Food-for-Thought Paper:
Achieving Irreversibility in Nuclear Disarmament

Working Group 1: Monitoring and Verification Objectives
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Introduction

Throughout Phase I, the IPNDV Monitoring and Verification Objectives Working Group has examined key objectives for monitoring and verifying the dismantlement of a nuclear weapon, including the information, skills and expertise needed to support this process. This group is co-chaired by The Netherlands and the United Kingdom.

The Final Document of the Tenth Special Session of the General Assembly in 1978, the first special session devoted to disarmament (SSOD-I), articulated the ultimate objective of general and complete disarmament under effective international control. This document referred explicitly to verification, while the concepts of irreversibility and transparency evolved later. Yet, the three concepts were derived from the SSOD-I objective.

Irreversibility, verification, and transparency are closely inter-linked. Through transparency measures and credible verification, assurances can be obtained that weapons are irreversibly destroyed according to treaty obligations. The three core concepts are fundamental in fostering the necessary confidence for achieving and maintaining a world without nuclear weapons.

Yet, there is a need for more clarity and common understanding on the actual meaning of these three principles. This paper deals with irreversibility. The main added value of IPNDV discussing the concept of irreversibility is that it provides us with a chance to make the concept less abstract and, with that, more practical and usable. Important lessons can be drawn from past arms control agreements and initiatives. In addition, important analytical studies on irreversibility have been published over recent years. Although total irreversibility can be, and in most cases is, viewed as a desirable tool in order to make sure that there is no “roll-back” from a certain achieved disarmament step or stage, it seems today not feasible to regard and treat irreversibility in too absolute and rigid terms. Cost issues, technical constraints, and the fact that expertise and knowledge on how to produce nuclear weapons will remain for a long time in any given disarming State. It is even possible to consider that irreversibility could be viewed as a hindrance for disarmament: If a State perceives that there is no step back from a given disarmament measure,

it may be unwilling to try it and open this path if it suspected that others were in non-compliance to their disarmament obligations. This is where verification and transparency come in as essential auxiliary measures that in a longer perspective can ensure that a State will not step back from disarmament commitments made. This paper thus argues for a more realistic approach by identifying a combination of legal, political, and physical measures, which can contribute to an increased level of irreversibility—or adequate irreversibility—and to timely discover any potential of non-compliance. Such an irreversibility level could provide the necessary assurances to move the nuclear disarmament process forward.

The Evolution of Irreversibility

Irreversibility gained enhanced prominence in the 1990s, at the end of a decade where the Strategic Arms Reduction Treaty (START), Chemical Weapons Convention (CWC), and Comprehensive Nuclear-Test-Ban Treaty (CTBT) opened for signature and the International Atomic Energy Agency (IAEA) approved the Additional Protocol to Safeguards Agreements.[1] Already in January 1994, the Presidents of the United States and Russia, Bill Clinton and Boris Yeltsin, agreed to ensure "transparency and irreversibility of the nuclear arms reduction process."[2] Later, at a Summit in Helsinki in March 1997, the two presidents issued a Joint Statement stating that once the START II agreement would enter into force, the United States and Russia would begin negotiations on a START III agreement, which would include transparency measures that should promote the:

> "…irreversibility of deep reductions including prevention of a rapid increase in the number of warheads."[3]

An *Irreversibility Working Group* was established to look deeper into the term and the different options for promoting irreversibility in the planned START III process as required by the statement from the Helsinki Summit.

The text of the Nuclear Non-Proliferation Treaty (NPT) does not refer to irreversibility in nuclear disarmament, but irreversibility was reflected in the Final Document of the NPT Review Conference of 2000. The Final Document presented what is known as the 13 Practical Steps toward nuclear disarmament, including step five on irreversibility:

> "…the principle of irreversibility to apply to nuclear disarmament, nuclear and other related arms control and reduction measures."[4]

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[1] Ian Anthony, *Irreversibility in Nuclear Disarmament—Political, Societal, Legal and Military-Technical Aspects* (Stockholm: SIPRI, 2011).

[2] U.S. Department of Energy, *Transparency and Verification Options: An Initial Analysis of Approaches for Monitoring Warhead Dismantlement*, Office of Arms Control and Nonproliferation (May 19, 1997).

[3] The White House, *Joint Statement on Parameters on Future Reductions in Nuclear Forces*, Office of the Press Secretary (Helsinki, Finland, March 21, 1997), available at . https://clintonwhitehouse6.archives.gov/1997/03/1997-03-21-joint-statement-on-reductions-in-nuclear-forces.html.

[4] 2000 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Final*

The Conference also welcomed the efforts of several States to:

> "cooperate in making nuclear disarmament measures irreversible, in particular, through initiatives on the verification, management and disposition of fissile material declared excess to military purposes."[5]

The importance of irreversibility in nuclear disarmament was underscored again in the Final Document of the NPT Review Conference of 2010. Even though there are many references to irreversibility, there is neither a unified use of the word in relation to nuclear disarmament, nor a common understanding of how to establish a comprehensive framework that will ensure irreversibility. According to the dictionary definition, irreversibility is something that cannot be "undone" or "altered," where it is "impossible to return to a previous condition."[6] These traditional definitions of irreversibility are not well suited in the context of nuclear disarmament, because all nuclear disarmament steps are in principle reversible, as it will never be physically *impossible* for a former nuclear weapons State to re-arm, either with the same materials used again, or producing new materials from scratch.[7] It is extremely difficult to be certain that disassembled warheads will never be reassembled, and that all fissile material is rendered useless for future use in nuclear warheads. It will not least demand very encompassing and reliable verification measures by third actors and transparency measures by the disarming party. All this brings formidable challenges for future IPNDV work.

As stated in the introduction and specified above, *irreversibility* often appears in connection with transparency and verification. The link between the three concepts is tight, but the principle of irreversibility is without doubt the least discussed among the three concepts. Many scientists and researchers have tried to develop a generally agreed definition of the term, but this has been difficult because the word can have a different meaning in a different context. Some definitions focus primarily on technical aspects of irreversibility, whereas other definitions emphasize the legal, political, or normative aspects of irreversibility.

It also follows that irreversibility cannot be viewed in isolation from the broader political environment. In a tense political climate, the threshold would be higher for considering disarmament steps taken by the other side if the steps are not sufficiently irreversible.

Different Approaches to Irreversibility

In nuclear disarmament, irreversibility is often associated with the *fissile material* extracted from warheads, and the available measures to control and prevent the fissile material from being re-used in weapons.[8] Most definitions have this as a common basis. However, it is also relevant to

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Document, Volume I, available at https://www.un.org/disarmament/wmd/nuclear/npt2000/final-documents.

[5] Ibid.

[6] Oxford Living Dictionaries and Cambridge Dictionary, s.v. "irreversibility." This was also emphasized in the report by David Cliff, Hassan Elbahtimy, and Andreas Persbo, *Irreversibility in Nuclear Disarmament: Practical Steps against Nuclear Rearmament* (VERTIC, September 2011).

[7] Cliff, Elbahtimy, and Persbo, *Irreversibility in Nuclear Disarmament.*

[8] NTI, *Innovating Verification: New Tools & New Actors to Reduce Nuclear Risks: Verifying Baseline Declarations of*

point out—as is the cases mentioned above related to existing disarmament treaties such as the START I—that irreversibility also relates to nuclear warheads.

One of the early definitions of irreversibility in nuclear disarmament is found in a non-paper sent from the United States to Russia in 1994, in relation to a joint working group on "Safeguards, Transparency and Irreversibility" (STI) where irreversibility was referred to as follows:

> "The measures should build each side's confidence that the nuclear arms reductions being carried out are irreversible, and in particular that fissile materials declared excess to military needs (including civilian weapons-usable material) are not being used to build new nuclear weapons."[9]

This definition is narrow in the sense that it focuses mainly on *existing* fissile material removed from warheads, without considering the nuclear infrastructure that could potentially produce new fissile material for new nuclear weapons.

The Nuclear Threat Initiative's (NTI) 2014 study introduced a definition of irreversibility as follows:

> "the quality or state of not being able to be reversed." [10]

The study distinguishes between legal, physical, and political irreversibility. *Legal irreversibility* is achieved when a State makes "a legally binding commitment not to use particular material in weapons again."[11] The study further underscores that verification measures can contribute to ensuring that the legal commitments are honored. *Physical irreversibility* is achieved when it is "physically difficult and costly to recover material for use in weapons." This is exemplified with the down-blending of highly enriched uranium (HEU) to low-enriched uranium (LEU) or using plutonium in mixed oxide fuel (MOX). *Political irreversibility* is achieved when a State makes "a political commitment not to return particular material to weapons use." A combination of these three measures would bring a State further toward irreversibility in nuclear disarmament.

The Verification Research, Training, and Information Centre (VERTIC) in 2011 did a comprehensive study on irreversibility where irreversibility was considered in light of:

> "the costs and difficulty of reversal."[12]

This study looked at irreversibility as a scale instead of an absolute value, where States would move up or down the irreversibility scale depending on different measures implemented. A high degree of irreversibility would mean that it would be costly, difficult, and time-consuming to reverse the actions. The question is *how high* the cost of reversal should be, and how difficult, time-consuming, and likely to be detected by the international community, in order to recognize

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Nuclear Warheads and Materials" (Washington, DC: NTI, July 2014).

[9] U.S. Department of Energy, *Transparency and Verification Options*.

[10] NTI, *Innovating Verification*.

[11] Part of the definition of "legal irreversibility" NTI derived from the U.S. Department of Energy, *Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives*, DOE/NN-0007 (Washington DC: DOE, 1997).

[12] Cliff, Elbahtimy, and Persbo, *Irreversibility in Nuclear Disarmament.*

a disarmament process as irreversible. VERTIC's study focused mainly on the practical and technical dimensions of irreversibility in nuclear disarmament.

The Stockholm International Peace Research Institute (SIPRI) in 2011 introduced the political, societal, legal, and military-technical dimensions of irreversibility.[13] The political dimension focused on the national discourses inside the States, while the societal dimension focused on establishing a general norm against the use of nuclear weapons and to increasing the knowledge level through education programs to strengthen this norm. The legal dimension focused on the importance of multilateral processes and of expanding the legal framework "to go beyond international public law" and to "incorporate international humanitarian law, international criminal law and national criminal law" into this framework.[14] The last dimension focused on the military-technical aspects of irreversibility in nuclear disarmament. According to SIPRI, all four aspects would have to be considered in order to preventing backsliding and ensuring irreversible disarmament.

Some scholars, including researchers from VERTIC, stress the importance of distinguishing between States' current nuclear arsenal on the one hand and the supporting infrastructure on the other.[15] As long as the supporting nuclear infrastructure remains, there is no guarantee of irreversibility. SIPRI refers to this as the narrow and broad approaches to irreversibility. Whereas the narrow approach focuses on practical measures regarding the fissile material extracted from one specific warhead, the broad approach includes all stocks and other facilities capable of producing new material for new weapons.[16]

Despite the fact that there is no universally accepted definition of irreversibility, most experts agree that irreversibility will be essential in all future nuclear disarmament treaties. It can, however, be said that as a minimum there seems to be a general understanding among experts that irreversibility in most cases is associated with the fissile material extracted from warheads.

Irreversibility before Zero or After?

VERTIC's irreversibility scale was developed mainly to address situations where the nuclear disarmament had already taken place and no weapons remained. In IPNDV it can be useful to look at irreversibility as a broader term that also has relevance and validity in the *process* toward nuclear disarmament. It is desirable to implement measures early in the process to set the standard for agreements to come and prevent re-armament at a later point in time. A previous IPNDV paper proposed four disarmament categories that are relevant in this regard:

(1) Reduction in nuclear weapon numbers

(2) Limitations on nuclear weapon numbers

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[13] Ian Anthony, *Irreversibility in Nuclear Disarmament—Political, Societal, Legal and Military-Technical Aspects,* (SIPRI, 2011).

[14] Ibid.

[15] Cliff, Elbahtimy, and Persbo, *Irreversibility in Nuclear Disarmament.*

[16] Ian Anthony, *Irreversibility in Nuclear Disarmament*.

(3) Reaching global zero

(4) Maintaining global zero

The principle of irreversibility might have relevance in all these phases. However, the more strategically significant the advantage gained by breaking an agreement, the more notice States will want of this happening. In addition, the lower the number of nuclear weapons, the more significant that advantage would generally become. Following this line of thinking, irreversibility demands that verification mechanisms are designed to signal non-compliance at different stages. Even in category 4 this question will be relevant, as all States—even in a world of global zero—would not necessarily be equal. Scott Sagan has argued that the former nuclear weapon States (NWS) will always have an advantage compared to others because of the technological expertise and operational experience they possess, making them what he calls "more latent" than others even after the disarmament has taken place.[17] In a similar way, non-nuclear weapon States (NNWS) with advanced nuclear knowledge and industry will have an advantage compared to NNWS with no nuclear infrastructure. They would all be engaging in "nuclear hedging"—although maybe with different breakout times.

Cases and Lessons Learned

The list of real world cases is not long, but there are some cases to draw lessons from where irreversibility has been more or less successful. Building on past experiences and lessons, such as the Trilateral Initiative, the PMDA, and dismantlement of the facilities in Pierrelatte and Marcoule, gives an opportunity not to start with a blank slate.

Trilateral Initiative

The Trilateral Initiative between the United States, Russia, and the IAEA still represents one of the most important efforts of achieving irreversibility in nuclear disarmament. The initiative, running from 1996 until 2002, tried to develop a legal framework and a technical verification system where the IAEA would carry out verification on classified weapon-origin fissile material in the two countries, without the inspectors gaining access to sensitive information about the weapons design or construction and complying with NPT obligations. By using an information barrier system, the inspectors would be able to verify an object by comparing it to some reference characteristics. Additionally, the initiative also included the irreversible destruction of non-nuclear explosives during the dismantlement process.

The initiative is of continued interest. In the final document of the 2000 Review Conference it was highlighted that the completion and implementation of the Trilateral Initiative was an important effort of implementing article VI of the NPT.[18] Many scientists have suggested to use

[17] Scott D. Sagan, "Shared Responsibilities for Nuclear Disarmament" in Scott D. Sagan et. al, *Shared Responsibilities for Nuclear Disarmament: A Global Debate* (Cambridge, Massachusetts: American Academy of Arts and Sciences, 2010), 12.

[18] 2000 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Final Document*.

the Model Verification Agreement developed by the parties in the Trilateral Initiative as a basis for future agreements between the IAEA and other States.[19]

PMDA

The United States-Russia Plutonium Management and Disposition Agreement (PMDA) focuses on disposition of excess plutonium. The PMDA requires conversion to oxide, followed by mixing with other material and burning in a reactor as mixed oxide fuel (MOX). However, this agreement has run into trouble in part because of the unexpectedly high cost of this treatment.[20]

Pierrelatte and Marcoule

The main French enrichment plant for HEU for weapons purposes was in the town of Pierrelatte in the south east of France. When this facility was closed in 1996, the French government started a dismantlement process, and the physical work on dismantlement of the facilities was started in 2002.[21] France also had three plutonium-producing reactors and a reprocessing plant located in Marcoule south of Pierrelatte. The first phase of dismantling these reactors has been carried out, while the second phase is scheduled for 2020–2035. Dismantlement of the reprocessing plant started in 1997 and will last until 2035.

France presented Working Papers to the NPT Review Conference in 2010 on the dismantling of plants for the production of fissile material for nuclear weapons and the dismantling of the Pacific Testing Centre. Both cases are described as being done in an irreversible and transparent manner, and can be seen as good examples of political commitment to irreversibility with additional transparency measures but without any legal requirement for verification.

A Combination of Irreversibility Measures

As can be seen from the examples above, irreversibility measures have, to a limited extent, already been implemented in different contexts for nuclear weapons. The disarmament treaties between the United States and Russia are furnished with declarations on irreversibility. The treaties themselves contain provisions on physical and legal irreversibility attached to the weapons systems that are abolished under a verification regime. The Trilateral Initiative and the PMDA have in general aimed at providing legal and physical irreversibility for the amounts of plutonium that the United States and Russia were willing to retrieve from their weapons programs. The measures of irreversibility at Pierrelatte and Marcoule are of a political nature and exist in the shape of declarations from the French authorities.

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[19] See for example Thomas E. Shea and Laura Rockwood, "Nuclear Disarmament: The Legacy of the Trilateral Initiative," DeepCuts Working Paper, No. 4 (March 2015).

[20] See for instance Pavel Podvig, "Can the U.S.-Russia Plutonium Disposition Agreement Be Saved?" *Bulletin of the Atomic Scientists* (April 28, 2016).

[21] "Dismantling of Plants for the Production of Fissile Material for Nuclear Weapons," Working Paper submitted by France, presented at the 2010 Review Conference of the Parties to the NPT, NPT/CONF.2010/WP.37 (April 12, 2010).

Adequate Irreversibility

It could be an idea to focus on the term *adequate irreversibility* instead of total irreversibility. Adequate irreversibility would be achieved when the country cannot reverse its commitment without the observing countries being made aware of the country's intentions, significantly before the reversal achieves any major strategic benefit for the country. This will make irreversibility rely on very substantial and robust verification measures. This should cover, but not necessarily be limited to, the fissile material component of the nuclear weapons.[22] The fissile material should be subject to monitoring until it is rendered useless for future use in nuclear weapons.

As with the term irreversibility, adequate irreversibility could have a different meaning in a different context. Because the definition is closely tied to the *commitment,* not focusing on either stockpile size or warhead destruction, the definition is relevant both in the context of arms control and nuclear disarmament. Agreeing to measures providing adequate irreversibility can also contribute to reducing the costs of implementing verification measures.

Measures Providing Adequate Irreversibility

As underscored by the NTI study, irreversibility—or adequate irreversibility as we suggest—is achievable through a combination of legal, physical, and political measures. The road to irreversibility is not necessarily a systematic process, but rather a number of standalone measures that in combination can lead to adequate irreversibility. The relevance of the various measures will differ significantly depending on the circumstances and purposes, but as a start, a good balance between the legal, physical, and political measures is vital. The level of irreversibility can increase or decrease over time depending on the measures implemented.

Effectiveness is generally about whether a party to an agreement has *adequate* confidence in the compliance by other parties.[23] It is not possible to verify all measures of irreversibility. It would not be practical, nor is it desirable or necessary. *Verification* refers to the control mechanisms carried out to verify the correctness and completeness of the information provided by a State. *Correctness* is about the inspecting party being able to verify the correctness of the declared information, while *completeness* is a conclusion about the absence of undeclared nuclear material or activities.

Political measures of irreversibility are not easily verifiable. A State can make a political commitment not to return particular material to weapons use, but the credibility of political intentions can be disputed. Nuclear postures, for instance, are not immutable but may shift over time. Transparency measures can be seen as an important way to build confidence in political

[22] Destruction of other key components, such as high explosives, could be problematic in real life given the military conventional uses of such components and the fact that components are outside normal NNWS safeguards.

[23] IPNDV WG1 Deliverable 1, *A Framework Document with Terms and Definitions, Principles, and Good Practices* (November 2017): https://www.ipndv.org/reports-analysis/deliverable-one-principles-nuclear-disarmament-verification-key-steps-process-dismantling-nuclear-weapons-14-step-diagram/

commitments. Political measures are still important in ensuring irreversibility, especially in combination with legal and physical measures.

Legal measures of irreversibility are less changeable compared to political measures, but easier to verify. There are several historical examples of the verification of legal measures, such as the Trilateral Initiative where a legal framework and a technical verification system was developed (although so far not implemented) to verify weapon-origin fissile material.

The *physical measures* of irreversibility are usually more practical or technically oriented, focusing on specific barriers to preventing the fissile material from being re-used in weapons. As an example, VERTIC in 2011 developed a scale of irreversibility consisting of five levels of irreversibility.[24] The scale focused on the practical and technical aspects of nuclear disarmament. At the lower levels 1–2, which entailed the disarmament of warheads, it would be quite easy to re-arm. In the higher levels 3–5, which also entailed measures to prevent States from producing new warheads from new fissile material, it would be significantly more difficult and costly to re-arm.

It is crucial to have a reliable and transparent verification mechanism. However, no such verification mechanism can guarantee with 100 percent certainty that a State never will re-arm. In fact, it will always be possible to produce new fissile material for new nuclear weapons as long as nuclear production facilities exist. Therefore, a combination of legal, political, and physical measures can contribute to an *increased level* of irreversibility—or adequate irreversibility—and to a *timely discovery* of non-compliance, early enough so that no major strategic benefits have been achieved. It also follows that the general political environment must be sufficiently conducive to allow a common understanding on what would constitute adequate irreversibility. It might be helpful to apply these considerations to all 14 steps of the dismantlement and disarmament process that has been analyzed and discussed during the IPNDV Phase I process.

[24] Cliff, Elbahtimy, and Persbo, *Irreversibility in Nuclear Disarmament.*

About IPNDV: The International Partnership for Nuclear Disarmament Verification

The International Partnership for Nuclear Disarmament Verification (IPNDV), is an ongoing initiative that includes more than 25 countries with and without nuclear weapons. Together, the Partners are identifying challenges associated with nuclear disarmament verification, and developing potential procedures and technologies to address those challenges. Learn more at www.ipndv.org.

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