UNMAKING THE BOMB

VERIFYING LIMITS ON THE STOCKPILES
OF NUCLEAR WEAPONS

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Short Course on Nuclear Weapon and Related Security Issues
American Physical Society, Washington, DC, April 21, 2017
INTERNATIONAL PARTNERSHIP
FOR NUCLEAR DISARMAMENT VERIFICATION

Established in 2015; currently 26 participating countries

Working Group One: “Monitoring and Verification Objectives” (chaired by Italy and the Netherlands)
Working Group Two: “On-Site Inspections” (chaired by Australia and Poland)
Working Group Three: “Technical Challenges and Solutions” (chaired by Sweden and the United States)

www.state.gov/t/avc/ipndv
WHAT’S NEXT FOR NUCLEAR ARMS CONTROL?

2015 STATEMENT BY JAMES MATTIS

“The nuclear stockpile must be tended to and fundamental questions must be asked and answered:

• We must clearly establish the role of our nuclear weapons: do they serve solely to deter nuclear war? If so we should say so, and the resulting clarity will help to determine the number we need.
• Is it time to reduce the Triad to a Diad, removing the land-based missiles? This would reduce the false alarm danger.
• Could we re-energize the arms control effort by only counting warheads vice launchers?
• Was the Russian test violating the INF treaty simply a blunder or a change in policy, and what is our appropriate response?”

General James N. Mattis, USMC (Ret.)
Former Commander, United States Central Command

Senate Armed Services Committee
Global Challenges and U.S. National Security Strategy
January 27, 2015
WHAT IS TO BE VERIFIED?
THOUSANDS OF NUCLEAR WEAPONS
ARE CURRENTLY NON-DEPLOYED (i.e., IN RESERVE OR AWAITING DISMANTLEMENT)

W87/Mk-21 Reentry Vehicles in storage, Warren Air Force Base, Cheyenne, Wyoming
Photo courtesy of Paul Shambroom, www.paulshambroom.com
MAPPING NUCLEAR VERIFICATION

www.verification.nu
VERIFICATION CHALLENGES OF DEEP REDUCTIONS

- Establishing confidence in the absence of undeclared stocks or production
- Verifying numerical limits on declared nuclear warheads
- Confirming the authenticity of nuclear warheads
COUNTING WARHEADS
TAGGING

TRANSFORMING A “NUMERICAL LIMIT” INTO A “BAN ON UNTAGGED ITEMS”

Source: www.automoblog.net

WARHEAD TAGGING OPTIONS

VERIFYING NUMERICAL LIMITS OF DECLARED NUCLEAR WARHEADS

1. Serial number on warhead
2. Unique ID on warhead
3. Simple Buddy Tag
4. Buddy Tag with serial number


Source: John Rogers, University of Illinois
HASHED DECLARATIONS

ITEM 01: 67d9780b84a6db872aacc400a0f5eaeecbec52012503111891b0d1e89711605
ITEM 02: 8edd164eb3fd9116 SITE C :: W99 :: TIME 12345678 a562c8ffeefbc2fb
ITEM 03: 2abd37560821d1e5007a26c3ec0e25a1646dce5258605e0a2ef207ecf98520
ITEM 04: 340bcbda4afb3409fd2759f0a3ac029270727c87c63568db6417d8153765a2
ITEM 05: f5c53f5c375c22f6e20554d5d7488f1cc678aaa4fd50ca7707c4755d7b12b
ITEM 06: bca498040e0b5d2f8533d91d68e268178752111538edee4401277bc6cfa2e3
ITEM 07: 368bfb3e543c11dec2511b38e59dd4dadf7eb0d87d3128d8f3f13c0b37073c5
ITEM 08: a1e89078ac797a3cfc8423965ca96664b62e212597e1b9c2a0e041778fd4
ITEM 09: 4108821ea003aaceefdb8c2d86126c33a51562043bd36e5e126cb3e1446896
ITEM 10: 4161814ef03933b605958325ca0a4fd50ca7707c4755d7b12b
ITEM 11: 023cc75fce8d55eb9ceca6a4fb9f797d50335549084abfccc147c9790d6642
ITEM 12: f800ac30c39e2662fa6f082f2a574ae865308be5bb49cde11d0ebf26b6a8c
ITEM 13: 540bcd04af3409fd2759f0a3ac029270727c87c63568db6417d8153765a2
ITEM 14: 023cc75fce8d55eb9ceca6a4fb9f797d50335549084abfccc147c9790d6642
ITEM 15: 8edd164eb3fd9116 SITE C :: W99 :: TIME 12345678 a562c8ffeefbc2fb
ITEM 16: 368bfb3e543c11dec2511b38e59dd4dadf7eb0d87d3128d8f3f13c0b37073c5

Declaration in hashed form (with one entry per item)

ITEM 01: 67d9780b84a6db872aacc400a0f5eaeecbec52012503111891b0d1e89711605
ITEM 02: 8edd164eb3fd9116 SITE C :: W99 :: TIME 12345678 a562c8ffeefbc2fb
ITEM 03: 2abd37560821d1e5007a26c3ec0e25a1646dce5258605e0a2ef207ecf98520
ITEM 04: 340bcbda4afb3409fd2759f0a3ac029270727c87c63568db6417d8153765a2
ITEM 05: f5c53f5c375c22f6e20554d5d7488f1cc678aaa4fd50ca7707c4755d7b12b
ITEM 06: bca498040e0b5d2f8533d91d68e268178752111538edee4401277bc6cfa2e3
ITEM 07: 368bfb3e543c11dec2511b38e59dd4dadf7eb0d87d3128d8f3f13c0b37073c5
ITEM 08: a1e89078ac797a3cfc8423965ca96664b62e212597e1b9c2a0e041778fd4
ITEM 09: 4108821ea003aaceefdb8c2d86126c33a51562043bd36e5e126cb3e1446896
ITEM 10: 4161814ef03933b605958325ca0a4fd50ca7707c4755d7b12b
ITEM 11: 023cc75fce8d55eb9ceca6a4fb9f797d50335549084abfccc147c9790d6642
ITEM 12: f800ac30c39e2662fa6f082f2a574ae865308be5bb49cde11d0ebf26b6a8c
ITEM 13: 540bcd04af3409fd2759f0a3ac029270727c87c63568db6417d8153765a2
ITEM 14: 023cc75fce8d55eb9ceca6a4fb9f797d50335549084abfccc147c9790d6642
ITEM 15: 8edd164eb3fd9116 SITE C :: W99 :: TIME 12345678 a562c8ffeefbc2fb
ITEM 16: 368bfb3e543c11dec2511b38e59dd4dadf7eb0d87d3128d8f3f13c0b37073c5

Declaration with entries for Site C revealed

Adapted from:
Monitoring Nuclear Weapons and Nuclear-Explosive Materials
National Academy of Sciences, Washington, DC, 2005
CONFIRMING THE AUTHENTICITY OF WARHEADS
VERIFICATION CHALLENGES OF DEEP REDUCTIONS

Confirming the authenticity of nuclear warheads
NUCLEAR WEAPONS HAVE UNIQUE SIGNATURES
BUT THEY ARE SENSITIVE AND CANNOT BE REVEALED TO INSPECTORS

U.S. Scientists on a Soviet Cruiser in the Black Sea, 1989
### NUCLEAR WARHEAD VERIFICATION

#### KEY CONCEPTS OF (PROPOSED) SYSTEMS

<table>
<thead>
<tr>
<th>Attribute Approach</th>
<th>Confirming selected characteristics of an object in classified form (for example, the presence/mass of plutonium)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Template Approach</td>
<td>Comparing the radiation signature from the inspected item with a reference item (“golden warhead”) of the same type</td>
</tr>
<tr>
<td>Information Barriers</td>
<td>Technologies and procedures that prevent the release of sensitive nuclear information (generally needed for both approaches)</td>
</tr>
</tbody>
</table>

*edited by D. Spears, 2001*
WARHEAD AUTHENTICATION AND VERIFIED WARHEAD DISMANTLEMENT

IMPORTANT PRECEDENTS EXIST AND FUTURE WORK CAN BUILD ON THEM
WHAT’S NEXT?
WHAT TO DO WHEN THERE REMAIN ENDURING CONCERNS WITH REGARD TO VERIFICATION TECHNOLOGIES AND APPROACHES

CONTINUE IMPROVING TECHNOLOGIES AND APPROACHES

Work on information barriers with a particular focus on certification and authentication; in particular, identify joint hardware and software development platforms.

REINVENT THE PROBLEM: NEVER ACQUIRE SENSITIVE INFORMATION TO BEGIN WITH

Explore radically different verification approaches; for example, consider zero-knowledge protocols and develop alternatives to onsite inspections at certain sensitive facilities.

REVEAL THE SECRET

Requirement to protect sensitive information is typically the main reason for complexity of verification approaches; for example, mass of fissile material in a nuclear weapon.

Source: Author (top and bottom), Christian Zenger (middle)
“DEFERRED VERIFICATION”

Areas that are off limits for inspectors (requires robust perimeter control)
“DEFERRED VERIFICATION”


Footprint of off-limit areas shrinks over time
VIRTUAL REALITY FOR NUCLEAR ARMS CONTROL

(with full-motion capability, co-presence, and real-time virtual radiation fields)

TO ENGAGE THE PUBLIC AND INTERNATIONAL GOVERNMENT PARTNERS