments against their will. Their views will be integral to any negotiations on how to eliminate their nuclear weapons, and they will have to consent to the outcome.[9]

United Nations General Assembly, *Taking forward multilateral nuclear disarmament negotiations*, UN document A/RES/68/46, 10 December 2013; and United Nations General Assembly, *Taking forward multilateral nuclear disarmament negotiations: Report of the Secretary-General*, UN document A/69/154, 17 July 2014, and its addendum, UN document A/69/154/Add.1.

6 See International Law and Policy Institute and UNIDIR, *A Prohibition on Nuclear Weapons: A Guide to the Issues*, February 2016, pp. 18–24.

7 See the 23 State OEWG working paper, *A progressive approach to a world free of nuclear weapons: revisiting the building blocks paradigm*, UN document A/AC.286/WP.9/Rev.1, 21 April 2016.

8 John Borrie and Tim Caughley, "After Oslo: Humanitarian Perspectives and the Changing Nuclear Weapons Discourse", in *Viewing Nuclear Weapons through a Humanitarian Lens*, UNIDIR, United Nations, 2013, pp. 100–104.

9 See OEWG working paper, UN document A/AC.286/WP.9/Rev.1, op. cit., paragraphs 14 and 15.

2. Explaining verification

2.1. Summary

This section spells out in general terms what we mean by 'verification' and its role in arms control treaties. Brief insights into possible forms or methods of verifying the elimination of nuclear weapons are also offered—for more detailed analysis see the reference list.

2.2. Verification

In plain English, verification means establishing the truth or accuracy or existence of something, or the absence thereof. In the context of this paper, verification is the ability to confirm compliance with treaty obligations (i.e. providing assurances of compliance) through a mechanism that would detect non-compliance (thus deterring non-compliance). Essentially, verification involves a three-step process of:

- monitoring actions related to fulfilling treaty obligations;
- analysing evidence that may point to non-compliance with those obligations; and
- determining whether non-compliance has in fact occurred.

Box A: Difference between verification, monitoring and compliance

Verification

- A process, sometimes referred to as a verification mechanism, that is built into a treaty to enable inspections or other means of assuring other parties that treaty obligations are being implemented.

Compliance

- The carrying out and fulfilling of international treaty obligations by a treaty party. Such acts of compliance are capable of being confirmed by a verification mechanism.

Monitoring

- The process of observing activities of the parties relevant to their obligations under a treaty. The International Monitoring System of the Comprehensive Test Ban Treaty (CTBT), through which the CTBT Organization analyses and determines whether a nuclear weapons test has been conducted, is a relevant model (although that treaty is not yet in force).

2.3. Role of verification

'One state's non-compliance with its obligations under a treaty on arms control or disarmament may fundamentally and negatively affect the security of others … Conversely, continued compliance with such treaty obligations impacts positively on security. In

both cases, credible verification to establish compliance or non-compliance is of major importance.'[10]

There are many activities the control of which will be central to the ultimate elimination of nuclear weapons. These include prohibiting the production of fissile material; destroying stocks of fissile material usable in nuclear weapons or ensuring that those materials are converted to peaceful uses; and dismantling nuclear weapons and warheads and other infrastructure that is unique to the delivery or existence of such armaments. Each of the nine nuclear-armed States (NAS) will want to be assured that the implementation of obligations relating to those activities can be verified in such a manner as to ensure compliance.[11] At the point at which the last weapons in the individual arsenals of a NAS are purged, the stakes against 'breakout' by any other possessor or possessors will be considerable.

As Jozef Goldblat noted, the form and modalities of verification depend upon the nature, scope and military significance of the agreed constraints, but 'the main role of verification is the same for all arms control treaties, namely, to deter cheating'.[12] It is generally assumed that States enter international treaties in good faith, that is, with the intention to abide by their commitments. 'In restricting their own freedom of action, they expect others to do the same'.[13] Nevertheless, the parties usually verify whether the contracted obligations are being observed, especially when vital matters, such as national security, are involved. The possibility to check compliance—to detect and deter violation of treaty obligations—will thus be an integral element of negotiations to eliminate nuclear armaments.

Box B: Effective verification

John Carlson has explained that verification underpins the effectiveness of WMD treaties in a number of ways:

- The risk of detection deters non-compliance and reinforces the norms of behaviour set out in the treaty;
- By constraining the use of declared facilities, verification increases the difficulties confronting the proliferator; and
- Importantly, verification provides an objective mechanism for identifying non-compliance, so that if necessary enforcement action can be taken.

Source: John Carlson, *Experience and Challenges in WMD Treaty Verification: A Comparative View*, Australian Safeguards and Non-Proliferation Office, Background Papers on Nuclear Verification Issues, 30 January 2009.

10 Weapons of Mass Destruction Commission, *Weapons of Terror—Freeing the World of Nuclear, Biological and Chemical Arms*, 2006, p. 169.

11 The nine nuclear-armed states are China, the Democratic People's Republic of Korea, France, India, Israel, Pakistan, the Russian Federation, the United Kingdom, and the United States of America.

12 Jozef Goldblat, "How to Deter Violations of Disarmament and Non-proliferation Agreements", in *Assessing Compliance with Arms Control Treaties, Report of the International Group on Global Security–IGGS*, September 2007, pp. 54–62.

13 Ibid.

Verification also has confidence-building functions. The existence of a verification mechanism makes it easier for a party unjustly accused of a breach to demonstrate its innocence. By providing evidence that parties are fulfilling their obligations, and by stating that no prohibited activities have been found, verification instils trust among States that their interests are being protected.

Goldblat's observations on the adequacy and effectiveness of verification measures in arms control treaties are of particular interest in relation to the elimination of nuclear weapons. 'Most people', he noted, 'take the view that there will always be a limit to detecting violations, but that the threshold should be low enough to make the significance of undetected breaches negligible. The reasoning behind this pragmatic approach is that what matters most is not the fact of non-compliance but the effect of non-compliance'. 'Others', he continued, 'consider any deviation from the contracted obligations to be an offence that cannot be tolerated, regardless of its military significance, and insist on total verifiability'.[14] This latter test is likely to apply to verifying the elimination of nuclear weapons: the risk that one party would cheat and retain such arms when every other possessor had destroyed its arsenal would be intolerable.[15] Imposing sanctions or conventional military means against a nuclear-armed State that had violated the elimination treaty might at best be ineffective and at worst dangerous if the possessing State threatened to use its remaining weapon or weapons.

2.4. Forms and methods of verification

The forms and methods of verification described in this paper are confined to those that—as with the case of the Chemical Weapons Convention (CWC)—pertain to the disarmament activities; that is, the destruction of proscribed materials and facilities. While a fissile material production ban may already be in force by the time a verification mechanism for the elimination of nuclear weapons is negotiated, its scope[16] may or may not cover fissile material present in nuclear weapons. If not, the mechanism will need to ensure that destruction of the fissile material, the means of its production, and its weaponization are all verified.

14 Ibid.

15 This may depend to an extent on whether the renegade is a large or small State: see, for example, Pavel Podvig, "What if North Korea were the only nuclear weapon state?", *Bulletin of the Atomic Scientists*, 27 May 2009.

16 The negotiation of a Fissile Material Treaty or FM(C)T to ban the production of fissile material has been postulated since 1993. The "(C)" in FM(C)T denotes "Cut Off", an issue affecting the scope of the treaty. There is a divergence of views as to whether negotiations should cover all fissile material used for explosive purposes or should be confined (cut off) to apply only to future production.

Box C: Inspection-based verification system

Carlson has described an inspection-based verification system (such as that of the CWC) as typically including the following major elements:

- Definition of materials, facilities and activities subject to the treaty;
- Establishment of a treaty inspectorate;
- Requirement for parties to declare to the inspectorate relevant materials, facilities and activities;
- Application by the inspectorate of technical measures—including regular on-site inspections and monitoring—to confirm parties' declarations;
- Inspection procedures in case of suspected undeclared materials, facilities and activities. An alternative approach would be to leave it to the treaty parties to identify suspect locations for investigation by the inspectorate; and
- Procedures to deal with treaty breaches and non-compliance.

In Carlson's view, there are two main verification options for multilateral treaties.

- One is to negotiate a single treaty containing both the basic treaty objectives and commitments and the details of the verification system—the time-consuming approach taken in the case of the CWC, which entailed almost 20 years of negotiations.
- The alternative approach—as utilized by the NPT—is to have the basic political commitments in a principal treaty, and to set out the verification system in a secondary agreement or agreements. In the NPT's case, each party concludes a safeguards agreement with the International Atomic Energy Agency (IAEA) based on the model in IAEA document INFCIRC/153.[17] The merit of this approach is that it separates largely political from largely technical subject matters, and allows for an adaptable verification system. The model safeguards agreement, INFCIRC/153, was concluded two years after the NPT entered into force and was complemented in 1997 by the model Additional Protocol (INFCIRC/540).[18] This approach also allows for the possibility of major updates of the verification system without renegotiation of the principal treaty.[19]

17 See Section 4 of this paper.

18 Ibid.

19 John Carlson, *Experience and Challenges in WMD Treaty Verification: A Comparative View*, Australian Safeguards and Non-Proliferation Office, Background Papers on Nuclear Verification Issues, 30 January 2009.

2.5. Other relevant terms

2.5.1. Baseline declarations[20]

Formal statements made by States declaring information on current numbers, locations and technical details of items or activities covered by an arms control treaty. That information is generally required to be provided by a specified time such as the date of signature of the treaty or its entry into force. These declarations provide a baseline against which the phased implementation of treaty commitments can be measured.

2.5.2. Challenge inspections

The right of a State party to a treaty to formally request or demand an on-site inspection of any facility or location under the jurisdiction of any other State party in order to clarify and resolve questions concerning possible non-compliance with the provisions of the agreement. For example, under the CWC such an inspection might be conducted anywhere and without delay by an inspection team designated in accordance with the Convention's Verification Annex.

2.5.3. Fissile material[21]

Material such as highly enriched uranium or plutonium that can bring about an explosive fission chain reaction in a nuclear weapon. The measures appropriate to verifying the cessation of production or elimination of fissile material will depend on the type of material contained in warheads or stockpiles.

2.5.4. Nuclear disarmament

'Nuclear disarmament' is used variously in this paper to refer to:

1. The gradual reduction in numbers of nuclear weapons held in the arsenal of NAS;
2. Collective (multilateral) efforts by the international community and individual and bilateral efforts by NAS to bring about such reductions; and
3. The successful end-state of all such efforts, i.e. the elimination of nuclear weapons—a 'nuclear-weapon-free world'.

2.5.5. Safeguards[22]

Safeguards are activities by which the IAEA can verify that a State is living up to its international commitments not to use nuclear programmes for nuclear weapons purposes. Safeguards are auditing procedures for verifying whether declared nuclear material remains within the civil nuclear fuel cycle and is being used solely for peaceful

---

20 See Pavel Podvig, *Verifiable Declarations of Fissile Material Stocks: Challenges and Solutions*, UNIDIR, 2016.

21 For a full definition, see "IAEA Safeguards Glossary", *International Nuclear Verification Series*, No. 3, 2001, Chapter 4.

22 For a full definition, see ibid., Chapters 2 and 3.

purposes. The IAEA's safeguards system is described in greater detail later in this survey (Section 3.3.6).

3. Verification mechanisms overview

3.1. Summary

This section:

- *identifies prominent current or recent initiatives of direct relevance to nuclear disarmament and verification;*
- *notes draft agreements that have been proposed as a possible basis for future discussion among States, including some for verifying a prohibition on the production of fissile material—a ban that is widely regarded as an essential element in the elimination of nuclear weapons; and*
- *mentions verification in the context of the United Nations.*

The main purpose of this section is to note possible precedents and reflect work that is already under way in anticipation of the need to prepare the necessary foundations of trust and knowledge for negotiating nuclear weapon verification. Supplementary sources are listed in the bibliography.

3.2. Recent projects, proposals, international meetings and other collaborations

3.2.1 United Kingdom-Norway Initiative (UK-NI)

The UK-NI on dismantlement verification began in 2007. It is generally considered to be pioneering in that it has brought together a nuclear-weapon State and a non-nuclear-weapon State to collaborate on verification issues. Features of work to date and 'lessons learned' are set out in a comprehensive joint working paper submitted by the two States to the 2015 NPT Review Conference.[23] They expressed their 'strong belief' that there are no a priori barriers to collaboration between nuclear-weapon States and non-nuclear-weapon States—in other words, that their respective obligations under articles I and II of the NPT on transfer, control, acquisition, etc., will not be compromised by such acts of cooperation (see also Box D).

A current focus of that project is the 'United Kingdom-Norway Initiative Information Barrier'. The purpose of the Information Barrier is to determine, in a laboratory environment, the presence of 'weapons grade' plutonium (in this case defined as plutonium containing greater than a predefined fraction of the isotope plutonium-239).

23 2015 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *The United Kingdom-Norway Initiative: Further research into the verification of nuclear warhead dismantlement: Working paper submitted by the Kingdom of Norway and the United Kingdom of Great Britain and Northern Ireland*, document NPT/CONF.2015/WP.31, 22 April 2015.

Having succeeded in doing so in the laboratory, attention has turned to interpreting results when technical data is collected from an unknown item (or series of items) in an operational environment, data that may be incomplete because of the presence—for confidentiality reasons—of an information barrier. This work will continue through the current NPT review cycle.

Norway and the United Kingdom acknowledge that there is considerable scope for further work in order to advance technologies and procedures for nuclear arms control verification. They emphasize that much greater international effort and cooperation is required to achieve the ultimate objective of an effective nuclear weapon dismantlement verification regime.[24]

3.2.2. The International Partnership for Nuclear Disarmament Verification (IPNDV)

The IPNDV was launched by the United States on 4 December 2014. Announcing the initiative, former United States Under Secretary of State Rose Gottemoeller explained that the objective was to work with nuclear-weapon States and non-nuclear-weapon States to 'better understand the technical problems of verifying nuclear disarmament, and to develop solutions'.[25] More recently, United States Ambassador Robert Wood placed the work of the IPNDV in context in these terms:

> 'By focusing on the technical challenges, we can make real and important progress toward our shared disarmament goals, independent of the ebbs and flows of the political environment, and open new lanes of multilateral cooperation to achieve those goals. […] The IPNDV provides a forum for both countries that possess nuclear weapons, and those countries that do not, to work together to make tangible progress on the common goal of disarmament.[26]

Features of the IPNDV include the following:

- The United States believes that future steps in nuclear disarmament will pose significant verification challenges requiring the development and application of new technologies or concepts in which all countries have a stake. A larger, more diverse group of States with technical expertise in nuclear verification or the related sciences would contribute to the discussion and provide a broader intellectual basis for determining solutions.
- Such engagement would strengthen the goals of the NPT.
- The IPNDV is considering verification challenges across the lifecycle of nuclear weapons–including fissile material production and control, warhead production, deployment, storage, dismantlement, and disposition, with an initial focus on

24 Ibid., p.18.

25 *Rose Gottemoeller, "*The Vision of Prague Endures*"*, speech, 5 December 2014.

26 Remarks at IPNDV Working Group Meeting, Geneva, 18 February 2016. See also Opening Remarks of Frank A Rose, Assistant Secretary of State, Bureau of Arms Control, Verification and Compliance, at the IPNDV's 3rd Plenary, Tokyo, 28 June 2016.

the warhead dismantlement process and how to monitor storage of the resulting nuclear materials.

- The partnership will build on lessons learned from the UK-NI and the United States–United Kingdom Technical Cooperation Programme.
- The United States is advancing the project through an official public–private partnership with the Nuclear Threat Initiative (NTI) drawing on the latter's recently concluded project, 'Innovating Verification'.[27]

Box D: IPNDV working groups

Monitoring and verification

A central issue for this working group is how to carry out useful cooperation that does not touch on sensitive information about nuclear weapons and other classified material. The partnership's work to date has been conducted at the unclassified level with the goal of publishing key documents online. The classification issue has been characterized in these terms: how can credible conclusions be drawn about disarmament steps in a manner that is consistent with the classification rules of the disarming state? (*Comment*: to date, IPNDV—in contrast to the UK-NI project—appears to have taken a somewhat literal view of the NPT that nuclear weapon states are constrained by articles I and II from sharing information with non-nuclear-weapon states about making nuclear weapons.)

On-site inspections

One of the goals of this working group is to identify how verification objectives might best be achieved, including through the practice in which the inspecting party and the inspected party negotiate or 'manage' the extent of the inspectors' access to sensitive areas. While good rules on managed access can go a long way toward resolving differences over inspector access in the field, a critical balance between inspection intrusiveness and protection of national interests will have to be struck during future negotiations on treaty instruments.

Current and future verification technologies

A challenge for the IPNDV lies in its mission to develop technologies that will meet the needs of future agreements that for now are hypothetical. The Partnership is a technical exercise—'a bottom-up approach'—whereby answers to technical questions are developed and then policy catches up. This situation has been likened to the technical (seismic) work done by the Group of Scientific Experts (GSE) in the lengthy (20-year) lead up to the negotiation of the CTBT before the political conditions 'matured' and the negotiations were able to begin.

Source: Nuclear Threat Initiative, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks: Overview*, Cultivating Confidence Verification Series, 2014.

27 Nuclear Threat Initiative, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks: Overview*, Cultivating Confidence Verification Series, 2014. Also available in Arabic, Chinese, French, Russian and Spanish.

Initial membership of the IPNDV consists largely of States that have expressed an interest in verification, and are able and willing to provide technical expertise. Current members[28] are all party to the NPT. Expansion of the partnership (for instance, the inclusion of South Africa, which dismantled its apartheid-era nuclear arsenal) has not been ruled out.[29] NAS outside the NPT (Democratic People's Republic of Korea, India, Israel, and Pakistan) have not been included to date.

3.2.3. Nuclear Threat Initiative's Verification Pilot Project (NTI Project)

The main objective of this pilot project is to lay the 'technical and policy groundwork for future progress and government action on near-term and long-term arms control and non-proliferation challenges.'[30] The pilot project brought together a group of international technical and policy specialists to examine the issues and methods associated with verification.[31] It seeks to develop new solutions and approaches to current verification challenges and to bolster global confidence in them[32]. NTI is engaged in this work with the United States Departments of Defence, Energy and State. The governments of Norway, Sweden, and the United Kingdom have also been involved.[33] NTI characterizes the project as a toolkit of innovative mechanisms. Research proposals cover baseline declarations, global verification capacity and societal verification.[34] This project is based on a previous project conducted by NTI, 'Cultivating Confidence'.[35]

3.2.4. United Kingdom-United States Technical Cooperation Programme

Since 2000, the United States and United Kingdom have collaborated on technologies and methodologies to enable monitoring and verification of potential nuclear weapons arms control negotiations. They reported in 2015 that this technical collaboration had yielded a number of lessons learned.[36] For example:

---

28 Australia, Belgium, Brazil, Canada, Chile, China, Finland, France, Germany, Italy, Japan, Jordan, Kazakhstan, Mexico, Netherlands, Norway, Poland, Russian Federation, Republic of Korea, Sweden, Switzerland, Turkey, United Arab Emirates, United Kingdom, United States, the Holy See, and the European Union. See Daniel Horner and Kelsey Davenport, "Verification Partnership Coalesces", *Arms Control Today*, 4 March 2016.

29 Interview with Ambassador Piet de Klerk (Netherlands), co-chair, IPNDV monitoring and verification working group, 2 May 2016.

30 Nuclear Threat Initiative, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks: Overview*, Cultivating Confidence Verification Series, 2014, p. 11.

31 Ibid.

32 Ibid., p. 5.

33 Ibid., p. 2.

34 Malte Göttsche, Moritz Kütt, Götz Neuneck and Irmgard Niemeyer, *Advancing Disarmament Verification Tools: A Task for Europe?*, EU Non-Proliferation Consortium, Non-Proliferation Paper no. 47, October 2015, p. 2.

35 Nuclear Threat Initiative, *Cultivating Confidence: Verification, Monitoring, and Enforcement for a World Free of Nuclear Weapons*, Cultivating Confidence Verification Series, 2010.

36 United States Department of Energy, National Nuclear Security Administration, Defense Nuclear Nonproliferation, Office of Nonproliferation and Arms Control, and United Kingdom Ministry of Defence, *Joint U.S.-U.K. Report on Technical Cooperation for Arms Control*, 2015, p. 2.

1. the ability to strike a balance between information protection and information sufficiency is seen as key to an effective monitoring and verification regime. From the perspective of these two nuclear-weapon States, the monitoring party must be able to obtain sufficient data to confirm declarations, while a host party must have assurances that their most sensitive information will be protected throughout the monitoring and verification process;
2. the opportunity to test and evaluate technologies and processes in operational environments (as opposed to laboratory conditions) is regarded as essential for understanding actual capabilities and feasibility;
3. developing the necessary technologies and approaches to successfully monitor warhead dismantlement takes time. Safety and security procedures have to be rigorous and not readily amenable to change;
4. from a technical perspective, however, the monitoring and verification of nuclear warheads, components and sensitive processes appears feasible, although many complex classification, access, technology and legal challenges will arise in implementing a warhead dismantlement verification regime;[37] and
5. ongoing bilateral technical cooperation has the advantage of helping countries both gain confidence in their ability to protect classified and sensitive information and determine where work is still needed.

3.2.5. Trilateral Initiative

In September 1996, the Russian Federation, the United States and the IAEA began a joint project, the 'Trilateral Initiative'. The aim was to define the verification measures that could be applied at the Mayak fissile material storage facility in the Russian Federation and at one or more US facilities where excess weapon-origin fissile materials were to be stored. The Parties also sought to develop a model verification agreement as the basis for future bilateral agreements between the IAEA and each weapon State to verify weapon-origin fissile materials. Once materials were submitted to the IAEA, they would remain under the Agency's verification until they were determined to be unusable for the manufacture of nuclear weapons. Although the 'completion and implementation of the Trilateral Initiative' was one of the 13 agreed practical steps in the 2000 NPT Review Conference's consensus final outcome document[38] on implementing article VI of that treaty, the objectives of the Initiative were not realized because the priorities of the States involved subsequently changed.

It has been suggested that States consider the reactivation of the Initiative as an informal three-way study effort to flesh out a verification system for fostering nuclear

37 See, however, Anita E. Friedt, Principal Deputy Assistant Secretary, Bureau of Arms Control, Verification and Compliance, "Disarmament Verification and the Non-Proliferation Treaty (NPT) Ahead", Remarks at the Vienna Centre for Disarmament and Non-Proliferation, 20 March 2015.

38 See step 8 of the 13 "practical steps for the systematic and progressive efforts to implement article VI" of the NPT, in *2000 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons: Final Document*, document NPT/CONF.2000/28 (Parts I and II).

disarmament.[39] Alternatively, the Russian Federation and the United States, individually or jointly, could negotiate agreements for submitting weapons-origin fissile material to IAEA verification. It has also been observed, however, that although the preparatory work carried out by the Initiative was extensive, significant practical issues remained. Nonetheless, phasing in such agreements over time could allow progress to be made while confidence in the security measures is gradually acquired.

3.2.6. Fissile Material Prohibition Treaty (FMT)/(FM(C)T)

In addition to a reference to fissile material and the NPT in Section 3.3.5 below, three developments on fissile material in recent years warrant attention here:

1. In April 2015, France tabled a draft fissile material treaty in the Conference on Disarmament (CD).[40] The text proposes that, in order to verify compliance with the prohibition on the production of fissile material for weapons, a verification regime be established to:

    - certify the closing-down and dismantling or conversion to civilian uses of production facilities;
    - ensure that fissile material produced after the entry into force of the treaty in facilities declared under its provisions is not diverted to nuclear weapons or other nuclear explosive devices; and
    - assure the Parties that no fissile material is being produced in non-declared facilities.

    In the absence of agreement for two decades in the CD to begin negotiations on banning fissile material production, the French proposal has yet to receive close attention in the CD.

2. In September 2009, Canada, Japan and the Netherlands brought to the CD's attention a 'Draft for Discussion Prepared by the International Panel On Fissile Materials [IPFM]: A Treaty Banning the Production of Fissile Materials for Nuclear Weapons or Other Nuclear Explosive Devices, With Article-By-Article Explanations'.[41] Banning the production of fissile material for weapons in a verifiable manner is fundamental to the elimination of nuclear armaments. The IPFM's draft and

---

39 Thomas E. Shea, "The Trilateral Initiative: A Model for the Future?", *Arms Control Today*, 11 June 2008. Shea is the former head of the IAEA Trilateral Initiative Office.

40 Conference on Disarmament, *Letter dated 9 April 2015 from the Permanent Representative of France to the Conference on Disarmament addressed to the Acting Secretary-General of the Conference transmitting a draft Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices prepared by the Government of France*, document CD/2020, 9 April 2015.

41 Conference on Disarmament, *Letter Dated 16 September 2009 From the Permanent Representatives of Canada, Japan and the Netherlands to the Conference on Disarmament Addressed to the Secretary-General of the Conference Transmitting the Text of the "Draft for Discussion Prepared by the International Panel on Fissile Materials: A Treaty Banning the Production of Fissile Materials for Nuclear Weapons or Other Nuclear Explosive Devices, with Article-by-Article Explanations" Dated 2 September 2009*, document CD/1878, 15 December 2009.

accompanying commentary provide insights into the issues that will need to be mastered for effective verification of the cessation of production among those States not already subject to the safeguards requirements of the IAEA (discussed below). Like the French proposal, the IPFM text also contains definitions and covers the kinds of declarations that would be required for the purpose of demonstrating reductions in inventories of fissile material that could be used in nuclear weapons. And, also like the French proposal, the IPFM draft has provided a useful focus for debate in side events associated with the CD and NPT.

3. As Pavel Podvig noted in a 2016 UNIDIR publication,[42] efforts to formally commence fissile material negotiations have intensified. In 2013, the United Nations General Assembly adopted a resolution that established a Group of Governmental Experts (GGE) drawn from 25 States. In May 2015, the GGE reported that, while there were significant differences regarding the objectives, scope and definition of fissile material, there appeared to be a convergence of views on the general structure of a treaty and on the basic characteristics of the verification system that it would create.[43] Podvig's paper observed that to comply with their obligations under a fissile material treaty, States would have to declare their production facilities and submit them to verification. Thus one of the central elements of a verification system would be to ensure that all fissile material produced at production facilities is properly declared and accounted for.

3.3. Legally binding treaties and other relevant arrangements and initiatives

3.3.1. Summary

This section briefly outlines examples of agreements or arrangements containing verification mechanisms. It augments comments made in Section 2 about the CWC and NPT/IAEA verification mechanisms. Most of the following examples are multilateral treaties, but some are agreements and arrangements of a bilateral or trilateral nature. The purpose of this sample is to draw attention to the complexities and scope of verification measures. It also serves to demonstrate, however, that the negotiators on mechanisms to verify the elimination of nuclear weapons will be able to draw on past practice. (Box E lists other relevant instruments that, for reasons of lack of space, are not elaborated upon here.)

3.3.2. Bacteriological and Toxin Weapons Convention (BTWC)

The BTWC of 1972 (usually referred to as the Biological Weapons Convention) was the first multilateral disarmament treaty to ban an entire category of weapons. Its States Parties

42 Pavel Podvig, *Fissile Material (Cut-off) Treaty: Elements of the Emerging Consensus*, UNIDIR, 2016.

43 United Nations General Assembly, *Report of the Group of Governmental Experts to make recommendations on possible aspects that could contribute to but not negotiate a treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices*, UN document A/70/81, 7 May 2015.

(now numbering 174[44]) have undertaken 'never in any circumstances to develop, produce, stockpile or otherwise acquire or retain microbial or other biological agents, or toxins that had no peaceful purposes, or weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict'.[45] The treaty is a key element in the international community's efforts to address the proliferation of weapons of mass destruction. Nevertheless, in terms of verification, the treaty merely requires States Parties to consult with one another and cooperate, bilaterally or multilaterally, to solve compliance concerns. In lacking a verification regime, the BTWC is very different from the comprehensive provisions of the CWC. The BTWC, however, does allow States Parties to lodge a complaint with the Security Council if they believe other States Parties are violating the convention. The Security Council can investigate complaints, but this power has never been invoked.

Historically, there have been efforts to add a verification regime to the BTWC through an 'Ad Hoc Group of Verification Experts (VEREX)', set up in 1991 with the aim of identifying and evaluating potential on-site and off-site verification measures for the Convention.[46] The VEREX group concluded that some combinations of verification measures 'would' rather than 'might' contribute to strengthening the convention.[47] In 1994 a special conference of BTWC States Parties tasked the ad hoc group with negotiating a legally binding protocol to strengthen the treaty. The instrument developed by the group envisaged that States would submit declarations of treaty-relevant facilities and activities to an international body. That body would conduct routine on-site visits to declared facilities and could conduct investigations of suspect facilities or suspicious outbreaks of disease. Yet a number of fundamental issues—such as the nature of on-site visits and investigations, and the role that export controls would play in the regime—proved difficult to resolve. Ultimately, in July 2001 at the group's last scheduled meeting, the United States rejected the draft, arguing that such a protocol would not help strengthen compliance with the BTWC and could hurt the national security and commercial interests of the United States.[48] No negotiations on a verification mechanism for the treaty have since been undertaken.

Mention should, however, be made here of the United Nations Secretary-General's mechanism to carry out prompt investigations in response to allegations brought to his attention concerning the possible use of chemical and bacteriological (biological) and toxin weapons. Although a compliance tool rather than one of verification, this 1988 mechanism [49] authorizes the Secretary-General, on request by a Member State, to launch an investigation, including dispatching a fact-finding team to the site of an alleged incident, and to report to all Member States. The aim is to ascertain in an objective and scientific manner the facts of alleged violations of the 1925 Geneva Protocol (a precursor

44 As at 1 July 2016.
45 Article 1 of the BTWC.
46 See Jez Littlewood, *The Biological Weapons Convention: A Failed Revolution*, Ashgate, 2005.
47 Jonathan B. Tucker, "Biological Weapons Breakdown", *Arms Control Today*, 1 May 2005.
48 Arms Control Association, *The Biological Weapons Convention (BWC) at a Glance*, September 2012.
49 United Nations General Assembly, *Chemical and bacteriological (biological) weapons*, resolution 42/37 C, 30 November 1987, endorsed by the Security Council in resolution 620, 26 August 1988.

of the BTWC and CWC banning the use of chemical and biological weapons) or other relevant rules of customary international law.[50]

3.3.3. Chemical Weapons Convention (CWC)

This 1993 treaty prohibits its States Parties (which now number 192)[51] from developing, producing, acquiring, retaining, stockpiling, transferring and using chemical weapons. It also prohibits all States Parties from engaging in military preparations to use chemical weapons, and from assisting or encouraging other States to engage in activities prohibited by the treaty. The CWC established an agency, the Organisation for the prohibition of Chemical Weapons (OPCW), to help States Parties to implement the Convention.

A Verification Annex provides a comprehensive regime for verifying all chemical weapons-related activities, as well as routine monitoring of the chemical industry through on-site inspections. It stipulates the requirements for the declaration and verification process. The Verification Annex is by far the most comprehensive portion of the CWC.[52] Indeed the annexes on verification, declarations, inspections and alleged use total 102 pages. All States Parties are required to make detailed declarations providing information on chemical weapons, production, storage, destruction and facilities used in the past for their development. Similarly, all States Parties are required to make chemical industry declarations related to toxic chemicals and precursors that are mentioned in the CWC's three schedules of chemicals.

Verification activities are carried out by a Verification Division and an Inspectorate, with the latter providing and supporting the OPCW inspectors. The Verification Division shapes the verification process by collecting, evaluating, and compiling declared data, planning inspections, and reviewing inspection reports. The Division keeps States Parties informed about the operational results—for example, by providing statistics, by drafting the Verification Implementation Report, and by supplying information concerning verification activities on demand. The CWC also contains an annex on the protection of confidential information, and provides measures for protecting sensitive installations.

3.3.4. Comprehensive Nuclear-Test-Ban Treaty (CTBT)

The CTBT of 1996 established a verification regime to monitor countries' compliance with the new prohibition on carrying out any nuclear explosion, whether for military or peaceful purposes.[53] The regime is designed to detect any nuclear explosion conducted on Earth—underground, underwater or in the atmosphere. The States Parties established a Preparatory Commission (CTBTO) to develop this regime and to ensure that it is

---

50 United Nations Office for Disarmament Affairs, "Secretary-General's Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons", webpage, 2016.

51 As at 1 July 2016.

52 Peter Boehme, "The Verification Regime of the Chemical Weapons Convention: An Overview", Organisation for the Prohibition of Chemical Weapons, 28 November 2008.

53 For detailed insights into the negotiation of the CTBT's verification regime, see Rebecca Johnson, *Unfinished Business: The Negotiation of the CTBT and the End of Nuclear Testing*, UNIDIR, 2009, Chapter 7, pp. 145–173.

operational by the time the treaty enters into force (which will be once the remaining designated eight States have joined it).[54]

The CTBT verification regime consists of three main elements[55]:

1. The International Monitoring System (IMS). The IMS has 337 monitoring facilities—321 monitoring stations and 16 radionuclide laboratories—around the globe. Its verification technologies detect, locate, and identify nuclear explosions:
    - Seismic stations monitor the ground for shock waves generated by explosions;
    - Infrasound and hydro-acoustic stations listen for corresponding sound waves; and
    - Radionuclide stations scan the atmosphere for traces of radioactive particles and gases, which indicate whether a given explosion is nuclear.
2. Data collected by the IMS is transferred in real time via six geostationary satellites and secure terrestrial communication lines of the Global Communications Infrastructure to the International Data Centre (IDC) in Vienna, the second pillar of the verification regime. The data are analysed to detect, locate, and identify natural and man-made events, including potential nuclear events. From the IDC, data and analysis, both automated and human, are forwarded to the CTBTO Member States.
3. The remaining element of the global alarm system is the On-site Inspection (OSI) regime, which provides clarity on an event recorded by the IMS and analysed by the IDC. Although an OSI can be invoked only after entry into force of the CTBT, OSI procedures have already been established and tested in the field.

3.3.5. Non-Proliferation Treaty (NPT)

This 1968 treaty established a nuclear 'safeguards' system (see Section 3.3.6 below) to verify compliance with the NPT through inspections conducted by the IAEA. The system is designed to ensure that non-nuclear-weapon States are prevented from diverting 'nuclear energy from peaceful uses to nuclear weapons or other explosive devices'.[56] For that purpose: 'Each Non-nuclear-weapon State Party to the Treaty undertakes to accept safeguards, as set forth in an agreement to be negotiated and concluded with the IAEA in accordance with the Statute of the IAEA and the Agency's safeguards system, for the exclusive purpose of verification of the fulfilment of its obligations assumed under this Treaty'.[57]

The NPT does not establish formal means of verifying compliance by the five nuclear arms-possessing States Parties with their obligations under the treaty. All of those States, however, have voluntarily concluded safeguards agreements covering some or all

54 China, Democratic People's Republic of Korea, Egypt, India, Islamic Republic of Iran, Israel, Pakistan, United States.

55 Joint Comprehensive Plan of Action, 14 July 2015.

56 Article III of the NPT.

57 Treaty on the Non-Proliferation of Nuclear Weapons.

of their peaceful nuclear activities.[58] Under those 'Voluntary Offer Agreements' (VOAs), facilities are notified to the IAEA by the State concerned and offered for the application of safeguards. The IAEA applies safeguards under VOAs to nuclear material in selected facilities. The five nuclear-armed States Parties are additionally bound by the rules of international treaty law to fulfil their NPT obligations.

Verification has been the subject of numerous proposals in the five-yearly NPT Review Conferences including most recently in 2015.[59] The most notable references in consensus outcome documents of Review Conferences include:

- Step 13 in the 'practical steps for the systematic and progressive efforts to implement article VI' of the NPT under which the States Parties agreed in 2000 that 'further development of the verification capabilities […] will be required to provide assurance of compliance with nuclear disarmament agreements for the achievement and maintenance of a nuclear-weapon-free world'[60];
- Action 2 under which the States Parties in 2010 reaffirmed the 13 steps and renewed their commitment to apply the 'principles of irreversibility, verifiability and transparency in relation to the implementation of their treaty obligations';[61]
- Action 17 under which all States (also in 2010) were 'encouraged to support the development of appropriate legally binding verification arrangements, within the context of IAEA, to ensure the irreversible removal of fissile material designated by each nuclear-weapon State as no longer required for military purposes';[62]
- Action 19 under which all States agreed (also in 2010) the importance of international cooperation 'aimed at increasing confidence, improving transparency

---

58 The first such agreements were concluded by the United Kingdom, with the IAEA and EURATOM, in 1978, and by the United States in 1980 with the IAEA. France concluded a VOA with the IAEA and EURATOM in 1981; the Soviet Union concluded a VOA with the IAEA in 1985, and China did so in 1988. Source: John Carlson, *Expanding Safeguards in Nuclear-Weapon States*, Nuclear Threat Initiative paper, 2012.

59 Recent proposals of relevance include 2015 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Verification: Working paper submitted by the Group of Non-Aligned States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons*, NPT/CONF.2015/WP.3, 9 March 2015; *Safeguards: Working paper submitted by the Group of Non-Aligned States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons*, NPT/CONF.2015/WP.6, 9 March 2015; *Draft elements for a plan of action for the elimination of nuclear weapons: Working paper submitted by the Group of the Non-Aligned States Parties to the Treaty on the Non-Proliferation of Nuar Weapons*, NPT/CONF.2015/WP.14, 13 March 2015; *The United Kingdom-Norway Initiative: Further research into the verification of nuclear warhead dismantlement: Working paper submitted by the kingdom of Norway and the United Kingdom of Great Britain and Northern Ireland*, document NPT/CONF.2015/WP.31, 22 April 2015; and *Transparency, Reporting and Strengthening the Review Process: Working paper submitted by Japan*, document NPT/CONF.2015/WP.32, 22 April 2015.

60 2000 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Final Document*, document NPT/CONF.2000/28 (Parts I and II), p. 15.

61 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Final Document*, document NPT/CONF.2010/50 (Vol. I), p. 20.

62 Ibid., p. 24.

and developing efficient verification capabilities related to nuclear disarmament';[63] and

- Action 30 under which the 2010 Conference called for the 'wider application of safeguards to peaceful nuclear facilities in the nuclear-weapon States, under the relevant voluntary offer safeguards agreements, in the most economic and practical way possible, taking into account the availability of IAEA resources, and stresses that comprehensive safeguards and additional protocols should be universally applied once the complete elimination of nuclear weapons has been achieved'.[64]

3.3.6. IAEA safeguards

Safeguards are activities by which the IAEA can verify that a State is living up to its international commitments not to use nuclear programmes for nuclear-weapon purposes. The IAEA's safeguards system functions as a confidence-building measure, an early warning mechanism, and the trigger that sets in motion other responses by the international community if and when the need arises. Safeguards are based on assessments of the correctness and completeness of a State's declared nuclear material and nuclear-related activities. Verification measures include on-site inspections, visits, and ongoing monitoring and evaluation conducted for the purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices.

Basically, two sets of measures are carried out in accordance with the type of safeguards agreements in force with a State:

- one set relates to verifying State reports of declared nuclear material and activities. These measures—authorized under NPT-type comprehensive or 'full-scope' safeguards agreements[65]—are largely based on nuclear material accountancy, complemented by containment and surveillance techniques, e.g. tamper-proof seals and cameras installed by the IAEA at facilities;
- the second set adds measures to strengthen the IAEA's inspection capabilities. They include those incorporated in what is known as an 'Additional Protocol'[66]—that is, a legal document complementing comprehensive safeguards agreements. The measures enable the Agency to verify the non-diversion of declared nuclear material and to provide assurances as to the absence of undeclared nuclear material and activities in a State.

---

63 Ibid.

64 Ibid., p. 25.

65 *The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, IAEA document INFCIRC/153/Corr, 1 June 1972, also known as the Model Safeguards Agreement or Comprehensive Agreement, developed by the IAEA to encompass a State's entire fuel cycle —'full-scope safeguards'—and implement Article III (1) of the NPT.

66 *Model Protocol Additional to the Agreement(s) Between State(s) and the International Atomic Energy Agency for the Application of Safeguards*, IAEA document INFCIRC/540, 1 September 1997, also known as the Model Additional Protocol.

The various types of on-site inspections and visits carried out by the IAEA under comprehensive safeguards agreements include the following:

- **Ad hoc *inspections*** are typically made to verify a State´s initial report of its nuclear material or reports on changes thereto, and to verify the nuclear material involved in international transfers.
- ***Routine inspections***—the type most frequently used—may be carried out according to a defined schedule or they may be of an unannounced or short-notice character. The Agency´s right to carry out routine inspections under comprehensive safeguards agreements is limited to those locations within a nuclear facility, or other locations containing nuclear material, through which nuclear material is expected to flow (strategic points).
- ***Special inspections*** may be conducted under defined procedures if the IAEA considers that information made available by the State concerned, including explanations from the State and information obtained from routine inspections, is not adequate for the Agency to fulfil its responsibilities under the safeguards agreement.
- ***Safeguards visits*** may be made to declared facilities at appropriate times during the lifecycle of nuclear-related activities for verifying the safeguards-relevant design information. For example, such visits may be carried out during construction to determine the completeness of the declared design information; during routine facility operations and following maintenance, to confirm that no modification was made that would allow unreported activities to take place; and during a facility decommissioning, to confirm that sensitive equipment was rendered unusable.

Activities that IAEA inspectors perform during and in connection with on-site inspections or visits at facilities may include auditing the facility´s accounting and operating records and comparing these records with the State´s accounting reports to the Agency; verifying the nuclear material inventory and inventory changes; taking environmental samples; and applying containment and surveillance measures (e.g. seal application and installation of surveillance equipment).

3.3.7. Nuclear-weapon-free zones (NWFZs)

Currently, there are five NWFZs covering continental or subcontinental groups of countries, including their territorial waters and airspace.[67] Although their provisions differ, verification arrangements under existing NWFZ agreements provide for international inspection through the IAEA and additionally by regional structures. Moreover, a former IAEA Head of Verification and Security Policy Coordination has observed that the recognized requirement of verifying that contracting parties are complying with their

67 These five NWFZs were established by the treaties of Tlatelolco (Latin American and the Caribbean countries; 25 April 1969), Rarotonga (South Pacific; 11 December 1986), Bangkok (South-East Asia; 28 March 1997), Semipalatinsk (Central Asia; 21 March 2009), Pelindaba (Africa; 15 July 2009). There is one United Nations-recognized zone consisting of a single country: Mongolia (28 February 2000). Additionally, three treaties established NWFZs in Antarctica (23 June 1961), in outer space (10 October 1967) and on the seabed (18 May 1972).

treaty obligations can be met by ensuring that all nuclear material, facilities, and activities are subject to full-scope IAEA safeguards.[68]

NWFZs have provided for regional control mechanisms to be set up to oversee and review the application of the IAEA safeguards system.[69] All States within each zone must implement the Agency's Comprehensive Safeguards Agreements. This includes enabling challenge inspections authorized by the Zones' regional control mechanisms, but carried out by IAEA inspectors. The Latin American treaty (Tlatelolco) additionally provides for reports and exchanges of information, and special reports requested by OPANAL (the agency for the prohibition of nuclear weapons in Latin America and the Caribbean established by the Tlatelolco Treaty).

3.3.8. United-States–Russian Federation bilateral collaboration

The United States and the Russian Federation (formerly of the Soviet Union) have a lengthy history of negotiating bilateral arms control agreements.[70] This brief outline of the verification provisions of two of those 'strategic arms reduction treaties', START 1 and New START, provides an insight into the possibilities even for strategic rivals to agree on measures to minimize the scope for misperceptions over the manner in which their bilateral treaty obligations are implemented.

START I verification includes:

- National Technical Means (NTMs) (e.g. satellites), together with a ban on actions that impair the effectiveness of NTMs of the other Party;
- Six-monthly data exchange, including numbers and locations of all deployed and non-deployed strategic delivery vehicles, and locations and diagrams of all facilities associated with strategic delivery vehicles, such as bases, storage and production facilities;
- On-site inspections to verify the accuracy of data, including short-notice visits, and the right to observe elimination of missiles and facilities;
- Monitoring of perimeter and portal (entry/exit points) of plants that produce mobile inter-continental ballistic missiles (ICBMs) (only applied to Russia); and
- A ban on encryption of telemetry transmitted from ballistic missiles during test launches and exchange of all such telemetry.

---

68 See Tariq Rauf, Khaled AbdelHamid, Ephraim Asculai, Christian Charlier, Edward M. Ifft, Olli Heinonen, Dorte Hühnert, Ibrahim Said and Hartwig Spitzer, "Possible Frameworks for Verification of a WMD/DVs Free Zone in the Middle East: The Nuclear Dimension", Academic Peace Orchestra Middle East, Policy Brief no. 33, August 2014.

69 Ibid. The policy brief lists the Organization for the Prohibition of Nuclear Weapons in Latin America (OPANAL), the Consultative Committee of the South Pacific Nuclear Weapon Free Zone, the Commission for the Southeast Asia Nuclear Weapon Free Zone and its subsidiary organ, the Executive Committee, and the African Commission on Nuclear Energy (AFCONE).

70 For a summary, see C.R. Wuest, The Challenge for Arms Control Verification in the Post-New START World, Lawrence Livermore National Laboratory, 2012, pp. 22–25.

Measures in New START that modify those in START I include:

- Provisions to facilitate the use of NTMs for treaty monitoring;
- The annual exchange of telemetry data on a parity basis, for up to five ICBM and submarine-launched ballistic missile (SLBM) launches per year;
- Ten annual inspections with a focus on sites with deployed and non-deployed strategic systems. In these inspections, each Party will have the right to count the number of re-entry vehicles actually deployed on one ICBM or SLBM, rather than attribute a set number of warheads to each type of missile;
- Eight inspections on sites with only non-deployed strategic systems; and
- No continuous perimeter and portal monitoring at missile production facilities, although parties must provide notification within 48 hours of any treaty-limited item leaving a production facility.

One senior United States official has observed that the verification regime of New START provides a good basis for a discussion on how future verification challenges could be more complicated than in the past. Under New START, the inspecting State Party verifies a negative—that an item deployed on a ballistic missile, is non-nuclear as the inspected State declares. She noted, however, that 'as we get to lower numbers, future treaties will require verifying a positive–that an object declared as a nuclear warhead is in fact a nuclear warhead. This will be complicated by the fact that warheads are not only a fraction of the size of an intercontinental missile—their internal components are closely guarded national secrets'.[71]

These formidable challenges in verifying and monitoring nuclear weapons across their entire life cycles will require innovative solutions. Nonetheless, as the same United States official pointed out, they are not without precedent. In 1976, a Group of Scientific Experts (GSE) was established by the CD in the pre-negotiation phase of the CTBT to address a seemingly unsolvable task. How could data from hundreds of seismic monitoring stations all around the world be routed to a central location? Through international collaboration and an infusion of technical expertise, the GSE influenced the creation of a verification regime that makes it virtually impossible for a country to elude detection of a nuclear explosives test.

3.3.9. Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials (ABACC)

The ABACC treaty was concluded in 1991 under the Guadalajara Agreement between Argentina and Brazil for the exclusively peaceful use of nuclear energy. The agency is responsible for administering a Common System of Accounting and Control (SCCC), a full-scope safeguards system established to verify that nuclear materials used in all nuclear

71 Anita E. Friedt, Principal Deputy Assistant Secretary, Bureau of Arms Control, Verification and Compliance, "Disarmament Verification and the Non-Proliferation Treaty (NPT) Ahead", Remarks at the Vienna Centre for Disarmament and Non-Proliferation, 20 March 2015.

activities in both countries are not diverted to purposes prohibited by the agreement. In implementing the SCCC, the ABACC carries out inspections, designates inspectors, evaluates inspections, engages the necessary services to ensure fulfilment of the SCCC objectives, and is empowered to represent Brazil and Argentina before third parties in connection with the implementation of the SCCC. Under a Quadripartite Agreement[72] between the two governments, the ABACC, and the IAEA, the IAEA is given the responsibility for applying full safeguards in both countries. If a country were found to be in non-compliance, the IAEA would refer the case to the Security Council.

The ABACC's verification process has three distinct stages:[73]

1. Examination of material supplied by the country, including:
    - information on the design of facilities under safeguards;
    - accounting reports detailing movements and inventories of nuclear material;
    - documents covering facility operations providing data for preparation of the reports; and advanced notifications of international transfers.
2. Collection of information by the ABACC as to the outcome of:
    - inspections to verify design information;
    - inspections to verify records and reports, and to verify nuclear material; and
3. Special inspections in case of any serious discrepancy:
    - assessment of information supplied by the country and collected by the inspectors, in order to determine if the information is complete, correct, and valid.

3.3.10. European Atomic Energy Community (EURATOM)

Since 1957, one of the roles of EURATOM is to carry out nuclear safeguards inspections to ensure that nuclear materials are used only for the purposes declared by the users. This entails verifying the correctness of European Union nuclear operators' declarations by measurements and by auditing the operators' accountancy and control systems. The facilities where the materials are handled or stored have to be declared to EURATOM in detail and the related activities and processes need to be fully understood by the safeguards inspectors. Compared to those of the IAEA, EURATOM safeguards inspectors claim the additional experience of inspecting nuclear-weapon States (France and the United Kingdom) in a comprehensive and non-discriminatory manner.[74] Indeed, the EURATOM safeguards mandate is identical across NAS and the 26 non-nuclear-weapon States of the EU. While military material is not part of the scope of EURATOM safeguards

72 *Agreement of 13 December 1991 Between the Republic of Argentina, the Federative Republic of Brazil, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials and the International Atomic Energy Agency for the Application of Safeguards*, IAEA document INFCIRC/435, March 1994.

73 Nuclear Threat Initiative, "Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC)", webpage.

74 Peter Schwalbach, "EURATOM Safeguards experience and future verification regimes", Institute of Nuclear Materials Management, 2015.

in any State, it is noteworthy that some nuclear-weapon States' facilities hold or have held both civil and military material at the same time. The EURATOM safeguards system is thus unique in being an international inspection body with long experience of inspecting mixed facilities.[75]

3.3.11 Conventional Forces in Europe (CFE) Treaty

The objective of this 1990 agreement is to reduce the possibility for major offensive operations in Europe through the reduction of troops in central Europe and the placement of equal limitations on major armaments for NATO and the Warsaw Pact. On signature, the States Parties notified each other of the maximum levels of their holdings of armaments and equipment, and undertook to achieve the prescribed limitations by means of a three-phased reduction process within 40 months of the treaty's entry into force. Approximately 80,000 treaty-limited items in five categories have been eliminated under the treaty.[76]

To ensure verification of compliance with the CFE, the States Parties are required to provide notifications and to exchange information in accordance with a Protocol on Information Exchange. The treaty also gives them the right to conduct inspections and imposes an obligation to accept such inspections, in accordance with a Protocol on Inspection.

The purpose of those inspections is to verify compliance with the CFE's limitations and monitor the process of reduction. Inspections fall into three categories:

1. Passive inspection quotas (the total number of inspections which a party is obliged to receive within a specified time period at declared inspection sites);
2. Active inspection quotas (the total number of inspections each party is entitled to conduct within a specified time period); and
3. Passive challenge inspection quotas (inspections carried out anywhere on the territory of a party within an area of application other than a site otherwise subject to inspection).

In addition, the States Parties are entitled to use national and multinational technical means (NTM and MTM) to ensure verification of compliance with the provisions of the Treaty. Use of concealment measures that might impede verification by means of NTM and MTM was prohibited.[77]

3.3.12. Intermediate-Range Nuclear Forces (INF) Treaty

The 1987 INF Treaty required the United States and the then Soviet Union to eliminate and permanently forswear all of their nuclear and conventional ground-launched ballistic

---

75 Ibid.

76 Edward Ifft, "Issues in Implementation and Verification", in *Assessing Compliance with Arms Control Treaties, Report of the International Group on Global Security – IGGS*, September 2007, p. 84.

77 Nuclear Threat Initiative, "Treaty on Conventional Armed Forces in Europe (CFE)", webpage.

and cruise missiles with ranges of 500 to 5,500 kilometres. The treaty marked the first time the two States had agreed to reduce their nuclear arsenals, eliminate an entire category of nuclear weapons, and utilize extensive on-site inspections for verification. The INF Treaty's protocol on missile elimination names the specific types of ground-launched missiles to be destroyed and the acceptable means of doing so (e.g. by exploding them while they were unarmed and burning their stages, or by cutting the missiles in half and severing their wings and tail sections).

The INF Treaty's verification protocol certifies reductions through a combination of NTMs (e.g. satellite observation) and on-site inspections—a process by which each State Party could send observers to monitor the other's elimination efforts as they occurred. The protocol explicitly bans interference with photo-reconnaissance satellites, and States Parties are forbidden from concealing their missiles to impede verification activities. On-site inspections could be conducted at each other's facilities in the United States and Soviet Union and at specified bases in Belgium, Italy, the Netherlands, the United Kingdom, the former Federal Republic of Germany, and the former Czechoslovakia.[78]

3.3.13. Joint Comprehensive Plan of Action (JCPOA): Islamic Republic of Iran

On 14 July 2015, the five permanent members of the Security Council and Germany, the European Union and the Islamic Republic of Iran concluded a JCPOA[79] to ensure that Iran's nuclear programme would be exclusively peaceful. Under the JCPOA, Iran is required to adhere to the Additional Protocol to its Safeguards Agreement with the IAEA, which provides for extensive access for the IAEA to investigate evidence of suspicious activities anywhere.

The IAEA monitors and verifies Iran's supply chain of nuclear materials, centrifuge production lines, and any purchases that might be used for a nuclear programme. The Agency also provides regular updates to the Board of Governors, and, as provided for in the Plan, to the Security Council. In order to receive relief from economic sanctions, Iran is required to dismantle two thirds of its centrifuges, remove 98 per cent of its uranium stockpile, and permanently alter its plutonium reactor at Arak, actions that will also be verified by the IAEA.[80]

The JCPOA with its considerable technical detail and sensitive political underpinnings provides useful insights into the complexities of verification and of ways of overcoming them by negotiation.[81]

78 Arms Control Association, "The Intermediate-Range Nuclear Forces (INF) Treaty at a Glance", May 2014.

79 Joint Comprehensive Plan of Action, 14 July 2015.

80 Council for a Livable World, Center for Arms Control and Non-Proliferation, "The Real Facts on the Iran Nuclear Deal", 2015.

81 See also Mark Hibbs, "Vigorous Verification in Iran", Carnegie Endowment for International Peace, 28 June 2016.

Box E: Other relevant treaties and instruments

- Partial Test Ban Treaty (PTBT), 1963
- Outer Space Treaty, 1967
- Seabed Treaty, 1971
- Anti-Ballistic Missile Treaty (ABM), 1972 (no longer in force)
- Convention on the Prohibition of Military or any Hostile Use of Environmental Modification Techniques (ENMOD Convention), 1977
- Convention on the Physical Protection of Nuclear Material, 1980
- Missile Technology Control Regime (MTCR), 1987
- Hague Code of Conduct (HCOC), 2002

3.4. The United Nations and verification Issues

3.4.1. Security Council

When the United Nations was founded in 1946, disarmament and "arms regulation"[82] were given a prominent place in post-war security arrangements. It was recognized in the Charter that the proliferation of arms presented an ongoing risk to international security and constituted a huge opportunity cost in terms of economic and social development, as resources were diverted towards armaments. The Security Council was given the lead responsibility for developing plans and oversee programmes of disarmament and arms regulation. The General Assembly was accorded the power to consider the principles governing disarmament and the regulation of armaments, and to make recommendations on such principles to Member States or to the Security Council or to both.

The Security Council's role in relation to verification has been widespread. There is room here to give only a few examples: witness

- the inspection regimes created by the Council such as the United Nations Special Commission and the United Nations Monitoring, Verification and Inspection Commission (UNMOVIC);
- resolution 1160 (1998) which authorized the immediate deployment of the Kosovo Verification Mission as set up by the Organization for Security and Co-operation in Europe (OSCE);
- resolution 1540 (2004) requiring States to refrain from supporting non-State actors attempting to acquire nuclear, chemical or biological weapons, and establishing a committee to report back to it on implementation of the resolution; and
- resolution 2231 (2015), which endorsed the JCPOA concluded by the five permanent members of the Security Council and Germany, the European Union and the Islamic Republic of Iran.

82 See articles 11, 24 and 26 of the United Nations Charter.

3.4.2. General Assembly

In 1946, the General Assembly recommended that the Security Council formulate practical measures to provide for the general regulation and reduction of armaments and armed forces, and to ensure that such regulation and reduction would be generally observed, in effect reaffirming the Security Council's obligations under the United Nations Charter.[83] The Assembly has also taken such actions as:

- convening the tenth Special Session of the United Nations General Assembly, 1978, (UNSSOD-1). UNSSOD-1 established three maxims of verification: (a) to create confidence States should accept appropriate provisions for verification to facilitate the conclusion and effective implementation of disarmament agreements; (b) adequate methods and procedures for verification should be developed; and (c) those methods should be non-discriminatory and respect the internal affairs of States;[84]
- establishing the United Nations Disarmament Commission (UNDC): Based on the three UNSSOD-1 points, the UNDC in 1988 agreed 16 Principles of Verification,[85] strong evidence of the extent to which verification had by that stage become an accepted and necessary part of arms control and disarmament;[86] and
- establishing (in 1990 and 1993) two groups of governmental experts on 'Verification in all its aspects' to develop those Principles. These groups produced two studies, *Verification in All its Aspects: Study on the Role of the United Nations in the Field of Verification*,[87] and *Verification in All its Aspects, including the Role of the United Nations in the field of Verification*.[88] In 2006, building on those reports, a further Panel[89] took a more focused approach, discerning recent trends and developments[90] following which the United Nations Office for Disarmament Affairs produced a report[91] on the Panel's work.

---

83 United Nations General Assembly, *Principles governing the general regulation and reduction of armaments*, UN document A/RES/41(I), 14 December 1946.

84 United Nations General Assembly, *Final Document of the Tenth Special Session*, resolution S-10/2, 30 June 1978, paragraphs 91 and 92. See also paragraph 50.

85 United Nations General Assembly, *Verification in All its Aspects: Study on the Role of the United Nations in the field of Verification*, UN Document A/45/372, 28 August 1990, Section II.

86 United Nations Institute for Disarmament Research (UNIDIR) and the Verification Research, Training and Information Centre (VERTIC), *Coming to Terms with Security: A Handbook on Verification and Compliance*, UNIDIR, 2003, p. 5.

87 United Nations General Assembly, *Verification in All its Aspects*, op. cit.

88 United Nations General Assembly, *Verification in All its Aspects: Study on the Role of the United Nations in the field of Verification*, UN Document A/50/377, 22 September 1995.

89 Dr Patricia Lewis, then Director of UNIDIR, served as Consultant to the Panel.

90 United Nations General Assembly, *Verification in all its aspects, including the role of the United Nations in the field of verification*, UN document A/61/1028, 15 August 2007.

91 United Nations Office for Disarmament Affairs, *Verification in All Its Aspects, Including the Role of the United Nations in the Field of Verification*, United Nations, 2008.

3.4.3. Secretary-General

The United Nations Secretary-General, in the first point of his five-point proposal on nuclear disarmament, urged all NPT States Parties to invest more in verification research and development, particularly the nuclear-weapon States.[92] Although not strictly a verification matter, the role given to the Secretary-General by a number of arms control and disarmament treaties[93] for facilitating compliance with those treaties is also notable.

3.4.4. Open-Ended Working Group (OEWG) 2016

This OEWG (referred to in the introduction) held its second (of three) sessions from 2 to 13 May 2016.[94] States and civil society discussed the four issues listed in the Group's mandate,[95] one of which was transparency measures surrounding nuclear weapons. Verification issues were mentioned in this context. OEWG participants generally concurred that a verification mechanism would be an integral component of the legal framing for the elimination of nuclear weapons. Verification was seen as a key measure of the confidence-building necessary to assure all States that there would be no circumvention of such an agreement. In this connection, verification measures agreed would be required to be transparent, verifiable and irreversible. Differing views were expressed, however, on the level of intrusiveness, confidentiality and technical complexity needed for such mechanisms.

Proponents of a nuclear weapon prohibition treaty acknowledged that verifiable elimination of nuclear armaments would be essential. However, the view was expressed that it would not be necessary to integrate detailed verification measures immediately into a ban treaty. In contrast, some States promoting the step-by-step or 'progressive' approach stated that multilateral energies were best spent not on prohibitions that they believed the NAS will eschew but on verification mechanisms—particularly as part of an FM(C)T treaty, drawing on progress reflected in the 2015 GGE report. Other States suggested that the international community needed to take notice of and support the IPNDV's work and research on verification. Several States regarded the IAEA as having the experience required to be the Agency conducting verification. Other suggestions related to the need for the nuclear-weapon States to make baseline declarations of their existing stocks and capabilities. In sum, although the focus of the debate in the OEWG was on transparency measures rather than verification per se, awareness of some of the political and technical complexities of the latter was evident.

The OEWG concluded its work on 19 August 2016 with the adoption (by vote) of a report (A/71/371) containing a number of references to verification, notably in paragraph 44 and Annex II.

---

92 Ban Ki-moon, address to the East-West Institute, 24 October, 2008.

93 For example, the Anti-personnel Mine Ban Convention, 1997, and the Convention on Cluster Munitions, 2008.

94 See background information in UNIDIR, *The Treatment of the Issue of Nuclear Disarmament since the Open-Ended Working Group in 2013*, OEWG Briefing Paper no. 2, UNIDIR, 2016.

95 United Nations General Assembly, UN document A/RES/70/33, 11 December 2015.

3.4.5. Draft Model Convention on Nuclear Weapons

The draft Model Convention put forward in 2007 by Costa Rica and Malaysia[96] defined but does not contain detailed provisions on verification. Under the Model, all States would be prohibited from pursuing or participating in the 'development, testing, production, stockpiling, transfer, use and threat of use of nuclear weapons'. Those States that possess nuclear weapons would be obligated to destroy their nuclear arsenals in five phases:

1. taking nuclear weapons off alert;
2. removing weapons from deployment;
3. removing nuclear warheads from their delivery vehicles;
4. disabling the warheads, removing and disfiguring the 'pits'; and
5. placing the fissile material under international control.

Delivery vehicles would also have to be destroyed or converted to a non-nuclear capability. In addition, the Model would prohibit the production of weapons-usable fissile material. The States Parties would also establish an agency for the prohibition of Nuclear Weapons that would be tasked with verification, ensuring compliance, decision-making, and providing a forum for consultation and cooperation among all Parties.[97]

The draft Model defines 'verification' as meaning a 'comprehensive system for ensuring the compliance with and implementation of this Convention. Verification measures include obtaining, providing, and assuring the accuracy of information on nuclear weapons, nuclear material, nuclear facilities, and nuclear weapons delivery vehicles, including information in archives, data bases, and transportation systems, through declarations, monitoring, agreements on sharing information, consultation and clarification, on-site inspections, confidence-building measures, reporting and protection, preventive controls, and any other measures deemed necessary by the Agency [for the Prohibition of Nuclear Weapons]'.[98]

The Model also provides for the making of declarations relating to nuclear weapons and nuclear materials (see Section III of the draft) and enumerates 25 'elements' for a verification regime (Section V). Element 12, which sets out the activities, facilities and

---

96 United Nations General Assembly, *Letter dated 17 December 2007 from the Permanent Representatives of Costa Rica and Malaysia to the United Nations addressed to the Secretary-General*, UN document A/62/650, 18 January 2008; and Preparatory Committee for the 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Model Nuclear Weapons Convention: Working paper submitted by Costa Rica*, document NPT/CONF.2010/PC.I/WP.17, 1 May 2007. The proposal was based on an updated version of a text prepared by the civil society groups IALANA, INESAP and IPPNW that had been submitted by Costa Rica to the United Nations Secretary-General in 1997. The proposal was also tabled in the 2016 OEWG: See OEWG working paper, *Model nuclear weapons convention Submitted by Costa Rica and Malaysia*, UN document A/AC.286/WP.11, 24 February 2016.

97 Nuclear Threat Initiative, "Proposed Nuclear Weapons Convention (NWC)", webpage.

98 Preparatory Committee for the 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Model Nuclear Weapons Convention: Working paper submitted by Costa Rica*, document NPT/CONF.2010/PC.I/WP.17, 1 May 2007.

materials that would be subject to verification, refers to a 'Verification Annex'. This annex would form an integral part of a negotiated NWC, but is not included in the draft Model.

3.4.6. Fissile Material Group of Government Experts

A brief account of the work of a GGE on Fissile Material (established by the General Assembly in 2013) was provided earlier in this paper (see Section 3.2.6).

4. Key verification challenges and analogies

4.1. Summary

Drawing on features of existing WMD verification mechanisms and of current work listed in Section 3, this section identifies challenges and some lessons learned of relevance to policymakers as they approach the complex issue of nuclear disarmament verification.

4.2. General

Heightening international tensions and a divergence of views over how and when to advance multilateral nuclear disarmament form the backdrop to the current debate on eliminating nuclear weapons. It is significant because the development of verification mechanisms will itself require collective will and commitment from States, including those with nuclear weapons (some of which happen to be those with the starkest differences of viewpoint). In view of their likely complexity and the political sensitivities of potentially intrusive verification measures, this adds up to a considerable —perhaps even insuperable—challenge in the current geostrategic climate.

For most—if not all—States, the elimination of nuclear arsenals nevertheless remains a firm, avowed objective, even among nuclear-weapon States. The reaffirmation in the consensus outcome document of the 2010 NPT Review Conference by China, France, the Russian Federation, the United Kingdom and the United States of the 'unequivocal undertaking of the nuclear-weapon States to accomplish the total elimination of their nuclear arsenals leading to nuclear disarmament'[99] has to be seen in that light, the more so given the responsibilities that those States exercise as permanent members of the Security Council.

The challenges of engendering progress in the unsettled international security environment and in the absence of any consensus on the next moves to be made towards nuclear disarmament are considerable. The question, however, is whether those circumstances should be regarded as an incentive rather than a hindrance to fostering progress. Complex

99 See step 6 (of the 13 'practical steps for the systematic and progressive efforts to implement article VI' of the NPT), in 2000 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Final Document*, document NPT/CONF.2000/28 (Parts I and II).

agreements have in the past been reached in unpropitious circumstances (e.g. START 1, the CFE Treaty and the JCPOA with the Islamic Republic of Iran[100]).

In any event, this paper has served to highlight a number of key political and legal issues that negotiation of verification mechanisms will present, many of which are interconnected.[101] For example:

4.3. Pre-negotiation bodies

Pre-negotiation bodies like the CD-established GSE that preceded the negotiation of the CTBT can, if needed, have several advantages:

1. they make a head-start on building up detail and possible solutions to issues of considerable scientific, legal or technical complexity in advance of negotiations;
2. they can help nurture and spread expertise and understanding necessary for an informed resolution of such issues; and
3. they allow progress to be made at a technical level while awaiting political conditions to 'mature' to a point where diplomatic negotiations can get under way.

4.4. Confidence-building

Verification procedures can themselves be regarded as confidence-building measures in establishing mechanisms that are designed—in relation to WMD—to prevent abuse of rules in which every State has a vital stake, i.e. that no treaty party will retain a covert arsenal of the weapons being outlawed. Increasing trust among States that possess nuclear weapons, as well as those that do not, will be fundamental to ensuring the elimination of all such armaments.

4.5. Transparency

There are numerous elements involved in building confidence. Transparency is prime among these. In the NPT the five nuclear-weapon possessors are under continuing pressure from other States (including their allies[102]) for increased transparency, especially on reporting. As Japan noted, 'Without transparency, nuclear disarmament cannot be

---

100 See OEWG working paper, *The road to zero: The progressive approach*, UN document A/AC.286/WP.25, 21 April 2016, paragraph 5.

101 Nuclear Threat Initiative, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks: Overview*, Cultivating Confidence Verification Series, 2014, pp. 5–7.

102 See 2015 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Transparency, Reporting and Strengthening the Review Process: Working paper submitted by Japan*, document NPT/CONF.2015/WP.32, 22 April 2015; and Preparatory Committee for the 2015 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Increased transparency in nuclear disarmament: Working paper submitted by the members of the Non-Proliferation and Disarmament Initiative (Australia, Canada, Chile, Germany, Japan, Mexico, Nigeria, the Netherlands, the Philippines, Poland, Turkey and the United Arab Emirates)*, document NPT/CONF.2015/PC.III/WP.10 (NPDI), 19 March 2014.

verified, nor would States have complete confidence that nuclear disarmament measures have been accomplished in an irreversible manner'.[103] Increased application of safeguards both in non-nuclear-weapon States and possessor States provides an example of relevance to building the confidence, transparency and trust required to underpin further disarmament steps such as the development of verification mechanisms. Any costs involved in extending safeguards in nuclear-weapon States could be contained through utilizing 'State Level Approaches' and possibly through further regional safeguards arrangements such as EURATOM.[104] 'State Level Approaches' entail evaluation by the IAEA of all safeguards-relevant information about a State as a whole rather than the more resource-intensive facility-by-facility approach, and, where possible, tailoring safeguards to fit the State concerned. Greater willingness among States to accept extensions of this nature should be conducive to confidence-building among them.

4.6. Baseline declarations

Transparency will be fundamental to the notion of baseline declarations. As the NTI Pilot Project has suggested, a 'baseline declaration' will be a crucial element for initiating a verification mechanism. What is envisaged is a 'statement of the number or quantity of accountable items or materials—perhaps specified by parameters such as type or category—against which other information may be compared and future progress may be measured'.[105] Such a declaration is seen as an essential first step for constructive cooperation (and confidence-building) because 'without a clear understanding of warhead and nuclear material inventories, it will be nearly impossible to confirm that there are no hidden items or clandestine activities'.[106]

4.7. Intrusiveness: maintaining confidentiality

While accurate baseline declarations of inventories held by possessing States will be the foundations on which verification is based, the real test for any mechanism that accounts for reductions and eventual elimination of weapons-holdings will be whether it manages to lift the veil of secrecy that surrounds those arsenals and the materials within them. As the NTI Project has counselled, 'Parties must balance the need for intrusive verification activities with requirements for protecting sensitive information.'[107] This will undoubtedly

---

103 2015 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Transparency, Reporting and Strengthening the Review Process: Working paper submitted by Japan*, document NPT/CONF.2015/WP.32, 22 April 2015, paragraph 2. See also United Nations General Assembly, *Issues and challenges in actual reduction and elimination of nuclear weapons Submitted by Japan*, document A/AC.286/WP.23, 14 April 2016, paragraph 9.

104 John Carlson, *Expanding Safeguards in Nuclear-Weapon States*, Nuclear Threat Initiative paper, 2012.

105 Nuclear Threat Initiative, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks: Verifying Baseline Declarations of Nuclear Warheads and Materials*, Cultivating Confidence Verification Series, 2014, p.12.

106 Ibid.

107 Nuclear Threat Initiative, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks: Verifying Baseline Declarations of Nuclear Warheads and Materials*, Cultivating Confidence Verification Series, 2014, p.25.

be a fine line. Nonetheless, the UK-NI sees no a priori barriers to collaboration between nuclear-weapon States and non-nuclear-weapon States in this regard (although work in the laboratory has yet to be applied in an operational environment).

4.8. Technical feasibility

'Many of the basic technical methods and equipment required for warhead verification exist today, but some do not.'[108] Verification policy decisions will need to be informed by what is technically feasible. It is important therefore to be continuously receptive to improvements in technology. Experimental projects such as those of UK-NI and US-UK are valuable both for testing the limits of technology and also ascertaining what is feasible or not, politically and technically. New options for verification may emerge such as 'antineutrino detectors', technology which detects emissions (antineutrinos) that arise from all fission nuclear processes and cannot be blocked or shielded.[109]

4.9. Experience and expertise

Effective verification will also depend on the availability of technical and other experts. Expertise has been established in the United States and the Russian Federation through collaboration in implementing bilateral agreements such as START. Similarly, cooperation between the United States and the United Kingdom and between the latter and Norway has helped built up useful experience, but broader expertise among non-nuclear-weapon States will be needed when it comes to developing multilateral verification mechanisms. Nonetheless, this deficit is capable of being remedied over time. In addition, some non-nuclear-weapon States also have nuclear civil facilities and may also benefit through exercises with the IAEA in relation to verification in NWFZs.

4.10. Scope: nuclear lifecycle

States will have to define the scope of the mechanisms needed for ensuring the verifiable elimination of nuclear weapons and of the fissile materials they contain. Ideally, the mechanisms will be applied to the entire cycle of developing and disposing of materials needed for nuclear weapons. Practical considerations, however, such as costs and the availability of technical means (if they exist), logistical elements and expertise may oblige negotiators to prioritize those parts of the fuel cycle that will be governed by verification. The IPNDV and NTI projects may help shed light on this factor.

4.11. Collaboration between nuclear-weapon States and non-nuclear-weapon States

Efforts to achieve universality in relation to nuclear weapons treaties have not always been successful as has been demonstrated in the case of the NPT (five States have yet

108 Ibid., p.20.

109 Kelly Wadsworth, "The nuclear verification technology that could change the game", *Bulletin of the Atomic Scientists*, 13 October 2015.

to commit to it) and CTBT (eight Parties short of entry into force). Yet initiatives such as those mentioned in Section 3.2 have not been deterred by this reality. Collaboration between some NAS and non-possessing States has been productive to date. EURATOM is another case in point. Although that organization's mandate does not extend to military material, it has acquired relevant verification experience in the course of inspecting facilities in weapon States that have held civil and military material at the same time.

4.12. Collaboration among nuclear-weapon States

As already mentioned, collaboration between the United States and the Russian Federation and the United States and the United Kingdom has demonstrated the feasibility of cooperation among possessors of nuclear arms where there is a will and mutual interest to do so with a view to nuclear verification.

4.13. Collaboration among non-nuclear-weapon States

The experience of non-nuclear-weapon States in establishing regional NWFZs and in fulfilling their NPT, IAEA and EURATOM safeguards agreements has helped establish a measure of experience in relation to verification of nuclear activities, albeit of a general kind. For exposure to technical complexities of verification mechanisms, non-nuclear-weapon States will otherwise initially be largely reliant on South Africa's know-how in dismantling its small nuclear arsenal in the early 1990s and Norway's experience gained from the UK-NI.

4.14. Considerations of equity

An abiding criticism of the NPT is its two-tier structure of membership that distinguishes between the five nuclear-weapon States recognized by the treaty and non-nuclear-weapon States, imparting a discriminatory character to the NPT.[110] This dichotomy may have proved tolerable if expectations among the latter group about the pace of disarmament by the nuclear-weapon States had been met. Mention is made of it here because it may complicate the task of building trust and balancing efficient verifiability, non-discrimination and intrusiveness among States on the highly sensitive question of access to military complexes, for instance. The inspection regime will be a key component in this regard.

4.15. Costs

Choices relating to the intrusiveness, scope and complexity of verification mechanisms will obviously affect their cost. For example, a verification mechanism under an FM(C)T that prohibited only future production of fissile material for use in nuclear weapons will be substantially less complex than one that also dealt with existing, weaponized fissile

110 Paul Meyer, "A problematic nuclear Nonproliferation Treaty", *OpenCanada*, 14 May 2015. See also Richard Rhodes, "Opinion", *Washington Post*, 15 July 2016, penultimate paragraph.

material. Even in the case of declarations, 'how the declaration is structured will affect not only how it is verified, but also how and where inspections can take place'.[111]

4.16. Choice of institution: existing or new?

A major factor affecting the costs of verification will be the choice of institution to carry out or oversee the implementation of the mechanism(s). The choice is likely to come down either to setting up a new organization or co-opting a relevant existing one such as the IAEA. Given the IAEA's experience in administering nuclear safeguards, it would be a logical contender to assume additional verification responsibilities, funding permitting, and this sentiment was expressed publicly by some States during the 2016 OEWG. The IAEA also has derived relevant experience through its role in the dismantlement of South Africa's nuclear weapons. The annual budget for the IAEA amounts to approximately US$400 million of which (in 2016) $150m is allocated for verification activities. Depending on the nature of any additional verification activities, resourcing would likely need to be revisited with a view to increasing funding.

The CWC and CTBT each established new bodies to carry out the verification role agreed by their States Parties. Current budgets for the OPCW are US$74 million ($33 million for verification costs) and for the CTBTO US$37 million. Contributions to bodies such as these are generally based on the United Nations scale of assessments, which is adjusted to match the composition of membership of the organization concerned. (With the scope of verification activities focused largely on nuclear-weapon possessors, the costs of the regime will be at minimal levels initially, increasing only when possessors become parties and verification mechanisms are triggered.)

4.17. Time

Even with the best intentions, the verification process is likely to be a protracted one. A relevant example of a lengthy process for the development of a verification mechanism is the CTBT's GSE, established in 1976 by the CD, 20 years before negotiations of the CTBT actually began.[112] Indeed, leaving aside the political dimensions relevant to nuclear weapons, the timeline for negotiations of verification for the elimination of those arms could take longer than previous negotiations simply because of the level of technical complexity and the sensitive national security information involved. These considerations are part of the rationale for initiatives such as the IPNDV and the UK-NI.

---

111 Nuclear Threat Initiative, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks: Verifying Baseline Declarations of Nuclear Warheads and Materials*, Cultivating Confidence Verification Series, 2014, p.21.

112 See Sandra Alwardt, *The GSE and the Negotiations for the CTBT in the Historical Context of the International Scientific and Political process of Nuclear Arms Control*, University of Hamburg, Occasional Paper No. 8, March 2009.

5. Conclusion

'The international community needs a transparent, sustainable and credible plan for multilateral nuclear disarmament—and measures that can fulfil the requirements for the verifiable elimination of nuclear weapons are central to that plan'.[113]

As a survey of verification issues that will arise in multilateral negotiations for the elimination of nuclear weapons, this collection of cooperative and preparatory activities, precedents and bibliography serves to highlight several salient points about the current environment.

The first and perhaps most obvious point is that a number of contentious elements will need to be brought together harmoniously if verification mechanisms capable of providing universal assurance that nuclear armaments and the means for making them have been eliminated and prohibited once and for all are to be the end result.[114] In particular, patient confidence-building among possessors and non-possessors will be needed to establish that there is a readiness to negotiate in good faith to overcome the challenges ahead. Efforts to this end should be redoubled now whatever the nature of future nuclear disarmament efforts. Work should focus on:

- developing productive ways to build confidence and engender an atmosphere of trust that facilitates increased transparency of all aspects surrounding possession of nuclear weapons;
- mitigating traditional concerns among possessing States and their militaries about intrusiveness into their military complexes, especially nuclear arsenals, to the extent that credible verification mechanisms can be agreed;
- improving understanding of the technical complexities that will arise in developing verification mechanisms and of the scope for new technologies that will allay concerns about intrusiveness;
- given the technical complexities involved, planning for the elimination of nuclear weapons will need to make provision for developing the expertise and skills that will be needed if the effectiveness of verification mechanisms is to be maximized; and
- costing the range of mechanisms and institutions that will be needed for effective verification.

The way ahead will need to surmount those and other obstacles listed in the previous section.

However challenging this may seem, it must also be observed that the architects of a verification regime for eliminating nuclear weapons will be able to draw on the

113 Des Browne, *Nuclear Verification Challenges and Opportunities – A Diplomatic Workshop*, Baden, 20 June 2014, p.7.

114 Nuclear Threat Initiative, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks: Overview*, Cultivating Confidence Verification Series, 2014, p. 9.

experience of a range of relevant treaties and organizations. Moreover, there are the practical experiences gained in the course of exercises like those of the IPNDV and the UK-NI. One senior United States official summed this up as follows:

> We can all acknowledge that verification will become increasingly complex at lower numbers of nuclear weapons, while requirements for accurately determining compliance will dramatically increase. Everyone who shares the goal of a world free of nuclear weapons should be devoting ample time and energy to address this challenge right now.[115]

The elimination of nuclear weapons is a common ideal of the international community. Nuclear warfare has the potential to have existential consequences: all nations therefore have a stake in achieving a nuclear-weapon-free world. Certainly, to be fully effective, legally binding agreements eliminating this remaining class of weapon of mass destruction will require universal participation. All States, whether possessors of nuclear weapons or non-possessors, will need to be assured that such agreements establish verification processes that are credible, technically feasible and affordable.

6. Bibliography

Alwardt, Sandra, *The GSE and the Negotiations for the CTBT in the Historical Context of the International Scientific and Political process of Nuclear Arms Control*, University of Hamburg, Occasional Paper No. 8, March 2009.

Arbatov, Alexey, Vladimir Dvorkin, and Natalia Bubnova, *Nuclear Reset: Arms Reduction and Nonproliferation*, Carnegie Moscow Center, 2016.

Arms Control Association, *The Biological Weapons Convention (BWC) at a Glance*, September 2012.

Avenhaus, Rudolf, Nicholas Kyriakopoulos, Michel Richard, and Gotthard Stein (eds.), *Verifying Treaty Compliance: Limiting Weapons of Mass Destruction and Monitoring Kyoto Protocol Provisions*, Springer Science & Business Media, 2007.

Berry, Ken, *Review of Recent Literature on Nuclear Issues*, International Commission on Nuclear Non-proliferation and Disarmament, 2008.

Blechman, Barry M., *Why We Need to Eliminate Nuclear Weapons – and How to Do It. Elements of a Nuclear Disarmament Treaty*, Henry L. Stimson Center, 2010.

Bodell, Nenne, "Annex A. Arms control and disarmament agreements", in *SIPRI Yearbook 2011*, SIPRI, 2011.

Boehme, Peter, "The Verification Regime of the Chemical Weapons Convention: An Overview", Organisation for the Prohibition of Chemical Weapons, 28 November 2008.

115 Rose Gottemoeller, "The Vision of Prague Endures", speech, 5 December 2014.

Borrie, John and Tim Caughley, "After Oslo: Humanitarian Perspectives and the Changing Nuclear Weapons Discourse", in *Viewing Nuclear Weapons through a Humanitarian Lens*, UNIDIR, United Nations, 2013, pp. 100–104.

Borrie, John and Tim Caughley, *An Illusion of Safety: Challenges of Nuclear Weapon Detonations for United Nations Humanitarian Coordination and Response*, UNIDIR, 2014.

Browne, Des, *Nuclear Verification Challenges and Opportunities – A Diplomatic Workshop*, Baden, 20 June 2014.

Bunn, Matthew, and John Carlson, *Verifying Baseline Declarations of Nuclear Warheads and Materials*, Nuclear Threat Initiative Report, July 2014 (see further references to this work under 'Nuclear Threat Initiative' below).

Carlson, John, *Experience and Challenges in WMD Treaty Verification: A Comparative View*, Australian Safeguards and Non-Proliferation Office, Background Papers on Nuclear Verification Issues, 30 January 2009.

Carlson, John, *Expanding Safeguards in Nuclear-Weapon States*, Nuclear Threat Initiative paper, 2012.

Carlson, John, "New Verification Challenges", *Journal of Nuclear Materials Management*, XXXVII:4, 2016.

Carlson, John and Andreas Persbo, *The IAEA Safeguards Function – Responsibilities under Safeguards Agreements, the NPT and the Statute*, Presentation to the Annual Meeting of the Institute of Nuclear Materials Management, Palm Desert, California, 14–18 July 2013.

Council for a Livable World, Center for Arms Control and Non-Proliferation, "The Real Facts on the Iran Nuclear Deal", 2015.

Enger, Elin, "The Challenge of Verification: The UK-Norway Initiative on Non-Nuclear-Weapon States' Participation in the Verification of Nuclear Disarmament", working paper prepared for *The Warsaw Workshop: Prospects for Information Sharing and Confidence Building on Non-Strategic Nuclear Weapons in Europe*, Warsaw, 7–8 February 2013.

European Union, Joint statement by EU High Representative Federica Mogherini and Iranian Foreign Minister Javad Zarif, 14 July 2015.

Fedchenko, Vitaly (ed.), *The New Nuclear Forensics: Analysis of Nuclear Materials for Security Purposes*, Oxford University Press, 2015.

Fetter, Steve, *Verifying Nuclear Disarmament, in Nuclear Weapons: The Road to Zero*, Westview Press, 1998, pp. 71–100.

Findlay, Trevor, "Verification and the Nuclear Non-Proliferation Treaty", *INESAP Information Bulletin*, no. 27, 2006.

Fuller, James, "Verification on the Road to Zero: Issues for Nuclear Warhead Dismantlement", *Arms Control Today*, 5 December 2010.

Glaser, Alexander, "Facilitating Nuclear Disarmament: Verified Declarations of Fissile Material Stocks and Production", *The Non-proliferation Review*, vol. 19:1, 2012.

Glaser, Alexander, Boaz Barak and Robert J. Goldston, "A Zero-Knowledge Protocol for Nuclear Warhead Verification", *Nature*, 510:7506, 2014, 497–502.

Goldblat, Jozef, *Arms Control: The New Guide to Negotiations and Agreements*, SAGE, 2002.

Goldblat, Jozef, "How to Deter Violations of Disarmament and Non-proliferation Agreements", in *Assessing Compliance with Arms Control Treaties, Report of the International Group on Global Security – IGGS*, September 2007.

Gottemoeller, Rose, "The Vision of Prague Endures", speech, 5 December 2014.

Göttsche, Malte, Moritz Kütt, Götz Neuneck and Irmgard Niemeyer, *Advancing Disarmament Verification Tools: A Task for Europe?,* EU Non-Proliferation Consortium, Non-Proliferation Paper no. 47, October 2015.

Hibbs, Mark, "Vigorous Verification in Iran", Carnegie Endowment for International Peace, 28 June 2016.

Hinderstein, Corey, *Cultivating Confidence: Verification, Monitoring and Enforcement for a World Free of Nuclear Weapons*, Hoover Press, 2013.

Horner, Daniel and Kelsey Davenport, "Verification Partnership Coalesces", *Arms Control Today*, 4 March 2016.

Hynek, Nik and Michel Smetana, *Global Nuclear Disarmament: Strategic, Political, and Regional Perspectives*, Routledge, 2016.

Ifft, Edward, "Issues in Implementation and Verification", in *Assessing Compliance with Arms Control Treaties, Report of the International Group on Global Security – IGGS*, September 2007.

International Atomic Energy Agency (IAEA), "IAEA Safeguards Glossary 2001 Edition", *International Nuclear Verification Series*, No. 3, 2001.

International Atomic Energy Agency (IAEA), *Verifying Compliance with Nuclear Non-Proliferation Undertakings*, IAEA, 2011.

International Law and Policy Institute and UNIDIR, *A Prohibition on Nuclear Weapons: A Guide to the Issues*, February 2016.

International Panel on Fissile Materials (IPFM), *Global Fissile Material Report 2009: A Path to Nuclear Disarmament*, Fourth annual report of the International Panel on Fissile Materials, IPFM, 2009.

International Partnership for Nuclear Disarmament Verification (IPNDV), *Working Group 1: Monitoring and Verification Objectives Terms of Reference*, 18 November 2015.

International Partnership for Nuclear Disarmament Verification (IPNDV), *Working Group 2: On-Site Inspections (OSI), Terms of Reference*, 18 November 2015.

International Partnership for Nuclear Disarmament Verification (IPNDV), *Working Group 3: Technical Challenges and Solutions Terms of Reference*, 18 November 2015.

Johnson, Rebecca, *Unfinished Business: The Negotiation of the CTBT and the End of Nuclear Testing*, UNIDIR, 2009.

Joint Comprehensive Plan of Action (JCPOA) between the Islamic Republic of Iran and the E3/EU+3 (China, France, Germany, the Russian Federation, United Kingdom and United States, with the High Representative of the European Union for Foreign Affairs and Security Policy), 14 July 2015.

Littlewood, Jez, *The Biological Weapons Convention: A Failed Revolution*, Ashgate, 2005.

Meyer, Paul, "A problematic nuclear Nonproliferation Treaty", *OpenCanada*, 14 May 2015. See also Richard Rhodes, "Opinion", *Washington Post*, 15 July 2016, penultimate paragraph.

Mian, Zia, Arend Meerburg and Frank von Hippel, *Scope and Verification of a Fissile Material (Cutoff) Treaty*, presentation, Conference on Disarmament, Geneva, 21 August 2009.

Nuclear Threat Initiative, *Cultivating Confidence: Verification, Monitoring, and Enforcement for a World Free of Nuclear Weapons*, Cultivating Confidence Verification Series, 2010.

Nuclear Threat Initiative, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks*, Cultivating Confidence Verification Series, 2014.

Persbo, Andreas and Angela Woodward, *National Measures to Implement WMD Treaties and Norms: The Need for International Standards and Technical Assistance*, The Weapons of Mass Destruction Commission, 2005.

Persbo, Andreas and Marius Bjørningstad, "Verifying Nuclear Disarmament: The Inspector's Agenda", *Arms Control Today*, 11 June 2008.

Podvig, Pavel, "What if North Korea were the only nuclear weapon state?", *Bulletin of the Atomic Scientists*, 27 May 2009.

Podvig, Pavel, *Transparency in Nuclear Disarmament*, UNIDIR, 2012.

Podvig, Pavel, *Fissile Material (Cut-off) Treaty: Elements of the Emerging Consensus*, UNIDIR, 2016.

Podvig, Pavel, *Verifiable Declarations of Fissile Material Stocks: Challenges and Solutions*, UNIDIR, 2016.

Rauf, Tariq, Khaled AbdelHamid, Ephraim Asculai, Christian Charlier, Edward M. Ifft, Olli Heinonen, Dorte Hühnert, Ibrahim Said and Hartwig Spitzer, "Possible Frameworks

for Verification of a WMD/DVs Free Zone in the Middle East: The Nuclear Dimension", *Academic Peace Orchestra Middle East*, Policy Brief no. 33, August 2014.

Revill, James, *A Peer-Review Mechanism for the Biological and Toxin Weapons Convention*, UNIDIR, 2013.

Rockwood, Laura and Thomas E. Shea, *Nuclear Disarmament: The Legacy of the Trilateral Initiative*, Deep Cuts Working Paper #4, The Deep Cuts Commission, 23 March 2015.

Schwalbach, Peter, "EURATOM Safeguards experience and future verification regimes", Institute of Nuclear Materials Management, 2015.

Shea, Thomas E., "The Trilateral Initiative: A Model for the Future?", *Arms Control Today*, 11 June 2008.

Shea, Thomas E. and Laura Rockwood, *IAEA Verification of Fissile Material in Support of Nuclear Disarmament*, The Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard University, May 2015.

Sur, Serge, *Verification of Current Disarmament and Arms Limitation Agreements: Ways, Means and Practices*, UNIDIR, 1991.

Tucker, Jonathan B., "Verifying a Multilateral Ban on Nuclear Weapons: Lessons from the CWC", *The Nonproliferation Review*, vol. 5:2, 1998, pp. 81–90.

Tucker, Jonathan B. "Biological Weapons Breakdown", *Arms Control Today*, 1 May 2005.

Tulliu, Steve and Thomas Schmalberger, *Coming to Terms with Security: A Lexicon for Arms Control, Disarmament and Confidence-Building*, UNIDIR, 2003.

United Kingdom Ministry of Defence, *UK/Norway Initiative on nuclear warhead dismantlement verification*, 31 March 2010.

United Kingdom and United States of America, *Overview of US and UK Cooperation to Address Technical Challenges in Verification of Nuclear Disarmament*, Presentation, UNHQ, 2 May 2014.

"United Kingdom – Norway Initiative", UK-NI, 2016, http://ukni.info.

United Nations, *Disarmament and Related Treaties*, UNODA, 2015.

United Nations Institute for Disarmament Research (UNIDIR) and the Verification Research, Training and Information Centre (VERTIC), *Coming to Terms with Security: A Handbook on Verification and Compliance*, UNIDIR, 2003.

United Nations Institute for Disarmament Research (UNIDIR), *Disarmament Forum*, no. 3, 2010.

United Nations Institute for Disarmament Research (UNIDIR), *The Treatment of the Issue of Nuclear Disarmament since the Open-Ended Working Group in 2013*, OEWG Briefing Paper no. 2, UNIDIR, 2016.

United Nations Office for Disarmament Affairs (UNODA), *Verification in All Its Aspects: Including the Role of the United Nations in the Field of Verification*, Disarmament Study Series, no. 32, UNODA, 2009.

United States, Department of Defense, Defense Science Board, *Task Force Report: Assessment of Nuclear Monitoring and Verification Technologies*, 2014.

United States Department of Energy, National Nuclear Security Administration, Defense Nuclear Nonproliferation, Office of Nonproliferation and Arms Control, and United Kingdom Ministry of Defence, *Joint U.S.-U.K. Report on Technical Cooperation for Arms Control*, 2015.

Venturini, Gabriella, "Control and Verification of Multilateral Treaties on Disarmament and Non-Proliferation of Weapons of Mass Destruction", *Journal of International Law & Politics*, Vol. 17:2, 2011.

Verification Research, Training and Information Centre, "Building Trust through Verification", 2016.

Wadsworth, Kelly, "The nuclear verification technology that could change the game", *Bulletin of the Atomic Scientists*, 13 October 2015.

Walker, John R., *The CTBT Verification and Deterrence*, VERTIC, 2011.

Weapons of Mass Destruction Commission, *Weapons of Terror—Freeing the World of Nuclear, Biological and Chemical Arms*, 2006.

Woolf, Amy F., Paul K. Kerr and Mary Beth D. Nikitin, *Arms Control and Nonproliferation: A Catalog of Treaties and Agreements*, Congressional Research Service, 2016.

Wuest, C.R., *The Challenge for Arms Control Verification in the Post-New START World*, Lawrence Livermore National Laboratory, 2012.

Note also the Nuclear Threat Initiative's valuable 'Monitoring and Verification Resource Collection' with its five subject areas: Arms Control Agreements, Demonstrations & Experiments; Future Monitoring & Verification Challenges; Warhead Confirmation & Radiation Measurements; Information Protection & Information Barriers; and Chain of Custody, Tags, Seals & Tamper Indicating Enclosures, September 2015, http://www.nti.org/analysis/reports/verification-resource-collection/.

UNIDIR

Nuclear Disarmament Verification: Survey of Verification Mechanisms

The objective of this survey is to provide a general overview of past and present verification activities and proposals relevant to the elimination of nuclear weapons. We look beyond the current debate on nuclear disarmament towards the development of the mechanisms required to provide assurances that a nuclear-weapon-free world can be achieved and maintained. Reaching these objectives will be challenging, but, as the paper shows, feasible.