Working Group 4 Deliverable
Part IV. Detailed Analyses of Various Aspects of Verification of Declarations

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Paper 1. Categorization of Nuclear Weapons

Working Group 4: Verification of Nuclear Weapons Declarations

June 2019

Abstract

This paper presents how nuclear weapons may be categorized according to

- Weapons technology;
- Intended use;
- Means of delivery;
- Operational status; or
- Names or model designations.

The relevance for nuclear disarmament verification of each method of categorization is discussed.

Introduction

Many different ways and many different terms are used to characterize nuclear weapons. Some may be relevant to nuclear disarmament verification, others most likely not. Some characteristics may be impossible to verify due to proliferation concerns. This paper provides a short overview of the terminology.

In Phase I of the IPNDV, a "nuclear explosive device" was defined simply as a device containing both weapons usable fissile materials and high explosives. For Phase II, the official P5 definition may be more appropriate: A "nuclear weapon" is a "weapon assembly that is capable of producing an explosion and massive damage and destruction by the sudden release of energy instantaneously released from self-sustaining nuclear fission and/or fusion."[1]

Nuclear weapons may be categorized in multiple ways according to weapons technology, intended use, means of delivery, and operational status, as well as by their actual names or model designations. This is discussed below.

How an inspector can be become confident that the system being verified is indeed of a specific, uniquely identified type, is a further question beyond the scope of this paper. Verifying

[1] P5 Working Group on the Glossary of Key Nuclear Terms: *P5 Glossary of Key Nuclear Terms*, China Atomic Energy Press, Beijing, April 2015, https://2009-2017.state.gov/documents/organization/243293.pdf.

that two systems are of the same type, based on measurable characteristics and supporting information as described throughout the paper, is more straightforward to accomplish.

Categorization According to Weapons Technology

Basic nuclear physics describes two different ways of releasing energy from atomic nuclei: “fission” (splitting) of heavy nuclei or “fusion” (merging) of light nuclei.

The early nuclear weapons were all fission weapons in which the fissile material, that is, uranium and/or plutonium of suitable quality, undergoes a very rapid fission chain reaction. Fissile material emits alpha and gamma radiation, the former is stopped by any kind of casing and is therefore irrelevant for nuclear disarmament verification, but the latter, especially gamma radiation from plutonium, will get through substantial layers of material and may therefore be of interest to disarmament verification inspectors.

There are two different types of nuclear weapons making use of fission: gun-type assemblies and implosion weapons. The type used in a given weapon may affect how and where the inspectors make their measurements.

Fusion weapons are also known as thermonuclear weapons. The fusion process requires large amounts of energy to begin, which is provided by first setting off a fission charge. Fusion weapons are therefore often referred to as two-stage weapons because each weapon contains two charges, a primary (fission) stage and a secondary (fusion) stage. The primary stage will contain fissile material as described above and may be of use for nuclear disarmament verification inspectors. Very little official information about the secondary stage has been made available to the public.

Basic nuclear physics limits the yield (the released energy) of a fission weapon, while in principle the yield of a fusion weapon is almost unlimited. The physical characteristics of nuclear weapons will, to some extent, depend on the technology used in a given weapon. However, this is hard to generalize because weight and shape also depends heavily on intended use of the weapon, engineering sophistication, yield, etc. Some weapons have been several meters long and weighed several tons, whereas other weapons could be launched by artillery guns.

Some knowledge of the technology applied in a given weapon is essential for nuclear disarmament verification purposes because this determines what possible radiation may be detected and which methods may or must be used in the verification process. Physical characteristics such as shape and dimensions of the outer casing may provide supporting verification information. Relevant technical information can only be provided by the weapons owner, for example as part of the declaration process.

Categorization According to Intended Use

This categorization divides all nuclear weapons into one of two possible categories: strategic nuclear weapons and non-strategic nuclear weapons. The dividing line between the categories is rather fuzzy. As the names imply, strategic weapons are intended to play a role in the bigger picture with deterrence and power balance, whereas non-strategic nuclear weapons may play a more operative role. Depending on their deployment, the same weapon systems could in many cases have either a strategic or a non-strategic function. Furthermore, for one State, strategic balance may be measured relative to its neighbor, while for another State, global balance may be the most important.

Several definitions exist of strategic and non-strategic nuclear weapons. However, the only usable definition seems to be the simple one stating that a strategic nuclear weapon is any weapon covered by a strategic arms control treaty. This definition applies only between the United States and Russia, although China also considers its longer-range weapons to be strategic nuclear weapons. Other States possessing nuclear weapons may have different views on what constitutes a "strategic weapon"; for example, if a nuclear weapon is capable of hitting the territory of a given State, the States in question may consider that weapon to be strategic regardless of its range.

"Non-strategic nuclear weapons" are often referred to by numerous other names such as "tactical nuclear weapons," "sub-strategic nuclear weapons," "battlefield nuclear weapons," or "theater nuclear weapons." There are no strict definitions of these terms; they could refer to yield, delivery vehicle, intended use, or other criteria, but again very similar systems in different States are likely to be defined differently. For example, in the United States, there is a differentiation between battlefield or tactical nuclear weapons and theater nuclear weapons, which are related to both range and intended use.

Whether a specific nuclear weapon is considered strategic or not should be of little or no importance to nuclear disarmament verification because the tools and procedures applied would be largely independent of the intended use of the weapon.

Categorization According to Means of Delivery

Many ways exist for delivering nuclear weapons to their intended point of detonation. At the highest level, all nuclear weapons would fall into one of three general categories classified by where the delivery systems are based: ground-launched, sea-launched, or air-launched/air-delivered. Space-based nuclear weapons, although possible, are not considered in this paper because they are prohibited by the widely accepted Outer Space Treaty,[2] which entered into force in 1967.

Ground-launched nuclear weapons include ground launched ballistic missiles (GLBMs) and ground launched cruise missiles (GLCMs) as well as artillery shells and landmines with nuclear

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[2] Formally known as the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies,* http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

charges. Many different types of ballistic missiles have been developed for different purposes. They have been designed to carry different weights over different ranges, and they use different propellants. They are often subcategorized according to range, for example as shown in the Table IV-1-1 below:

Table IV-1-1. Missile Subcategories and Ranges

Subcategory	Acronym	Range
Close range ballistic missile	CRBM	Less than 300 km
Short-range ballistic missile[a]	SRBM	300–1000 km
Medium-range ballistic missile[a]	MRBM	1,000–3,000 km
Intermediate-range ballistic missile	IRBM	3,000–5,500 km
Long-range ballistic missile	LRBM	
Intercontinental ballistic missile	ICBM	Greater than 5,500 km

[a] SRBM and MRBM may be combined to the term "theatre ballistic missile" (TBM) (range between 300 km and 3,000 km).

As an example of the lack of standardization of these terms, one may observe that the 1987 Intermediate-Range Nuclear Forces Treaty (INF Treaty)[3] defines an "intermediate-range missile" to have a range of 1,000–5,500 km and a "shorter-range missile" to have a range of 500–1,000 km. (This remains a non-standard definition of short range, however; the MTCR[4] definition of 300 km as the lower limit appears to have gained greater credence.)

Both GLBMs and GLCMs may be launched from fixed launchers (such as missile silos) or from mobile, land-based transporter-erector-launchers (TELs).

Many ballistic missiles are equipped with multiple re-entry vehicles (MRVs) or multiple independently targetable re-entry vehicles (MIRVs); thereby each containing several nuclear warheads. The term "nuclear warhead" is therefore often used for general bookkeeping purposes instead of the term "nuclear weapon," even though the term "warhead" is defined conventionally as referring only to the explosive elements delivered by a missile.

Sea-launched nuclear weapons include ballistic missiles and cruise missiles as well as torpedoes, depth charges, and mines equipped with nuclear charges. These weapons may be launched from surface vessels or submarines. The terms "SLBM" and "SLCM" are used somewhat ambiguously. They are often taken to mean submarine-launched ballistic missile and submarine-launched cruise missile, respectively, but "SL" could also be read as "sea-launched" or "ship-launched." For example, the United States generally uses SLCM to mean a sea-launched cruise missile regardless of whether it is launched from a ship or from a submarine. However, sometimes the term "ShLCM" has been used to specify a "ship-launched cruise

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[3] Formally known as the *Treaty between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate-Range and Shorter-Range Missiles,* https://www.state.gov/inf.
[4] MTCR is short for Missile Technology Control Regime, which is a multilateral export control regime for missile technology.

missile." Sea-launched ballistic missiles may be further subcategorized according to range as described above for ground-launched ballistic missiles.

Air-launched nuclear weapons include air-launched ballistic missiles (ALBMs) and air-launched cruise missiles (ALCMs). Torpedoes may also be launched from aircraft. Air-delivered nuclear weapons are nuclear bombs that are dropped close to the intended point of detonation. Traditionally, these were unguided bombs, also known as gravity bombs, but modern bombs may be precision-guided bombs, also referred to as smart bombs, which include tail kits to improve the accuracy of the bomb.

The term "nuclear triad" is used when discussing nuclear weapon possessor States that deploy (strategic) nuclear weapons in all three general basing modes, that is, ground-launched ballistic missiles, submarine-launched ballistic missiles, and nuclear capable aircraft.

As far as nuclear disarmament verification goes, the techniques and technologies applied would be the same regardless of means of delivery. One useful aspect of describing systems this way, however, is that it provides inspectors with an approximate idea of what they are likely to encounter in the field. Consistency with regard to delivery vehicle, location, certain characteristics, etc. may help build confidence.

Access requirements to sites with different categories of nuclear weapons may vary, and hence the verification procedures will depend somewhat on the type of site the systems are on (naval bases, silos, mobile launchers, etc.). In summary, some information on means of delivery may be important regarding the practicalities of nuclear disarmament verification, but may not provide sufficient information on its own to identify weapon systems or individual weapons or warheads.

Categorization According to Operational Status

This categorization may be carried out in multiple ways. The discussion below first follows the approach used by the Status of World Nuclear Forces, a commonly quoted non-governmental organization (NGO)[5] and then presents the system used in the United States. Other nuclear weapon possessing states probably have similar categories for weapons in their stockpiles.

At the top level in the NGO categorization, all nuclear warheads are either part of the military stockpile, that is, they are in military custody earmarked for military use, or they are awaiting dismantlement, that is, retired, but still intact. In late 2018, roughly one-third of all warheads fell in the latter category.

The warheads in the military stockpile may be further subdivided into those that are deployed with operational forces and those that are non-deployed. According to the same NGO source, in late 2018, about 40 percent of the nuclear warheads in the military stockpiles were deployed.

[5] Hans M. Kristensen and Robert S. Norris, *Status of World Nuclear Forces*, Federation of American Scientists, Washington, https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/.

The deployed warheads may be subdivided into those that are on high alert (ready to be used on short notice) and those that are not.

Non-deployed weapons may be awaiting deployment, undergoing maintenance, or be kept in long-term reserve. Reasons for keeping a substantial number of nuclear weapons in reserve may be to ensure that the State can meet possible future geopolitical challenges and/or to safeguard against potential technical problems due to an aging arsenal.

In the U.S. categorization, all nuclear warheads are part of the military stockpile. This stockpile can be further divided into the active stockpile and the inactive stockpile. Weapons in the active stockpile are maintained to ensure that the military requirements for operational warheads are met. The inactive stockpile is composed of warheads retained in a non-operational status and can provide augmentation or replacement warheads to the active stockpile. These two categories can be further broken down into subcategories.

There are three subcategories in the U.S. active stockpile: active ready, active hedge, and active logistics. Active ready consists of warheads available for wartime employment planning. Active ready warheads can be loaded onto missiles or made available for use on aircraft within required timelines. Active hedge warheads are retained for deployment to manage technological risks in the active ready stockpile or to augment the active ready stockpile in response to geopolitical developments. Active logistics warheads are used to facilitate workflow and sustain the operational status of active ready or active hedge quantities. They may be in various stages of assembly.

The inactive stockpile is composed of inactive hedge, inactive logistics, and inactive reserve. The inactive hedge consists of warheads retained for deployment to manage technological risks in the active ready stockpile or to augment the active ready stockpile in response to geopolitical developments. Inactive logistics warheads are used for logistical and surveillance purposes; these warheads may be in various stages of disassembly. Inactive reserve warheads are retained to provide long-term risk mitigation. Warheads in this category are exempt from future refurbishment modifications or alterations.[6]

Warheads in some of the different categories may have different characteristics, but these would not be directly observable to the nuclear disarmament verification inspectors. Different categories of warheads may be stored in different locations.

In and of themselves the above categories do not add much verification value unless they are accompanied by further information as to what this means for the physical location or state of the warhead. If a deployed system refers to the system being mated with a delivery vehicle, this would be verifiable, and similarly if it refers to the system being at a specific location. The nuclear disarmament verification inspectors would most likely prefer to meet the warhead that is to be dismantled as close to its end of deployment as possible. This will increase their

[6] *U.S. Nuclear Warhead Stockpile*, briefing presented to the International Partnership for Nuclear Disarmament Verification, March 19, 2015.

confidence that the device that they are introduced to really is the warhead that it is claimed to be.

Categorization According to Names or Model Designations

This form of categorization is quite obvious and straightforward. All types of nuclear warheads and nuclear weapons have a name (for example, Little Boy or Blue Danube) and/or an alphanumeric model designation (for example, B61, Mk53, W78, or WE177). Warheads of the same general model may also have different modifications that can further differentiate the warhead or bomb. For example, the B61 gravity bomb has appeared in several different modifications to enable different uses or to increase its safety, security, and reliability (identified as B61-1, B61-2, etc.). The differences represented by the modifications may or may not be observable for a nuclear disarmament verification inspector.

Furthermore, one would expect each individual warhead or bomb to be identified by a unique serial number.

In the field of nuclear disarmament verification, these designations are important for bookkeeping purposes. It is important to uniquely identify each object under verification in ways that are meaningful to all participating parties.

Conclusion

In this paper, we have presented five independent ways of categorizing nuclear weapons according to:

(1) Weapons technology;

(2) Intended use;

(3) Means of delivery;

(4) Operational status; and

(5) Names or model designations.

In principle, any nuclear weapons may be described by terms from all of these five categorization systems. In the earlier sections of this paper, we have discussed the relevance of each of the different systems to nuclear disarmament verification.

Paper 2. Evaluating Confidence in Compliance: Methods to Evaluate Random Selection Approaches and Confidence Building Statistics

Working Group 4: Verification of Nuclear Weapons Declarations

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Abstract

The measurement or quantification of confidence is a complex problem; first because confidence is a perception and as such is subjective by nature, indicating that even with the pertinent information, confidence may differ between evaluators; and second, because although one may want to collect all information, the practicalities of the real life limitations of resource constraints (number of inspectors that are both available and trained), time (the amount of time that is agreed in the treaty for the inspector's access to the sites), access constraints (host safety or security restrictions that limit access or restrict inspection activities in specific environments), and ultimately the cost of conducting an inspection overall. Because of these things, it is necessary to layer various different tools to not prove confidence, but instead provide evidence that can be used by assessors to bolster their perception of confidence. The existence of these real-life limitations suggests that although the inspectorate might want all to collect all information to provide enough confidence, realistically, the reality of those limitations make it such that random selection poses a more reasonable option.

Although random selection is a strong measure by itself, mechanisms exist to augment it by identifying tools and applications that, when applied to random selection, can create an effective and efficient approach for evaluating confidence. The three main levels at which confidence can be assessed are as follows: The first is at the single-item level: how confident can an inspector be about the compliance assessment of an item or its application given the current inspection tools? The second is at the multi-item level: how confident can an inspector be about a suite of tools or applications given the subset of items or the environments being inspected? The third and final level is at the systems level: across a site or a State, how confident can an inspector be about compliance across the entire regime based on the subset of inspection tools, applications sites, items inspected, based upon the known facilities and processes of a State? Because of subjectivity, mechanisms used to evaluate confidence must do so using very prescribed and consistent processes, designed in such a way to reduce the influence of personal perception to the greatest degree possible. Proposed approaches and their associated technical elements within a random selection regime can objectively produce

numerical data, creating quantitative tools to determine random selection inspection effectiveness in relation to the expected verification environment.

Using Random Selection

Although the constraints of reality indicate that random selection may be more realistic than measuring every item, it does not prevent everything from being "at risk" of inspection. In fact, the holding of everything at risk until such a time that the inspectorate determines which specific location and items will be inspected on that visit is an important tool to deter cheating. Limitations of random selection and the possibility that a treaty, such as the Conventional Forces Europe (CFE), may allow a number of items to be in temporarily deployed status but not have to be reported as transferred from that facility. Because of this, random selection decisions may be limited in nature to selecting a site and then pre-planning the number or percentage of items for visual and radiation detection inspections, while leaving the complete item selection until that actual serial number inventory and their status' are available. At this point, the available inventory can be held at risk through random selection, thus maintaining deterrence to cheating at the site level.

As mentioned previously, confidence is subjective, thus a single random selection verification inspection is not likely to deliver complete confidence from the inspectorate that they understand the host's processes and believe that the host is 100 percent compliant across the regime. Instead, evidence of consistency can be collected through multiple layers of statistical evaluations that provide evidence to support the growth of confidence over time and as each layer matures. Repeated random selection inspections also serve to help develop a growing body of evidence which over time, increases the inspectorate's perception of confidence. Over time, the ability to observe consistency in behaviors, processes, and documentation lends more credence to the host's claim of compliance through openness and transparency.

There may be a correlation between the inspectorate's desired level of confidence and the consequences of non-compliance. For example, if any evidence of non-compliance is detected, this could undermine the fundamental security relationships between States party to an agreement. A lower level of confidence in any sampling process might therefore be acceptable as the inspected State would have strong disincentives to cheat. On the contrary, if there are limited consequences to non-compliance, an inspecting entity may wish a greater rate of sampling to increase the confidence level.

Tools for Evaluating Random Selection Approaches

Not all tools and mechanisms are created equal. It is important to understand that in many cases, both in the design and implementation of evaluation, there are spaces in evaluation where subjectivity and perception retain roots. When constructing the data sheets for a technology, for example, technologists have certain perceptions of their technology's capabilities and performance that may not be repeatable in all environments. Additionally, in evaluation, there is subjectivity in the weighting scheme based upon the evaluator's perception of the environment. Last, there is subjectivity in the determination of what value product is necessary to deliver confidence (x=confidence). Because of this subjectivity, there is not necessarily a one-size-fits-all means for evaluating confidence. However, there are numerous different mechanisms that could be used to measure elements of a compliance regime and provide quantifiable data on the effectiveness of those elements in a single application, even though quantification of overall confidence may still be elusive.

> Although there is no universally accepted definition of verification, there is a common understanding of its meaning as "an activity whose purpose is to establish the degree of compliance with, or violation of, the specific terms of an agreement." Verification encompasses the technical elements of monitoring and inspection as well as information processing and evaluation. The aim of verification is to increase confidence that an agreement is being fully implemented by providing parties with the opportunity to convincingly demonstrate their compliance and to detect non-compliance, thereby deterring parties which may be tempted to cheat.[7]

This section discusses briefly several methods that could be used to evaluate random selection compliance approaches to verification. Within this paper we will discuss three layers of statistical approaches: For technology and application comparison, hybrid qualitative/quantitative approaches include The Arms Control Evaluation Criteria (ACEC), the Analysis of Alternatives (AoA) Methodology, and the Analytical Hierarchy Process (AHP). For combined technology suites or applications, we discuss mathematical approaches to assessing compliance like the statistical rule-of-three or estimates of probability. For the higher-level systems-level obligation assessments, tools such as Acquisition Pathway Analysis (State Level Concept), Discrete Event Simulation (DES) and Game Theory might be most applicable. Although these may not be the full breadth of all approaches that could be used, others very likely include elements or evolutions of these methods.

Informing Direct Comparison Activities

Hybrid Qualitative/Quantitative Approaches

When considering hybrid qualitative/quantitative approaches, application of the hybrid methods is applied differently than the individual qualitative or quantitative approach independently. Because each of these approaches still provides for inserting subjective perspectives that can influence the overall outcome, it is important to limit such influences through a direct and concise set of evaluation questions that both limit subjectivity and require proof of validity in the response. Confidence in each of the following approaches results from an amalgamation of results associated with each of the independent elements of the random selection regime and the quantified effectiveness that each element provides in delivering accurate results. These tools will help the inspection parties determine which technologies or

[7] N. Zarimpas, *Transparency in Nuclear Warheads and Materials: The Political and Technical Dimensions* (Oxford University Press, 2003).

approaches will be most effective in delivering the confidence levels expected based upon the effectiveness of their internal approach elements.

The Arms Control Evaluation Criteria

The ACEC is used to objectively assess and compare technologies and technology design features for effectiveness in meeting the verification needs for specific applications. The ACEC evaluation approach provides an easy-to-use methodology for the objective comparison of treaty verification technologies. Although this tool could potentially be used to compare entire suites of technologies within a hypothetical arms control agreement, its primary intent is to compare individual technologies that fulfill a specific monitoring objective (e.g., tamper indicating seals applied to secure equipment or rooms, which may be examined later to verify integrity of the item secured). The ACEC contains a detailed hierarchical structure of the two evaluation Criteria Suites (CS), which contain a total of six Evaluation Criteria (EC) that are used to assess competing technology options. EC are numbered according to their hierarchy, with the CS number listed first, followed by the evaluation criterion number. Inspected State-only criteria/considerations are indicated by an asterisk and should be examined with respect to inspected State-only perspectives; all other criteria/considerations should be jointly examined from both inspected State and inspecting entity perspectives. The user tool is a web-based tool that can capture and depict the resulting comparison.

The two CSs and corresponding six EC are summarized below:

- CS 1: Ability to demonstrate or verify compliance
  - EC 1.1 Confidence in the ability to meet the end-use application
  - EC 1.2 Confidence in the accuracy of information
- CS 2: Ability to be deployed in host facility
  - EC 2.1: Sensitive information protection*
  - EC 2.2: Hazard level
  - EC 2.3: Cost
  - EC 2.4: Deployment readiness

Several elements of this approach rely on subjective inputs to provide the data that are used to identify technologies that meet the needed criteria: how the criteria are weighted and what elements are prioritized or restricted. It does, however, provide a mechanism for both the host and inspector to evaluate technologies from their differing perspectives and to weight the criteria based upon the two different knowledge bases. Additionally, the ACEC allows for the user to adjust weighting of criteria based upon their perception of the criteria's importance to the regime. This adjustability of weighting criteria allows the evaluation process to be customized.

Analysis of Alternatives (AoA)

AoA is an analytical comparison used by the U.S. Department of Defense (DoD) to assess operational effectiveness, costs, and risks of alternative approaches to operations.[8] The AoA is different from the ACEC in that it is designed to compare multiple technologies at the same time, eliminating the need to perform multiple pair-wise or "head-to-head" comparisons. However, like the ACEC, the AoA relies on potentially subjective information of technical capability. It is critical to the AoA to have consistent and complete technical information to accurately evaluate technologies and reduce the likelihood of unverified inputs from subject matter experts being used for decision-making.

Additionally, the AoA method and associated tools (e.g., Microsoft Excel) provide a user-friendly evaluation rationale clearly depicting results with coded bullets (e.g., ++, +, =, -, --) to identify pros and cons for each option, and the scaling system for the AoA makes it easy to understand the meaning of the option's overall score (e.g., red, yellow, green stoplight-style chart). Using criteria considerations (CC) offers the flexibility to support multiple different tool evaluations. The ability to use CCs instead of independent criteria reduces unnecessary evaluation complexity. The AoA tools include two Excel components: the first defines and evaluates the value of that criterion, and assesses the technologies performance against those criteria, whereas the second describes the rationale for the weighting and documents pros and cons of each technology in comparison. Examples of the AoA assessment sheets are illustrated in Tables IV-2-1 and IV-2-2.

Table IV-2-1. Example Analysis of Alternatives Excel Tool: Values and Weighted Scores

Analyses of Alternatives Excel Tool: Values
Directions: Users of this criteria evaluation Excel tool should identify the end-use application, technologies to be examined, pertinent technology information, and criteria weighting before proceeding. This "Values" sheet should be where users specify the end-use application, technology names, and varied weight fractions. Users may also input technology scores for each criterion in this sheet after identifying rationale on the Rationale sheet. All user inputs should be made in the shaded Excel cells.

End-Use Application:	

			Technologies Examined				
Criteria	Equal Weights	Varied Weights	Tech1	Tech2	Tech3	Tech4	Tech5

[8] Office of Aerospace Studies, *Analysis of Alternatives Handbook: A Practical Guide to the Analysis of Alternatives* (Kirkland AFB, New Mexico, 2016).

Confidence in the ability to meet the end-use application	0.1667					
Confidence in the accuracy of information	0.1667					
Sensitive information protection	0.1667					
Hazard Level	0.1667					
Costs	0.1667					
Deployment Readiness	0.1667					
TOTAL SCORE (Equal Weights):			0.00	0.00	0.00	0.00	0.00
TOTAL SCORE (Varied Weights):			0.00	0.00	0.00	0.00	0.00

Table IV-2-2. Example Analysis of Alternatives Excel Tool: Rationale

Analyses of Alternatives Excel Tool: Rationale
Directions: Describe the rationale driving the scores on the Values sheet. Enter the rationale for each technology in the shaded boxes. Additional notes not affecting scores on the Values sheet may also be made in the additional note section of this sheet. Use the following system to identify positive/neutral/negative rationale: ++ Very Positive Feature + Positive Feature = Neutral Feature - Negative Feature -- Very Negative Feature

End-Use Application:	

	Technologies Examined				
Criteria	Tech1	Tech2	Tech3	Tech4	Tech5
Confidence in the ability to meet the end-use application					
Confidence in the accuracy of information					
Sensitive information protection					

Hazard Level					
Costs					
Deployment Readiness					
Additional Notes					

The Analytical Hierarchy Process (AHP)

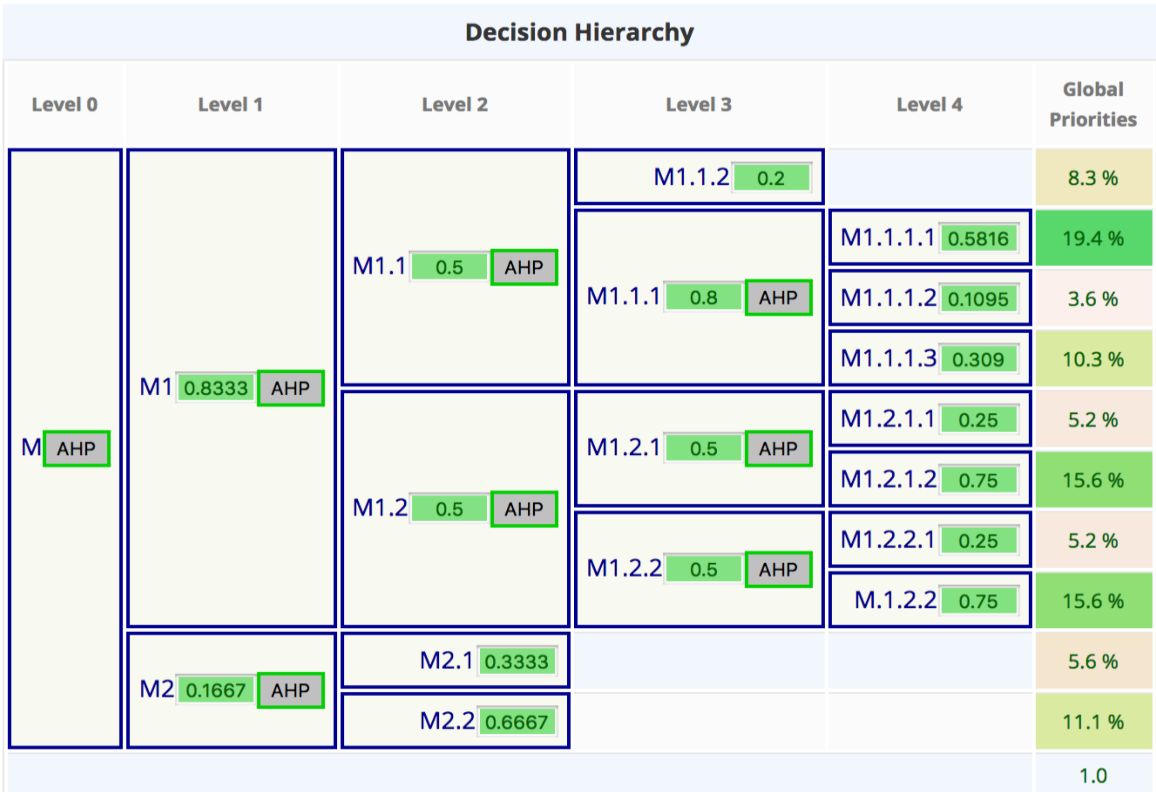
AHP is a rigorous decision-making tool that uses a set of values and perceived relationships between values, to help the user determine priorities and ultimately make the best decision between options based upon both subjective and objective inputs. Created by Thomas Saalty in 1980, AHP uses pairwise relative evaluations of both the criteria and the options provided by the user, to make the best decision determination. "The computations made by the AHP are always guided by the decision maker's experience, and the AHP can thus be considered as a tool that is able to translate the evaluations (both qualitative and quantitative) made by the decision maker into a multicriteria ranking." Using the AHP is simple because there is no need for a complex tool to capture expert knowledge. However, every criterion is necessarily compared for every pair of alternative tools considered, with a weighting vector to determine the importance of each individual criterion relative to the others (see Figure IV-2-1). For example, tool A is compared to tools B and C, and then tool B is compared to tool C, repeating for all criteria considered.

It follows, then, that "the number of pairwise comparisons grows quadratically with the number of criteria and options. For instance, when comparing 10 alternatives on 4 criteria, (4 x 3)/2 = 6 comparisons are requested to build the weight vector, and 4 x ((10 x 9)/2) = 180 pairwise comparisons are needed to build the score matrix."[9] To simplify the use of AHP, automation may be necessary, especially in the case of larger numbers of comparisons. Automated tools exist to compute the results after the input is provided, which reduce the overall magnitude of time needed to conduct the pairwise comparisons.

As an example of the magnitude of these pairwise comparisons, where a comparison is performed between seven tamper indicating seals, the AHP comparative approach would require 21 pair-wise comparisons to make an option determination. The decision-making process of the AHP requires a weighted decision-making hierarchy, which is then ultimately depicted in a comparison diagram in Excel.

[9] T.L. Saalty, *The Analytic Hierarchy Process* (New York: McGraw-Hill, 1980).

Figure IV-2-1. AHP Decision Hierarchy



Assessing Combinations of Technologies and Approaches for Evaluating Compliance

Mathematical Approaches

The various elements of verification all contribute to confidence in compliance, but it is problematic to combine them to mathematically gauge a single absolute measure of confidence. The element of inspections may come closest through statistical confidence measures that can be derived from the resulting inspection data. Inspections offer the opportunity to directly examine weapons via direct observations, measurements, and tests using various technologies.[10] With this, an inspection could determine if a weapon is compliant or not with its declared attributes. Ideally, such inspections could examine every documented weapon that is under the treaty and this would offer a definitive statement on the site being compliant or not. However, for various reasons (e.g., time and resource constraints, access limitations, and especially cost), it is typically not practical to inspect all weapons at a site.

[10] N. Zarimpas, *Transparency in Nuclear Warheads and Materials: The Political and Technical Dimensions* (Oxford University Press, 2003).

Rather a subset of the weapons determined via random selection is inspected and from this a statistical statement is formed that provides a confidence measure in compliance.

The same approach can be used when comparing suites of technology for effectiveness in delivering the measure of compliance needed to provide confidence that a specific activity or set of activities is being performed as expected and without deviation from the understood processes.

Statistical Rule of Three

A simple statistical rule in this regard is called "the-rule-of-three," which provides that if no "defects" are found in a batch of n items, then with 95 percent confidence there will be fewer than 3/n defects in all of the items.[11] So if a batch of 30 weapons are inspected and no defects—in this example, noncompliant weapons—are found, then with 95 percent confidence one could claim there are fewer than 3/30 or 1/10 noncompliant weapons overall at the site. This notion can be extended to other confidence levels such as 2/n, which would yield 86.5 percent confidence that there are fewer than 2/30 or 1/15 noncompliant weapons. Alternatively, using 5/n would yield 99.3 percent confidence that there are less 5/30 or 1/6 noncompliant weapons. In this case, there is a high degree of confidence in the stated numbers, but the potential of 1/6 noncompliant weapons are likely far from ideal in forming a statement about the overall confidence in an inspected State's declared nuclear weapons being compliant.

The only way to overcome this is by inspecting more weapons. For example, using 3/n again, if instead 300 weapons were inspected with no defects, one could state with 95 percent confidence that there are fewer than 1/100 noncompliant weapons at the site. Note that the above discussion assumes that inspectors can randomly sample any of the weapons at the site with equal likelihood (i.e., the site does not limit access to certain potentially noncompliant weapons). If this likelihood criteria is not met, other verification elements may act to further support an overall confidence claim.

Estimating Probability of Noncompliance

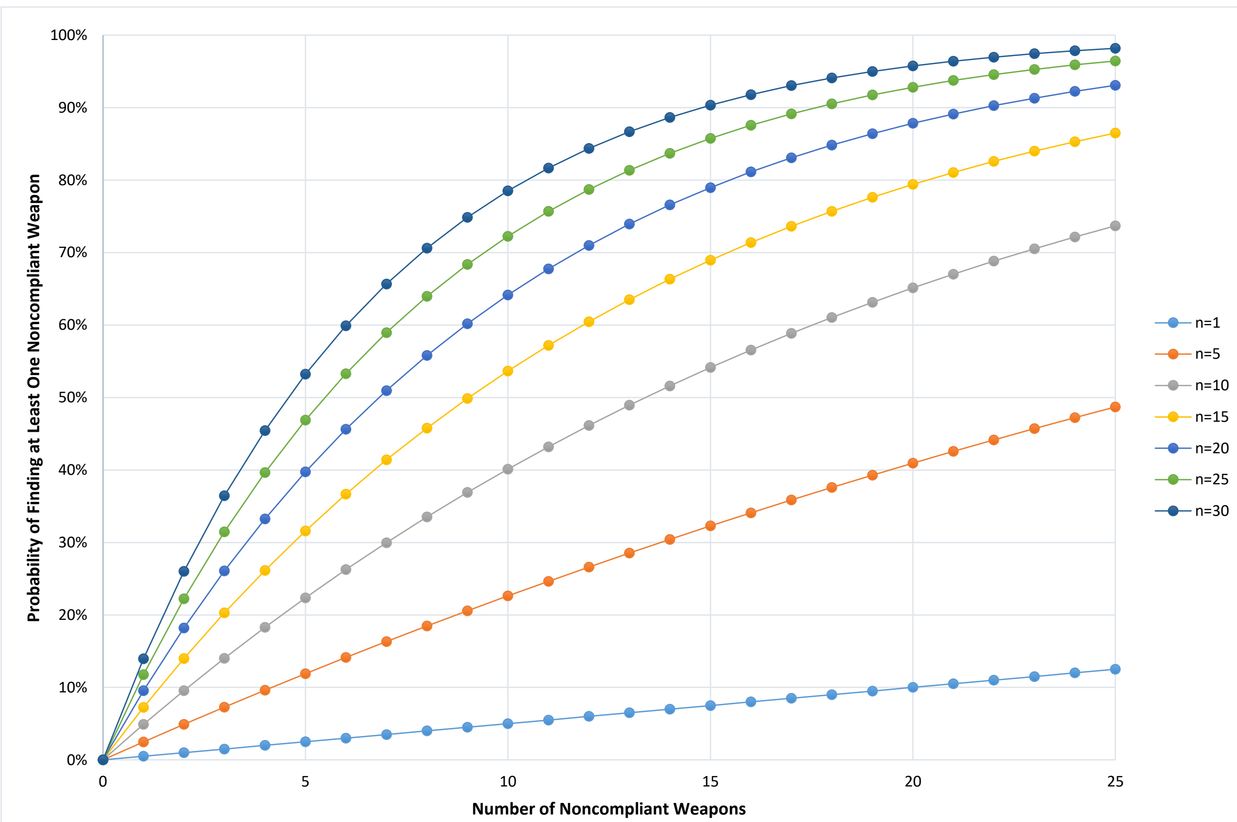
Another view of confidence comes from estimating the probability of identifying at least one noncompliant weapon as related to an assumed noncompliant weapon fraction at a site. If there are more noncompliant weapons, the inspector is more likely to find at least one, and more likely still if many weapons are inspected. For instance, Figure IV-2-2 shows a plot of the probability of finding at least one noncompliant weapon versus the assumed number of noncompliant weapons at a site as a function of the number of weapons randomly inspected. For convenience, we consider a site having 200 weapons, where the noncompliant fraction is used to determine the number of noncompliant weapons. For a site having a significant number of weapons (e.g., more than 50), the formula that provides an approximate probability for this

[11] Tony Gojanovic, *Zero Defect Sampling,* November 2007, http://asq.org/quality-progress/2007/11/basic-quality/zero-defect-sampling.html.

is P = 1 – (1 – F)n where F is the noncompliant fraction and n is again the number of weapons inspected.[12]

From this plot, one can see the trade-offs in dealing with confidence. For example, if one assumes a significant level of noncompliant weapons at a site (e.g., 10 percent noncompliance or 20 noncompliant weapons) and say 15 of the weapons (from the total pool of 200) are randomly inspected, there is about an 80 percent chance that at least one of the noncompliant weapons will be discovered. Hence, if no noncompliant weapons were found, although there is not a quantitative confidence level that can be assigned, one would have pretty good confidence that the site is compliant. However, if there is only 1 percent noncompliance (2 noncompliant weapons) at a site and 15 of the weapons are again randomly sampled, there is now only a 14 percent chance of finding at least 1 of the noncompliant weapons. So even though no discrepancies were identified, one's confidence in the site being compliant would not be as great in this case because the likelihood of discovering a noncompliant weapon was low.

Figure IV-2-2. Probability of Finding at Least One Noncompliant Weapon at a Site with 200 Weapons (n is the number of weapons randomly inspected)



[12] N. Zarimpas, *Transparency in Nuclear Warheads and Materials: The Political and Technical Dimensions* (Oxford University Press, 2003).

The essential challenge then is knowing the degree of noncompliance at a site, which obviously cannot be ascertained with certainty. However, if some past historical data are available, one can use this to potentially gauge where a site might fall in its level of compliance and then use this to support a confidence claim from the inspection results. It is also noted that a treaty partner could use this same sort of analysis to realize that if they only had one or two noncompliant weapons at their site, the probability that one of these would be detected via random sampling is relatively small. Although this is where the notion of deterrence comes into play, that is, by conducting the inspections and randomly selecting which weapons to inspect, the hope is that treaty partner(s) would be less inclined to cheat.

Furthermore, inspectors can keep track of which weapons have been previously inspected at a site so that these are not included in the next pool of weapons to be randomly inspected. This means that the fraction of noncompliant weapons in the remaining pool of weapons would increase, and in turn this would increase the probability that at least one noncompliant weapon is detected in the next round of inspections.

Finally, we note that this same approach (as well as the rule-of-three) could also be applied at a more detailed level of fidelity that considers specific weapon system types or specific technology suites used at a site for specific functions. Alternatively, the approach could be used to assess an entire regime, where each site is now treated as compliant or noncompliant and then a probability of identifying at least one noncompliant site via random sampling of sites across the regime could also be calculated, providing evidence for a confidence judgement in the overall regime.

Defining and Assessing Systems Level Obligations

Defining and assessing obligations occurs at a systems level. Each method for assessing compliance provides an estimate of confidence given current inspection parameters and measurements but can be re-framed to define obligations given a goal confidence level set by a given treaty. However, the compliance methods outlined do not consider the variability across sites, weapons, and facility types that may be encountered in a system in a cohesive way. Confidence in final compliance assessments relies on where in the weapons-pathway the assessment occurs; the methods in this section are designed first and foremost to identify potential areas where noncompliance can occur and best implement inspections to deter and detect it.

Acquisition Pathway Analysis (APA) IAEA State Level Concept

Although the APA in its original form is not designed to suit the needs of a weapons verification treaty, some tenets of weapons verification share commonalities with elements of the APA approach. The APA, as designed, estimates the time necessary to complete plausible routes to weapons-usable material based on all information available on a State. To more fully understand the breadth of a weapons disarmament treaty environment and determine which inspections and timings would be most effectively implemented as part of random selection, it would be essential to gain a similar understanding of the weapon's lifecycle behaviors across the State and what interactions exist between sites. Would one site expect to see storage primarily, with little transportation involved, whereas another sees limited storage or staging but significant transportation? When considering those transportation interactions, what modes of transportation would that site expect to see and where would weapons enter and depart?

Even in the IAEA APA approach, it is assumed that there will be areas of high-field inspection and low-field inspection activities.[13] This would also be a reasonable expectation in a random select application for weapon treaty compliance verification. Specific areas of priority would be selected because of what is known and assumed about the weapon's lifecycle behaviors, and then discrete numbers of random selection verifications chosen based upon predetermined inspection percentages, availability of inspection resources (people on the ground), time, and level of effort required. As mentioned in the beginning of this paper, the key to successful random selection is that everything should always be held at risk, until a final decision is made regarding the application of the random selection plan. Increased confidence in this case would result from the combination of lifecycle and behavior knowledge, witnessed or verified behaviors, and random selection verification measures.

Discrete Event Simulation (DES)

DES is an analytical "method of simulating the behaviors and performance of a real-life process, facility or system."[14] The rationale for using a discrete event simulation approach is that it does not rely on complex mathematical models, but instead attempts to recreate real world systems using logic and event-driven activities. DES codifies the behavior of a complex system as an ordered sequence of well-defined events. The strengths of DES include handling systems characterized by high variability, constrained or limited resources, and complex dynamic interactions. Processes include both those of the weapons enterprise and the monitoring system. For example, enterprise processes may include changes in the weapon lifecycle state, transportation to other sites, or maintenance activities. Monitoring system processes incorporate activities defined by Concepts of Operation (CONOPS). Likewise, enterprise resources and constraints, for example, include storage capacities and dismantlement bay availability. Example monitoring system resources are inspectors and monitoring system equipment.

PNNL developed such a DES that seeks to capture all processes and decision points associated with the progressions of virtual weapons through the monitoring system from initialization through dismantlement.[15] The simulation updates weapon progression (simulated physical movements and state changes at appropriate points) over the item lifecycle and up until

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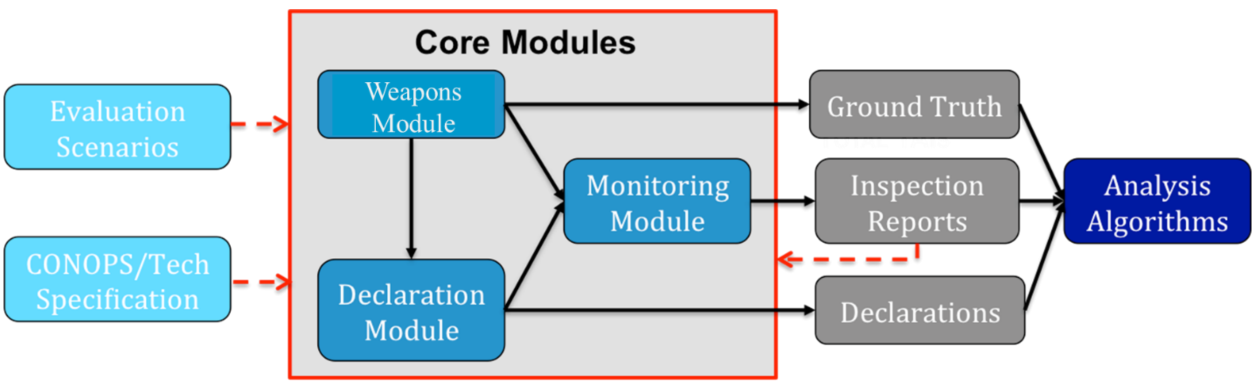
[13] Lance K. Kim, Guido Renda, and Giacomo G. M. Cojazzi, "Methodological Aspects of the IAEA State Level Concept and Acquisition Path Analysis: A State's Nuclear Fuel Cycle, Related Capabilities, and the Quantification of Acquisition Paths," *ESARDA Bulletin,* no. 53 (2015).
[14] E. Staton, G. Cates, R. Finn, K. M. Altino, K. L., Burns, and M. D. Watson, "Use of DES Modeling for Determining Launch Availability for SLS," AIAA Space Operations Conference (Pasadena, California, May 2014).
[15] C. Perkins, et al., "Using Simulation to Evaluate Warhead Monitoring System Effectiveness," Institute of Nuclear Materials Management 56th Annual Meeting, 2015 (Indian Wells, California, July 2015).

dismantlement (see Figure IV-2-3). Simulation of weapon lifecycles provides the basis for assessing how the order, frequency, and combination of functions in the CONOPS affect system performance. In addition to being a suitable framework for warhead monitoring activities, a DES approach also allows for a long-term view of the entire weapon monitoring process over a treaty regime. Once the DES framework is established and associated simulation parameters and logic (rules) are established, the simulation can be run over any desired period (from months to years to decades). A discrete event simulation approach can directly output metrics of concern to evaluate overall system performance. In this case such metrics might be related to overall confidence in the warhead monitoring declaration by a treaty partner as a function of the rules, CONOPS, and monitoring technologies that might be deployed.

Beyond providing insights related to warhead monitoring, a DES approach also enables analysis of warhead monitoring inspection effectiveness/confidence under various inspection paradigms (random, targeted, etc.) along with specific evaluations and sensitivity assessments of associated sampling plans.

Figure IV-2-3. DES Simulation Framework



Because future treaties related to arms control will likely include multilateral treaty partners and non-nuclear weapons States, the use of declarations as a confidence building measure is a good first step to engage these new treaty partners in the future. Moreover, these declarations will also form a knowledgebase for information pertaining to a treaty partner's nuclear weapons enterprise. False declarations could lead to a partner's ability to subvert a weapon-monitoring regime. Methods such as DES have been proposed to quantify that level of risk, improve the ability to detect false declarations and associated uncertainty, and characterize if and how much deterrence can help reduce that risk by a system that can identify false declarations. Ultimately, this capability can be used to inform a treaty negotiator and the results could also apply to the IAEA and the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) because declarations could be valuable verification elements of the State's NPT obligations, if applicable under country specific safeguards agreements. This analysis could potentially be used to increase confidence in these declarations, which the IAEA uses to determine compliance.

Game Theoretic Methods

Within the game theory field, inspection games have been developed to model the relationship between an inspector and host to ascertain the host's compliance with respect to a treaty or agreement.[16] An inspection game can account for the specific requirements of a treaty, practical limitations on inspector resources, and the host's potential interest in violation. In a simple two-player non-cooperative game, an inspector's goal is to deter any violations, and detect with high probability any violations that may occur. A host has the choice to violate the agreement or not, and if they violate, their goal is to avoid detection (assuming there is some negative consequence to a violation). In the random sampling inspection framework, game theoretic methods can be used to assess optimal inspection parameters such as sample size (i.e., number of items or sites inspected) as well as optimal political "punishment" to deter a violation. The results of game theory implementation directly inform best inspection practices, such as number of items to be inspected to maximize noncompliant item detection.

As in the previous sections, a major challenge is identifying the approximate noncompliance level of a site or State. In addition, game theoretic frameworks also require some knowledge of a host's interest in violation as related to interest in compliance. In quantifying these aspects, subjectivity does affect the game formulation and resulting confidence in inspection results. However, incorporating historic data to inform violation probability and the corresponding number of potentially noncompliant items, or even worst-case estimates, can moderate subjectivity's role and increase confidence in an inspection regime's detection capabilities. Recent advances[17] in safeguards game theory include quantifying advantage to a State for noncompliance using quantity and attractiveness of material/item obtained by violation, with attractiveness increasing the closer a material is to weapons-usable (see Table IV-2-3). This adds complication to the game theory model, as it includes an extra simulation step to generate these quantities, making it primarily applicable at the site level rather than system level, but removes subjectivity from the final analysis of the game as well. Overall, game theory models provide increased confidence that current and future inspection methods best implement finite resources to minimize the payoff of noncompliance for a host, and thus maximize deterrence and noncompliance detection. We believe game theoretic methods are a useful approach and will continue to see increased interest in use in both the arms control and disarmament and the safeguards domains.

Table IV-2-3. Example Game Table for Inspector/Host Relationship Assuming Inspection Is Synonymous with Detection (C is physical cost of inspection—reflects practical constraints)

Inspector\host	Compliance	Violation

[16] R. Avenhaus, "Inspection Games in Arms Control," *European Journal of Operational Research* 90 (1996).
[17] R.M. Ward and E.A. Schneider, "A Game Theoretic Approach to Nuclear Safeguards Selection and Optimization," *Science & Global Security* (2016).

Inspection	-C/0	1/-1
No Inspection	0/0	-1/1

Conclusion

In closing, it is important to remember that confidence is not necessarily something that one can quantify immediately due to the subjectivity and the reality of what is required to verify compliance. It may not be possible to collect all information that would be necessary to deliver complete confidence because of limitations of resources (number of inspectors that are both available and trained), time (the amount of time that is agreed in the treaty for the inspector's access to the sites), access constraints (host safety or security restrictions that limit access or restrict inspection activities in specific environments), and ultimately the cost of conducting an inspection. Instead it may be more realistic to understand that confidence is achieved through layers of evidence that ultimately deliver more complete perceptions through platforms that include direct comparative analytics tools, tools that can compare suites of tools or approaches and groups of activities, and systems level analysis that provides a higher level understanding of both what is required for compliance at the highest level and which things are most important. The addition of random selection approaches demonstrates evidence over time of behaviors, processes, and procedures that can, through consistency, demonstrate compliance with the treaty obligations.

When measuring the confidence of different random selection approaches, it is important to remember that not all tools and mechanisms are created equal. In many cases, there are spaces where subjectivity and perception retain roots. Additionally, there may be different types of random selection needs depending upon the circumstances or objectives of the verification. The random selection of items/weapons at a site verifies presence of declared numbers of items whereas the random selection of sites/facilities verifies the absence of declarable items/weapons. Because of these differences, the effectiveness of assessment tools may also differ, based upon the overall verification objective (verification of absence at declared or undeclared sites or presence of declared numbers of items). Statistical approaches, for example, might be appropriate for the assessing approaches that look to determine presence of declared numbers of items, whereas the examples of the IAEA APA, the DES, and game theoretic methods may be more effective for verification of absence at declared or undeclared sites assessments and provide a level of confidence that material is not being diverted clandestinely to weapons programs. In turn, methods like the ACEC, the AoA, and the AHP provide a level of confidence that the tools in use provide adequate information for program assessments for both verification of absence at declared or undeclared sites and presence of declared numbers of items objectives.

Paper 3. How to Resolve Inspection Ambiguities

Working Group 4: Verification of Nuclear Weapons Declarations

November 2019

Abstract

This paper addresses ways to resolve ambiguities, that is, uncertainties about the compliance of arms control/disarmament and non-proliferation treaties, by presenting existing examples, including multilateral and bilateral arrangements. Examples include not only nuclear weapons' arrangements, but also chemical, biological, and conventional weapons because we can learn lessons from them as well. Each arrangement has its own mechanism to address/resolve such ambiguities, but we can see roughly four kinds of mechanisms: (1) internal consultation between inspected State personnel on-site and the inspecting entity, (2) additional-treaty mandated or agreed (and possibly more intrusive) inspections, (3) resolution in a standing compliance body, and (4) intervention of the United Nations, including that of the Secretary-General and a specific body established under Security Council resolutions. They are chosen according to circumstances such as numbers of contracting parties, their relations, and political circumstances surrounding contracting parties, and independence of an inspecting body.

Introduction

This paper concerns ways to resolve ambiguities, that is, uncertainties about the compliance of arms control/disarmament and non-proliferation treaties. In Phase I, Working Group 2 addressed "On-Site Inspections" based on lessons learned from existing treaties. Its Deliverables Four, Five, and Six mention ways to address disagreement or ambiguity: internal consultations between the inspected State and the inspection team; complete documentation of discrepancies or ambiguities in the Inspection Report, if the two parties are unable to resolve them; and roles of the compliance body in resolving discrepancies or ambiguities.

Although an ambiguity can be an indicator of cheating, it can also be something more innocent. An ambiguity can be a failure, for various reasons, to obtain the expected outcomes of agreed procedures. For example, the inspected party may not correctly take the required measurements of the accountable object during an inspection or the measurement procedure or a piece of equipment did not function properly. The object itself may vary in length or circumference more than the expected value because items are not always uniform in size. Or, the object may not be present at the time of the inspection because it has been moved to a different location and the notification of movement has not caught up.

This paper presents examples of measures to address ambiguities in relevant arms control/disarmament and non-proliferation regimes.

International Atomic Energy Agency Comprehensive Safeguards Agreement

The basic undertaking of the International Atomic Energy Agency (IAEA) Comprehensive Safeguards Agreement (CSA) under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is to ensure that safeguards are applied on all source or special fissionable material in all peaceful activities within the territory of a State, under its jurisdiction, or carried out under its control anywhere, to verify that there are no indications of diversion of declared nuclear material and the basic undertaking of the Additional Protocol is to ensure that there are no indications of undeclared nuclear material or activities in a State as a whole from peaceful nuclear activities.

The IAEA pursues three generic safeguards objectives: (1) to detect any diversion of declared nuclear material at declared facilities, or locations outside facilities (LOFs), where nuclear material is customarily used; (2) to detect any undeclared production or processing of nuclear material at declared facilities or LOFs; and, (3) to detect any undeclared nuclear material or activities in a State as a whole. To this end, inspection is carried out.

The IAEA may carry out four types of inspections: ad hoc inspection, routine inspection, special inspection, and unannounced/short notice inspection. Under the CSA, if the IAEA considers that information made available by a State, including explanations from a State and information obtained from routine inspections, is not adequate for the IAEA to fulfill its responsibilities, the inspected State and the IAEA shall consult forthwith. As a result of such consultations, the IAEA may conduct special inspections in addition to routine inspection.[18] Special inspections have been rarely implemented by the IAEA and only in cases where there were serious suspicions of a breach of the obligations of a State with a Safeguards Agreement in force.

Any disagreement between the IAEA Secretariat and the State concerning the need for access to information or location in addition to that specified for ad hoc and routine inspection would be reported by Director-General to the Board of Governors. The Board could request the Director-General to initiate the procedure for carrying out such an inspection. If the State denies access or the IAEA to carry out the special inspection, the Boards may report the matter to the Security Council.

If the outcome of the special inspection is that undeclared facilities, locations, or materials are found that should have been declared under the safeguards agreement, it would be for the

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[18] IAEA, *The Structure and Content of Agreements between the Agency and the States Required in the Connection with the Treaty on the Non-Proliferation of Nuclear Weapons* (INFCIRC/153 Article 77), https://www.iaea.org/publications/documents/infcircs/structure-and-content-agreements-between-agency-and-states-required-connection-treaty-non-proliferation-nuclear-weapons.

Board to determine what action should be taken to remedy the non-compliance in accordance with Article XII of the Statute.

If the outcome of the special inspection is that in view of the available evidence, the questions that gave rise to the inspection are not adequately resolved and the IAEA is unable to verify that there has been no diversion of nuclear material required to be safeguarded under the Agreement, the Board may, as provided for in CSA, make a report to the Member State, the Security Council and General Assembly or take the other measures provided for in Article XII C of the Statute, as appropriate.

Any questions arising out of the interpretation or application of the Agreement, the parties must, at the request of either, consult about it. Any dispute arising out of the interpretation or application of the Agreement may be submitted to an arbitral tribunal, whose decisions would be binding on both parties.[19]

The Treaty between the United States of America and the Russian Federation on Measures for the Further Reduction and Limitation of Strategic Offensive Arms

Ambiguities that arise during an inspection are recorded in an inspection report. Although the inspected party may offer a means to resolve the ambiguity, such as a different measurement or a different way to make a measurement, the inspecting party may not consider the ambiguity to be resolved.

Part Six of the New START Treaty establishes the Bilateral Consultative Commission (BCC). The authority of the BCC includes, inter alia, the resolution of issues regarding a party's compliance, the resolution of questions raised by a side, and the resolution of ambiguities that may arise during inspections. The BCC may also reach agreements on additional measures to increase the viability and effectiveness of the Treaty. This latter authority can be critical to the resolution of compliance issues. The Joint Compliance and Inspection Commission (JCIC) served the same purpose for the START Treaty.

A session of the BCC must be convened at the request of either party normally in Geneva, Switzerland, and no fewer than two sessions of the BCC must be convened each year, unless otherwise agreed.

The agenda for each session consists of the questions specified by the parties in their communications. Additionally, questions can be raised and discussed by the Commissioners in the intersessional period. Thus, if a party has documented ambiguities that occurred during an inspection (i.e., failure to obtain requested/required measurements of an accountable item, incorrect measurements, lack of access, etc.), these can become agenda items for the session.

[19] INFCIRC/153 Article 22.

Additionally, if a party has questions about another party's compliance, they can raise this issue as a proposed agenda item.

Resolving ambiguities or compliance issues can take the form of promises to correct the behavior or activities that led to the ambiguity declaration. In some cases, it may be necessary to reach a new BCC agreement on procedures. For example, under the original START Treaty, access to a certain building that had been accessible on a previous inspection was denied due to an unannounced change in the entrance to the building. The parties eventually reach an agreement that resolved the issue.

Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on Their Destruction

The Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on their Destruction (CWC) has two mechanisms to resolve ambiguities regarding compliance of the Convention: the consultation mechanism (consultations and request for clarification,[20] and the Challenge Inspection.[21]

Without prejudice to the right of any State party to request a challenge inspection, State parties of the CWC should first make every effort to clarify and resolve, thorough exchange of information and consultations among themselves, any matter that may cause doubt about compliance with the Convention, or which gives rise to concerns about a related matter that may be considered ambiguous. In response to that, a State party that receives a request for clarification of any matter that the requesting State party believes causes such a doubt or concern is obliged to provide it, in any case not later than 10 days after the request, with information sufficient to answer the doubt or concern raised along with an explanation of how the information provided resolves the matter.[22]

Additionally, State parties can request an on-site challenge inspection of any facility or location in the territory or in any other place under jurisdiction or control of any other State party for the sole purpose of clarifying and resolving questions concerning possible non-compliance with the provisions of the Convention, and to have this inspection conducted anywhere without delay by an inspection team designated by the Director-General of the Organization for the Prohibition of Chemical Weapons (OPCW) and in accordance with the Verification Annex. This challenge inspection mechanism has no limit on inspection target, and State parties have no veto. Conversely, the Convention has a system to avoid any abuse of this right, that is, if the Executive Council of the OPCW considers inspection request to be frivolous, abusive, or clearly

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[20] Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on their Destruction (CWC), Article IX, Subparagraphs 1–7, https://www.opcw.org/chemical-weapons-convention/articles/article-ix-consultations-cooperation-and-fact-finding.

[21] CWC, Article IX, Subparagraphs 8–25, https://www.opcw.org/chemical-weapons-convention/articles/article-ix-consultations-cooperation-and-fact-finding.

[22] CWC, Article IX, Subparagraph 2, https://www.opcw.org/chemical-weapons-convention/articles/article-ix-consultations-cooperation-and-fact-finding.

beyond the scope of the Convention, it can decide by a three-quarter majority of all its members against carrying out the challenge inspection.[23]

With regard to the challenge inspection, the inspected State shall have (1) the rights and obligations to make every effort to demonstrate its compliance with this Convention and, to enable the inspection team to fulfil its mandate; (2) the obligation to provide access within the requested site for the sole purpose of establishing facts relevant to the concern regarding possible non-compliance; and (3) the right to take measures to protect sensitive installations, and to prevent disclosure of confidential information and data, not related to the Convention, and shall assist the inspection team throughout the challenge inspection and facilitate its task.[24]

The final report shall contain the factual findings as well as an assessment by the inspection team of the degree and nature of access and cooperation granted satisfactory implementation of the inspection, and the Executive Council reviews it and addresses any concern as to (1) whether any non-compliance occurred; (2) whether the request had been within the scope of this convention; and (3) whether the right to request a challenge inspection had been abused. If the Council concludes that further action may be necessary, it shall take the appropriate measures to redress the situation and to ensure compliance with the Convention.[25]

To date, the challenge inspection has never been requested and executed.

In the case of the destruction of Syria's chemical weapons, the OPCW Executive Council adopted decision EC-M-33/DEC.1, which was unanimously endorsed by the UN Security Council Resolution 2118. This decision requires Syria to allow inspectors the immediate and unfettered right to inspect any site identified as having been involved in the chemical weapons program.

Treaty on Conventional Armed Forces in Europe

Under the Treaty on Conventional Armed Forces in Europe (CFE), States parties shall, whenever possible, resolve during an inspection any ambiguities that arise regarding factual information.[26] Whenever inspectors request the escort team, a group of individuals assigned by an inspected State party, to clarify such an ambiguity, the escort team shall promptly provide the inspection team with clarifications.[27] If inspectors decide to document an unresolved ambiguity with photographs, the escort team shall cooperate with the inspection team's taking of appropriate photographs using a camera capable of producing instantly developed photographic prints. If an ambiguity cannot be resolved during the inspection, then the

[23] CWC, Article IX, Subparagraphs 8–9 and 14, https://www.opcw.org/chemical-weapons-convention/articles/article-ix-consultations-cooperation-and-fact-finding.
[24] CWC, Article IX, Subparagraphs 11 and 20, https://www.opcw.org/chemical-weapons-convention/articles/article-ix-consultations-cooperation-and-fact-finding.
[25] CWC, Article IX, Subparagraphs 21-23, https://www.opcw.org/chemical-weapons-convention/articles/article-ix-consultations-cooperation-and-fact-finding.
[26] Treaty on Conventional Armed Forces in Europe, Section VI, Article 38.
[27] CFE, Section VI, Article 38.

question, relevant clarifications, and any pertinent photographs shall be included in the inspection report.[28]

Inspectors shall have the right to take measurements to resolve ambiguities that might arise during inspections. Such measurements recorded during inspections shall be confirmed by a member of the inspection team and a member of the escort team immediately after they are taken. Such confirmed data shall be included in the inspection report.[29]

The inspection report may be, as a rule, made available to the Joint Consultative Group, which is a consultative body established in 1990 to resolve ambiguities in compliance of the Treaty. The group is composed of representatives designated by each State party, and if needed, alternates, advisors, and experts of a State party may take part in the proceedings. They meet for regular sessions to be held two times per year, in addition to that, at the request of one or more States parties additional sessions must be convened.[30]

Comprehensive Nuclear-Test-Ban Treaty

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) has not entered into force. It has its own verification regime to verify compliance with the Treaty: (1) an International Monitoring System (IMS), (2) consultation and clarification, (3) on-site inspection (OSI) and (4) confidence-building measures.[31] Although these mechanisms are not all used prior to entry into force, the IMS system is nearly complete and operating provisionally. It can and has been used to monitor activities. Information from the IMS is shared through the International Data Center with Signatories to the Treaty. OSIs cannot take place pending the entry into force of the Treaty, but various exercises have been done such as the Integrated Field Exercise in Jordan in 2014; as well, the manuals for conducting OSI are still being prepared so that once the Treaty is in force, full implementation of its provisions can proceed.

Verification activities must be based on objective information, must be limited to the subject matter of the Treaty, and must be carried out on the basis of full respect for the sovereignty of States parties and in the least intrusive manner possible consistent with the effective and timely accomplishment of their objectives. Each State party must refrain from any abuse of the right of verification.[32]

States parties should, whenever possible, first make every effort to clarify and resolve, among themselves or with or through the Comprehensive Nuclear-Test-Ban Treaty Organization, any matter that may cause concern about possible non-compliance with the basic obligations of the Treaty. This mechanism will not affect the right of any State party to request an OSI.[33] A State

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[28] CFE, Section VI, Article 38.
[29] CFE, Section VI, Article 37.
[30] Protocol on the Joint Consultative Group Articles 1–4, https://fas.org/nuke/control/cfe/text/prot_jointcons.htm.
[31] Comprehensive Nuclear-Test-Ban Treaty (CTBT), Article IV, 1, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[32] CTBT, Article IV, 2, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[33] CTBT, Article IV, 29, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.

party that receives a request must provide the clarification to the requesting State party, as soon as possible, in any case no later than 48 hours after the request.[34] A State party shall have the right to request the Director-General to assist in clarifying any matter that may cause concern about possible non-compliance with the Treaty.[35] A State party also has the right to request the Executive Council to obtain clarification from another State party on any matter that may cause concern about possible non-compliance with the basic obligations of the Treaty.[36] In this case, the requested State party must provide the clarification to the Executive Council as soon as possible, but in any case no later than 48 hours after its receipt.[37] If the requesting State party deems the clarification to be inadequate, it has the right to request the Executive Council to obtain further clarification from the requested State party. If the requesting State party considers the clarification to be unsatisfactory, it has the right to request a meeting of the Executive Council. The Executive Council must consider the matter and may recommend any measure to redress a situation and to ensure compliance, including sanctions in accordance with the Article V, that is, restricting or suspending the State party from the exercise of its rights and privileges under this Treaty, recommending to State parties collective measures that conform with international law, and bringing the issue to the attention of the United Nations.

The sole purpose of an OSI is to clarify whether nuclear weapons test explosion or any other nuclear explosion has been carried out, and to the extent possible, to gather any facts that might assist in identifying any possible violator.[38] The requesting State party must present the OSI request to the Executive Council. The Executive Council must begin its consideration immediately upon receipt of the request, and take a decision on the request no later than 96 hours after receipt of the request.[39] The OSI request must include necessary information, including all data upon which the request is based and the result of a consultation and clarification or explanation of the reasons why such a consultation and clarification process has not been carried out.[40]

The OSI will be conducted in the least intrusive manner possible, but then proceed to more intrusive procedures only as it deems necessary to collect sufficient information to clarify the concern about possible non-compliance with the Treaty.[41] Upon conclusion of the inspection, the inspection team shall meet with the representative of the inspected State party to review the preliminary findings of the inspection team and to clarify any ambiguities.[42]

The Director-General of the Technical Secretariat must promptly transmit the inspection report to the requesting State party, the inspected State party, the Executive Council and to all other

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[34] CTBT, Article IV, 30, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[35] CTBT, Article IV, 31, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[36] CTBT, Article IV, 32, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[37] CTBT, Article IV, 32 (b) , https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[38] CTBT, Article IV, 35, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[39] CTBT, Article IV 38, 39 and 46, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[40] Protocol, Part II, Article 41, , https://fas.org/nuke/control/cfe/text/prot_jointcons.htm.
[41] CTBT, Article IV, 58, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[42] Protocol Part II, Article 109, https://fas.org/nuke/control/cfe/text/prot_jointcons.htm.

States parties, after making draft inspection report available to the inspected State party.[43] The Executive Council must review the inspection report and address any concern as to whether any non-compliance with the Treaty has occurred and whether the right to request an OSI has been abused.[44] If the Executive Council reaches the conclusion that further action may be necessary, it must take appropriate measures in accordance with Article V.[45]

Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction

The Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (BWC) includes no verification mechanism, such as OSI, which enables State parties to this Convention to systematically find or resolve ambiguities. Yet there are two mechanisms to address this within the Convention.

The first one is consultation and co-operation within relevant State parties to this Convention. Article V of this Convention stipulates that the States parties undertake to consult one another and to co-operate in solving any problems that may arise in relation to the objective of, or in the application of the provisions of, the Convention. Consultation and Co-operation pursuant to this Article may also be undertaken through appropriate international procedures within the framework of the United Nations and in accordance with its charter.

The second one is lodging complaints with the Security Council of the United Nations. According to Article VI of this Article, if any State party to this Convention finds that any other State party is acting in breach of obligations deriving from the provisions of this Convention, it may lodge a complaint with the Security Council. Such a complaint should include all possible evidence confirming its validity, as well as a request for its consideration by the Security Council. Each State party to this Convention undertakes to co-operate in carrying out any investigation that the Security Council may initiate. In accordance with the provisions of the Charter of the United Nations, on the basis of the complaint received by the Council, the Security Council shall inform the States parties to the Convention of the results of the investigation.

A further two measures have been established outside the convention to counter alleged use of bacterial (biological) and toxin weapons. The first is the investigation mechanism carried out by the Secretary-General of the United Nations, which was established by the Resolution 42/38 C of the United Nations General Assembly. The investigation is carried out in response to reports that may be brought to the Secretary-General's attention by any Member States concerning the possible use of bacteriological (biological) or toxin as well as chemical weapons in order to ascertain the facts of the matter, and to report promptly the results of any such investigation to

[43] CTBT, Article IV, 58, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[44] CTBT, Article IV, 65, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.
[45] CTBT, Article IV, 66, https://www.ctbto.org/fileadmin/user_upload/legal/CTBT_English_withCover.pdf.

all Member States.[46] The Secretary-General, with the assistance of qualified experts provided by interested Member States, develops further technical guidelines and procedures for the timely and efficient investigation of reports of the possible use of such weapons.[47] In order to conduct investigation, the Secretary-General (1) appoints experts to undertake investigation, (2) where appropriate, makes the necessary arrangements for experts to collect and examine evidence and undertake such testing as may be required, (3) seeks assistance as appropriate from Member States and the relevant international organizations.[48]

The BWC's mechanisms have never been used to date since they were introduced. Investigations by the Secretary-General have never applied to bacteriological (biological) and Toxin Weapons case, but mechanisms were put to use in chemical weapons cases in Syria and Iraq.

The second is investigation conducted by the Security Council based on its resolutions in specific cases of suspected use of WMD, including bacteriological (biological) weapons. In 1991 the Resolution 687 was adopted, which authorized the establishment of the United Nations Special Commission on Iraq and the United Nations Monitoring, Verification and Inspection Commission. Their mechanisms can be seen in the next section.

United Nations Special Commission on Iraq

The United Nations Special Commission (UNSCOM) on Iraq was created by the Security Council Resolution 687 of April 3, 1991. Its mandate was (1) to carry out immediate OSIs of Iraq's biological, chemical, and missile capabilities, (2) to take possession for destruction, removal, or rendering harmless of all chemical and biological weapons and all stocks of agents and all related sub-systems and components and all research, development, support, and manufacturing facilities, (3) to supervise the destruction by Iraq of all its ballistic missiles with a range greater than 150 km and related major parts, and repair and production facilities, (4) and to monitor and verify Iraq's compliance with its undertaking not to use, develop, construct, or acquire any of the items specified above. The Commission was also requested to assist the Director General of the IAEA, who was also requested to undertake activities similar to those of the Commission but specifically in the nuclear field. Further, the Commission was entrusted to designate for inspection any additional site necessary for ensuring the fulfillment of the mandates given to the Commission and the IAEA.

With regard to monitoring and verification, the Secretary-General and the IAEA Director-General submitted to the Security Council two separate but closely coordinated plans for compliance monitoring. Under its Resolution 715 of October 11, 1991, the Council mandated the Commission to implement the plan for ongoing monitoring and verification of permitted chemical, biological, and ballistic missile activities. The Council also requested the Commission

[46] United Nations General Assembly, Resolution 42/38 C, paragraph 4, https://undocs.org/en/A/RES/42/38.
[47] United Nations General Assembly, Resolution 42/38 C, paragraph 5, https://undocs.org/en/A/RES/42/38.
[48] United Nations General Assembly, Resolution 42/38 C, paragraph 7, https://undocs.org/en/A/RES/42/38.

to assist and cooperate with the IAEA in the implementation of the plan for ongoing monitoring and verification in the nuclear field.

Under the plans, Iraq was obliged to provide, on a regular basis, full, complete, correct, and timely information on activities, sites, facilities, material, or other items, both military and civilian, that might be used for purposes prohibited under relevant resolutions. Furthermore, the Commission and the IAEA had the right to carry out inspections, at any time and without hindrance, of any site, facility, activity, material, or other items in Iraq. They could conduct unannounced inspections and inspections at short notice and inspect on the ground or by aerial surveillance any number of declared or designated sites or facilities.

The resolution has no provision of the limitation on time and location of inspections, so it is understood that there was no need for further technical mechanisms to resolve ambiguities as inspectors could simply undertake further inspections and any outstanding issues could be dealt with directly at the political level.

The Commission's inspection and supervision activities covered multiple WMDs, including more than 40,000 chemical weapons and more than 800 scud missiles, and their destruction.

Conclusion

In the event of ambiguities we can see roughly four kinds of mechanisms to address/resolve them: (1) internal consultation between inspected state personnel on-site and the inspecting entity, (2) additional treaty mandated or agreed (and possibly more intrusive) inspections, (3) resolution in a standing compliance body, and (4) intervention of the United Nations, including by the Secretary-General and a specific body established under Security Council resolutions.

During internal consultation, different measures to address ambiguities could be offered, including inspection, ad hoc measurements, or procedures to be recorded, but this would not necessarily resolve the ambiguities. In such a case, solutions would be left to a political decision, not the inspecting entity.

In regard to compliance bodies, for multilateral treaties, they tend to be independent, for example, the IAEA for the NPT. For bilateral treaties such as START and New START, they are not independent but composed of representatives from both parties. In principle compliance bodies are used in case parties to an agreement are unable to resolve ambiguities and compliance issues at a lower level. However, ambiguities aren't usually resolved at lower levels but become agenda items for the work of their respective compliance bodies. At the compliance body, the parties should be prepared to explain what transpired during the inspection. This is usually documented in the inspection report itself but may need further explanation. In the case of questions regarding a party's compliance, the party raising the question must be able to provide some evidence to reinforce their questions or concerns.

As for the intervention of the United Nations, the examples cited above were created under unique circumstances, and careful study should be applied to whether they would be generally appropriate for future disarmament verification arrangements under a mutually agreed multilateral treaty.

These four mechanisms are chosen according to circumstances such as numbers of contracting parties, their relations and political circumstances surrounding contracting parties, and independence of an inspecting body. Also note that even when a treaty has a resolution mechanism, contracting parties may be reluctant to use it. Addressing such a challenge is important for future work toward global zero.

Paper 4. Nuclear Cultural Anthropology: An Exploration of the Influence of Cultural Norms and Changing Cultural Behaviors on Nuclear Cultures

Working Group 4: Verification of Nuclear Weapons Declarations

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Abstract

Cultural anthropology explores the influences of both shared cultural beliefs and practices, and social and cognitive cultural structures on societal behavioral norms and environments. This paper seeks to distill cultural anthropology even more narrowly, to explore the type of influences and manifestations of those beliefs, practices, and cultures within the nuclear culture and in the inverse, what influences the elements of nuclear culture may have on broader cultural and behavioral norms. The study of cultural anthropology is grounded in observation, thus the information provided by this paper will be revealed through the explication of Heuristic Inquiry to explain the lived experience of the nuclear cultural environment.[49] The one issue with any explorative inquiry, including heuristics, is the potential for behavioral misinterpretation as a result of the interpreter's cognitive bias. This bias is commonly described with the term "mirror-imaging," a practice through which a behavioral interpreter establishes perceptions of another party's actions or intentions based upon the interpreter's personal experiences and cultural norms. Because of this potential, heuristic inquirers must ensure that only facts are gathered, and that those facts are based upon open-ended and non-guiding questions and empirically validated, historic information. so that the resulting themes are grounded in fact.

The Importance of Understanding Nuclear Cultural Anthropology

Nuclear cultural anthropology helps to explain the social and cultural behaviors that influence how and why nuclear weapon possessor States undertake different actions and exhibit or foster behaviors that are inherent to their nuclear safety and security environment. Although some common anthropological themes exist across nuclear weapon possessor States, the influence of the nuclear culture may manifest itself differently depending upon the country's root culture. In very large and culturally diverse nuclear weapon possessor States, those manifestations may differ regionally as well because of internal cultural variability. An understanding of a nuclear

[49] C. Moustakas, *Heuristic Research: Design, Methodology and Applications* (Newbury Park, California: Sage, 1990).

weapon possessor State’s nuclear cultural anthropology and regional variations could be very beneficial for treaty partners, especially when seeking to establish a common foundation from which to work.

The understanding of these cultural influences and how they manifest can serve to foster the development of greater trust between partner States. It can also serve as a mechanism to educate partners on information that could be shared to provide greater transparency and support future verification. Anthropological information may include such topics as what types of actions/behaviors are normal within a partner’s nuclear weapons environment, (e.g., what safety/security behaviors and actions are inherent in the lifecycle and how are they applied, what types of elements are critically protected and why, and where there may be spaces to collaborate, which would allow for establishing/building trust and delivering provisions by which confidence can be developed), and how lifecycle elements are defined. Equally important is an understanding of the cultural and behavioral norms within that partner’s overall culture, how they vary region by region, and why the different norms exist (history).

Understanding nuclear cultural anthropology as a construct will support the verification of specific nuclear disarmament agreements, for example, by creating over time a more comprehensive “map” of nuclear weapon activities/behaviors that are the “norm” or part of the culture and can be witnessed in regular interaction, against which it would be easier to detect anomalous behaviors, or behaviors that are outside that treaty party’s cultural norms.

The United States: A Culture of Deterrence

The United States has a culture of deterrence, and although some might find this difficult to believe, that deterrence culture is not simply rooted in nuclear weapons or even in defense. Instead, within and emanating from the U.S. contexts, there are two root causes for deterrence. First, an internal or domestically constructed system of checks and balances; and second, the external deterrence dimension resulting from a matured self-perception of world political roles, post–Pearl Harbor. Therefore the U.S. deterrence culture is a double helix or dyad particular to the U.S. context and does not necessarily exist for other nuclear weapon possessors. As a result of this dyadic circumstance, deterrence is not simply an external response for the United States; instead, it is embedded in the make-up of its cultural norms holistically.

The U.S. domestic deterrence culture originated and matured from a rules- and laws-based foundation firmly established by the United States Constitution, its amendments, and the Bill of Rights. The U.S. Constitution identifies the levels and divisions of power, divided between the executive, legislative, and judiciary branches of the U.S. government. This division of power and authority also includes within each purview, the element of deterrence. The Bill of Rights and Amendments to the Constitution are used to establish specific inalienable rights that cannot be restricted or removed by those in authority without changing the constitutional amendment itself. This level of deterrence assures that leadership is prevented from establishing rules and laws that benefit leadership but injure the people.

This deterrence culture is firmly entrenched in many aspects of American life, spanning from education to law enforcement. In both education and law enforcement, the culture of deterrence demonstrates the thinking that deterrence needs not to simply defend against bad behavior, but should also instill significant enough punishment as to deter others from engaging in the same behavior.[50] In many cases precursory behaviors are deterred at a much more gentle level in the hopes that the threat of greater punishment, if that behavior persists will be sufficient to prevent its escalation. In the case that it is not successful, the United States has provided mechanisms to deliver enough punishment and publicity of that punishment through the guarantees of the first amendment and accessibility of journalists to information, to deter bad actors from following the same path that was punished.

The U.S. deterrence culture matured into something strategically actionable during World War II, with the deterrence processes, procedures, steps, and responses most broadly recognized afterward between the U.S and Russia in the Cold War. One can discern at this point because of the existence of a Russian nuclear weapons State with which the U.S. had to contend. Deterrence in the U.S.–Russian relationship has been described as a force/counterforce balancing agreement, used to prevent what is agreed by both parties as an “unacceptable level of damage,” a term historically referring to the potential of catastrophic civilian casualties. It is perceived that only under the threat of such damage, would two parties with such a devastating destructive capability, agree to such balancing and prevent mutual destruction.

Although external deterrence is focused on whoever is determined to be the direct adversary, many internal cultural behaviors and functions exist that result from a deterrence culture and the need to ensure that the deterrence is credible (i.e., that it will function as expected if required, that the deterrer has the capability to act upon the threat, and that the threat can be communicated in such a way that it can be heard by the adversary).[51] The most pertinent of those cultural reflections includes risk aversion, resulting in heightened safety and security processes, procedures, and behaviors to protect the nuclear weapon, its environment, and personnel.

Behavioral Examples of the Deterrence Culture: Heightened Safety and Security Processes

In a deterrence culture the resulting heightened safety and security processes, procedures, and behaviors should be expected to include things like access control programs. In the United States, such programs assure that only personnel with the appropriate training and need-to-know have access to a nuclear weapon, and even with appropriate need-to-know, additional access requirements remain in place. The term “managed access” is commonly used in treaty-related discussions, but that same approach is also commonly applied to the employees of the

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[50] G.P. Shultz, S.D. Drell, and J. E., *Goodby Deterrence: It’s Past and Future* (Hoover Institution Press: Stanford, California, 2010).

[51] Ibid; and *Henry D. Sokolski and Robert Zarate, Nuclear Heuristics: Selected Writings of Albert and Roberta Wohlstetter*, January 2009, https://publications.armywarcollege.edu/pubs/1985.pdf.

weapon State as well. Different layers of access within sites and facilities prevent people without access approvals for getting near nuclear weapons operations. As each layer gets closer to the operation, the access requirement becomes more stringent.

For those afforded access to the operational areas, no lone person can have access to nuclear weapons regardless of their role or certifications. All nuclear weapons facilities require no fewer than two personnel to enter. Additionally, once in the facility, all personnel must be within visual line of sight of each other for general access and none can be within six feet of the weapon, alone. Along with this two-person concept is an additional safety/security operational function called "reader, worker, checker," which is an approach to conducting operations that ensures that both personnel performing work are paying complete attention to everything going on in the conduct of that work, including the behaviors of their partner so that each step must be affirmed as being performed correctly and recorded complete, before a new step can be undertaken.

In maintenance configurations, additional access constraints are applied on top of the general constraints, which ensure that if any operations are ongoing, two people are required to be within six feet of the nuclear weapon, and that there is no additional unescorted access during those operations. Those two people allowed within the six feet must be certified in the Human Reliability (HRP) or Personnel Reliability Programs (PRP), have the appropriate clearance and training, and both be certified to conduct the actions required for the operation. To be approved in the HRP or PRP programs, personnel must be certified to be physically and mentally stable, and that stability is reverified annually unless circumstances require more frequent review. HRP/PRP employees undergo continuous behavioral observation to ensure that external issues cannot negatively influence safety and security judgements. Additional factors such as risky financial behaviors, addictive behaviors, some health conditions, and emotional control issues may be grounds for decertification from either program. HRP/PRP certification gives confidence that workers can be trusted to behave within the requirements of the environment.

In addition to these access control requirements, all processes and procedures are tightly engineered and approved through a verification mechanism to ensure that all information has been validated with a safety basis process. Employees are not permitted to deviate from those procedures, and anyone caught attempting to do so will face severe consequences. Tools and equipment are also scrutinized at this same level to ensure that nothing that has not already been thoroughly reviewed and assessed can contact the nuclear weapon. Transportation protocols also exist, which determine when items can be transferred and how that transference can be performed. Traffic controls requirements may be in place to ensure the best probability of safe travel, as well as specialized containers used to protect weapons from weather hazards in some environments.

Broader Cultural Context

Historically, anthropologists have consulted three schools of thought regarding the context of culture: the first, espoused by Schwartzman (1992) perceives culture on a national level, externally influencing behaviors from a national cultural perspective. The second, harkening back to the results of the Hawthorn Studies describes culture as something that has both formal and informal elements that depend on the needs, expectations, and requirements of the organization and have little to do with national culture; and the third considers culture to be rooted instead in the organizational processes both formal and informal, developing a separate subculture to which workers within the organization belong in addition to their national, or in our case also potentially regional, culture.[52]

This third description explains the cross-pollination of nuclear culture and social culture behavioral elements that are commonly found when comparing the cultural behaviors of nuclear weapons workers and non-nuclear weapons workers. In some cases, those new behaviors bleed into the broader community as well.

For example, in the United States citizens are taught what is perceived as right and wrong culturally. When applied to the nuclear weapons environment, that right and wrong become more distinctly honed for nuclear environment specific activities, providing a strongly reinforced set of cultural norms that drive and control behaviors. Those things commonly translate into social culture through the development or need for more process-driven actions within day-to-day external activities, heightened safety practices and teaming. History has demonstrated that when people work in these types of environments, a separate sense of cultural orientation emerges over time. There grows a perspective of community with the people with whom the environment is shared, people grow to recognize differently the topics of focus, responsibility, and accountability that exceed that of traditional social culture.

Conclusion

While these behaviors may be considered "right" in the U.S. nuclear enterprise, it does not mean that those same behaviors may be considered right for another party or may even be defined in the same manner. When viewed through a lens of U.S. nuclear culture, difficulties exist in interpreting the nuclear cultural norms of other countries as valid. They may not align with our own because they are blended from the social culture of that party and how they define their nuclear environment as a result. This does not mean that it is impossible to learn about another possessor State's culture, only that because of cultural norms and perceptions, specific actions are necessary to develop an understanding of the differences between parties' cultures and why those exist.

In a disarmament context, this means that possessor states' understanding of each other's nuclear *Lebenswelt*[53] will be necessary to make progress. Although progress may be slow and constrained, the maturation of that understanding as a key aspect of the progress will ensure that a relationship can be built that may establish a foundation of trust upon which future

[52] Paul E. Bierly III and J.C. Spender, "Culture and High Reliability Organizations: The Case of the Nuclear Submarine," *Journal of Management* 21, no. 4 (1995): 639–56.

[53] *Lebenswelt* is defined as the world of lived experience. Merriam-Webster, s.v. "Lebenswelt," https://www.merriam-webster.com/dictionary/Lebenswelt?utm_campaign=sd&utm_medium=serp&utm_source=jsonld.

collaborations may be built; spaces can be identified in which both, or in some cases multiple, parties may still feel safe; and the diverse cultures may not be invalidated. Without the development of trust, the potential for progress is tightly limited and true collaboration likely can never be reached.

This is a product of the IPNDV Working Group 4: Verification of Nuclear Weapon Declarations. For more information on the IPNDV Working Groups, please see www.ipndv.org/working-groups.

About the IPNDV:

The 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.

The IPNDV is working to identify critical gaps and technical challenges associated with monitoring and verifying nuclear disarmament. To do this, the Partnership assesses monitoring and verification issues across the nuclear weapon lifecycle.

The IPNDV is also building and diversifying international capacity and expertise on nuclear disarmament monitoring and verification. Through the Partnership, more countries understand the process, as well as the significant technical and procedural challenges that must be overcome. At the same time, the Partnership is highlighting the importance of verification in future reductions of nuclear weapons.