Phased Irreversibility in Nuclear Disarmament

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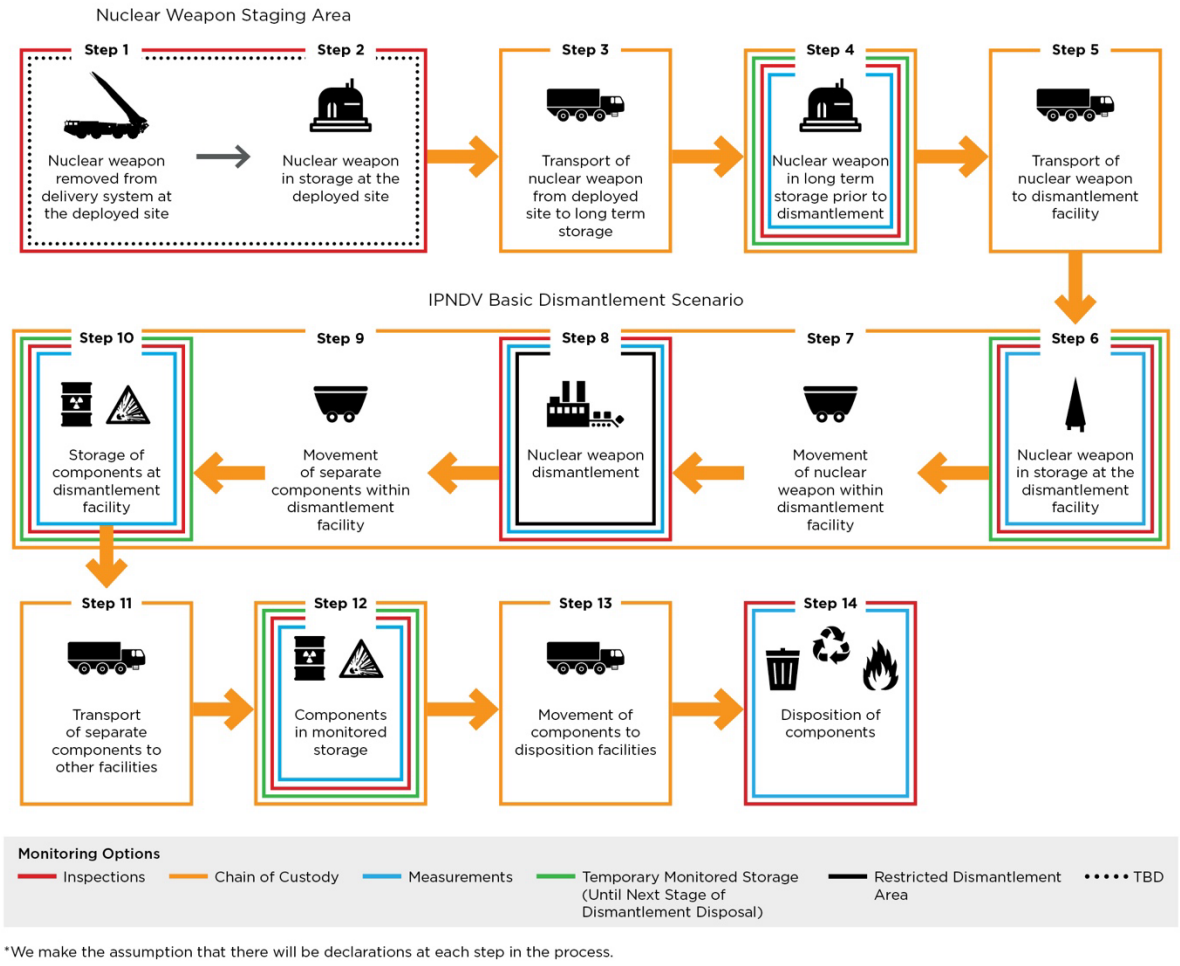
The concept of "irreversibility" is central to any credible and sustainable effort to achieve and maintain a world free of nuclear weapons. In the case of nuclear weapons, this concept applies both at the micro- and the macro-levels. At the micro-level, irreversibility focuses on dismantling a single nuclear weapon and ensuring its components can never be reassembled to form another nuclear weapon. At the macro-level, irreversibility refers to a state permanently dismantling its nuclear weapons enterprise (NWE) and then maintaining that status. In turn, analyzing irreversibility at the micro- and macro-levels makes clear that no one final, conclusive end-state of irreversibility exists but a spectrum of increasingly comprehensive levels of irreversibility that will accompany the process of nuclear disarmament. This is referred to as phased irreversibility.

The International Partnership for Nuclear Disarmament Verification (IPNDV) began its efforts by conducting a systematic analysis of various arms control agreements to identify the processes, procedures, techniques, and technologies that permit effective verification. Effective verification in turn provides states with sufficient confidence that other states are in compliance with their nuclear disarmament obligations. The Partners identified verification mechanisms that could effectively verify nuclear weapons dismantlement taking into consideration the unique safety, security, and non-proliferation requirements present in the dismantlement of nuclear weapons. This increases confidence in irreversibility at the micro-level.

The IPNDV's 14-step dismantlement model provides a visual depiction of how this concept of phased irreversibility lives on a spectrum and must be viewed from several perspectives rather than a single "final" state.

Figure 1: IPNDV 14-Step Process for Dismantling Nuclear Weapons



*We make the assumption that there will be declarations at each step in the process.

Verification needs change along with the number of nuclear weapons being dismantled (i.e., as an arsenal moves to smaller and smaller numbers). Moreover, the IPNDV recognized that verification and confidence in irreversibility of disarmament are inextricably linked. This paper discusses how differing verification requirements affect the overall concept of irreversibility in various phases of disarmament. The conclusion is that, although absolute irreversibility is not possible, robust verification measures can achieve effective irreversibility by making it too costly for a state to reverse its disarmament actions.

In its initial effort to define irreversibility, the IPNDV focused on what elements needed to be in place to permit states to be reasonably confident that nuclear disarmament could not easily be reversed. This "end-state" included the following elements:

- Removal of fissile material from ***all*** nuclear weapons

- Declassification[1] of ***all*** removed fissile material
- Transfer of declassified fissile material to a safeguards-like regime
- Complete elimination of ***all*** military grade fissile material production facilities (can include physical destruction or redirection to peaceful uses under safeguards)
- Redirection of all staff associated with fissile material and weapons production

Recognizing that this "end-state" will take many years to achieve, it is important to recognize that this reality is born out of the complexity of nuclear weapons dismantlement. Against this background, rather than seeing irreversibility only as one final "end-state," it may be more productive to acknowledge it as a "spectrum" that varies as the process of disarmament advances. Moreover, it should further be acknowledged that even when a state completely eliminates its NWE, there will remain a latent capability in the form of knowledge of nuclear weapons. Given this, there will always remain a possibility that a state may reverse course and re-develop its NWE, leaving open the notion that the irreversibility spectrum partially persists even after the eventual achievement of zero. To this end, establishing an organization that focuses on ongoing verification of still classified fissile material, as well as the process of its declassification and final disposition, is an option that could be considered to maintain confidence in the maintenance of zero.

Irreversibility Spectrum

Reductions Phase: Micro-Level Irreversibility

Given the many steps involved in nuclear disarmament, it will take many years to achieve complete zero; however, each step can be viewed as a contributor to the final "end-state" of irreversibility. Given the strategic value of nuclear weapons, a state will likely begin with gradual reductions of their arsenals rather than move toward complete elimination. This is the "reductions" phase. During this phase, it can be expected that given the need to maintain a specified number of nuclear weapons, nuclear weapons delivery systems, fissile material production facilities, stockpiles of fissile material, and the scientists associated with the weapons program will remain. The state still has nuclear weapons, and remains capable of producing more. But this phase is critical for building trust among the disarming states that each is abiding by their disarmament obligations, thus sowing the political and security seeds for further reductions, and eventual elimination of all nuclear weapons. It also helps to increase trust among non-nuclear weapons states by demonstrating that tangible progress is being made in disarmament. To this end, it is important to highlight that dismantlement on the irreversibility spectrum is based on the premise that once a state has elected to dismantle a nuclear weapon, it begins a sequence that makes it difficult for that weapon to ever be reassembled in the future. Additionally, it permits the verification regime to demonstrate that it is capable of verifying that the nuclear weapons identified for elimination have been removed from the stockpile, and not

[1] In this instance, "declassified" refers to fissile material that has lost the characteristics that are considered sensitive (proliferation significant) to nuclear weapons states.

returned, thus confirming the reduction and maintenance of the agreed upon number of weapons permitted in the reduction phase. On this "spectrum," irreversibility is at the micro-level—that the specified number of nuclear weapons has been eliminated and permanently removed from the stockpile. The spectrum changes as a state approaches and achieves zero nuclear weapons.

Toward Zero: Phased Irreversibility

As a state nears and then achieves zero nuclear weapons, a whole series of actions is taken leading to effective irreversibility. These include things like dismantling nuclear weapons delivery systems, perhaps at a faster rate, eliminating or redirecting fissile material production facilities to peaceful uses, removing and declassifying special nuclear material from nuclear weapons that would permit rigorous verification, and redirecting nuclear weapons scientists and technical staff to non-weapon applications of nuclear science.

The methodology of the Cooperative Threat Reduction program[2] is one example of past efforts whose lessons learned can be used in any future efforts. Note that the redirection of nuclear scientists would likely fall outside the scope of any verification regime associated with a disarmament agreement. Yet again, none of these elements can be expected to occur quickly or simultaneously. Knowledge of nuclear weapons production cannot be easily forgotten or erased, and fissile material will take years to either be treated in a manner that renders it practically useless for nuclear weapons (such as downblended or vitrified), disposed of or declassified. Moreover, the dismantlement process will take years, with only a finite number of weapons being able to be dismantled per year, leaving a number of nuclear weapons in storage for several years.

The concept of phased irreversibility gives options that, despite the presence of key elements of a nuclear weapons program, can still contribute to confidence that a state is in compliance with its nuclear disarmament obligations. This involves actions under an agreement to dismantle existing capabilities and putting in sufficient barriers coupled with rigorous verification to make it too technically, financially, and/or politically costly to reconstitute a previously dismantled nuclear weapons capability. Such actions can include destroying all nuclear weapons delivery systems, regulating dual-use systems like space launch vehicles and fissile material production facilities while putting in place sufficient verification over the storage facilities containing nuclear weapons and associated components awaiting dismantlement/final disposition to detect clandestine diversion. Using multiple barriers demonstrates that irreversibility is a cumulative process, employing a "defense-in-depth" approach. This can include eliminating the high explosives and non-nuclear components that make up nuclear weapons and monitoring the country's defense strategies and military spending to see if it reflects a state's commitment to irreversibility, or to maintaining a hedge capability. Although the latter is also beyond the scope of any nuclear disarmament agreement. These barriers can provide a sufficient level of confidence that the verification regime will detect any diversion even beyond the complete elimination of a state's nuclear enterprise.

[2] See Defense Threat Reduction Agency, "Cooperative Threat Reduction Cooperative," https://www.dtra.mil/About/Mission/Cooperative-Threat-Reduction/.

Maintaining Zero: Effective Irreversibility at the Macro-Level

The Treaty on the Non-Proliferation of Nuclear Weapons recognizes that so long as peaceful nuclear energy programs exist, the possibility of their misuse endures. But in the same manner that the International Atomic Energy Agency provides assurance that non–nuclear-weapons states are not pursuing nuclear weapons, so too can a rigorous nuclear disarmament verification regime. Although the idea of complete irreversibility is not possible, we should focus on the concept of "adequate irreversibility."

Adequate irreversibility involves putting in place verification mechanisms sufficient to ensure a states' actions to reverse their disarmament efforts would be detected in time to deny them the advantage of that reversal. Key elements that are required to permit "phased irreversibility" that can contribute to "adequate irreversibility" include:

- Nuclear disarmament agreements that clearly define key milestones or phases of disarmament, permitted verification mechanisms, and means for addressing compliance concerns.
- Effective verification at all stages in the disarmament process. Relevant facilities, systems, and capabilities need to be held at risk of detection to ensure any attempts at cheating are detected in a timely manner.
- Costs, both technically, economically, and politically, must be so high that it becomes impractical for a state to cheat.
- Effective disarmament and regulation of supporting infrastructure such as delivery systems (including and dual-use capabilities) needed for nuclear rearmament.

Conclusion

Confidence in the irreversibility of nuclear disarmament is achievable but will take considerable time and involve many steps. Nuclear disarmament is complex and involves unique safety, security, and non-proliferation concerns that other arms control initiatives do not face. It is further subject to political and strategic forces that will determine both when disarmament may begin, and for how long it will be maintained. In thinking about irreversibility, it is important to recognize that a spectrum of irreversibility linked to the nuclear disarmament process exists. Effective verification at all stages of the dismantlement process can build confidence that nuclear weapons are being eliminated. As disarmament advances toward eliminating all nuclear weapons, confidence in states' commitment to irreversibility can best be demonstrated by developing nuclear disarmament agreements with robust and effective verification regimes. Even if elements of a nuclear weapons program initially remain, effective verification and associated barriers impede diversion of nuclear weapons or production of new ones. In a disarmed world, effective verification measures can provide adequate confidence that any reversal could be detected in sufficient time. This in turn builds confidence that effective irreversibility is being achieved all along the road to zero.

About IPNDV the International Partnership for Nuclear Disarmament Verification

The International Partnership for Nuclear Disarmament Verification (IPNDV) convenes countries with and without nuclear weapons to identify challenges associated with nuclear disarmament verification and develop potential procedures and technologies to address those challenges. The IPNDV was founded in 2014 by the U.S. Department of State and the Nuclear Threat Initiative. Learn more at www.ipndv.org.