

UNMAKING THE BOMB

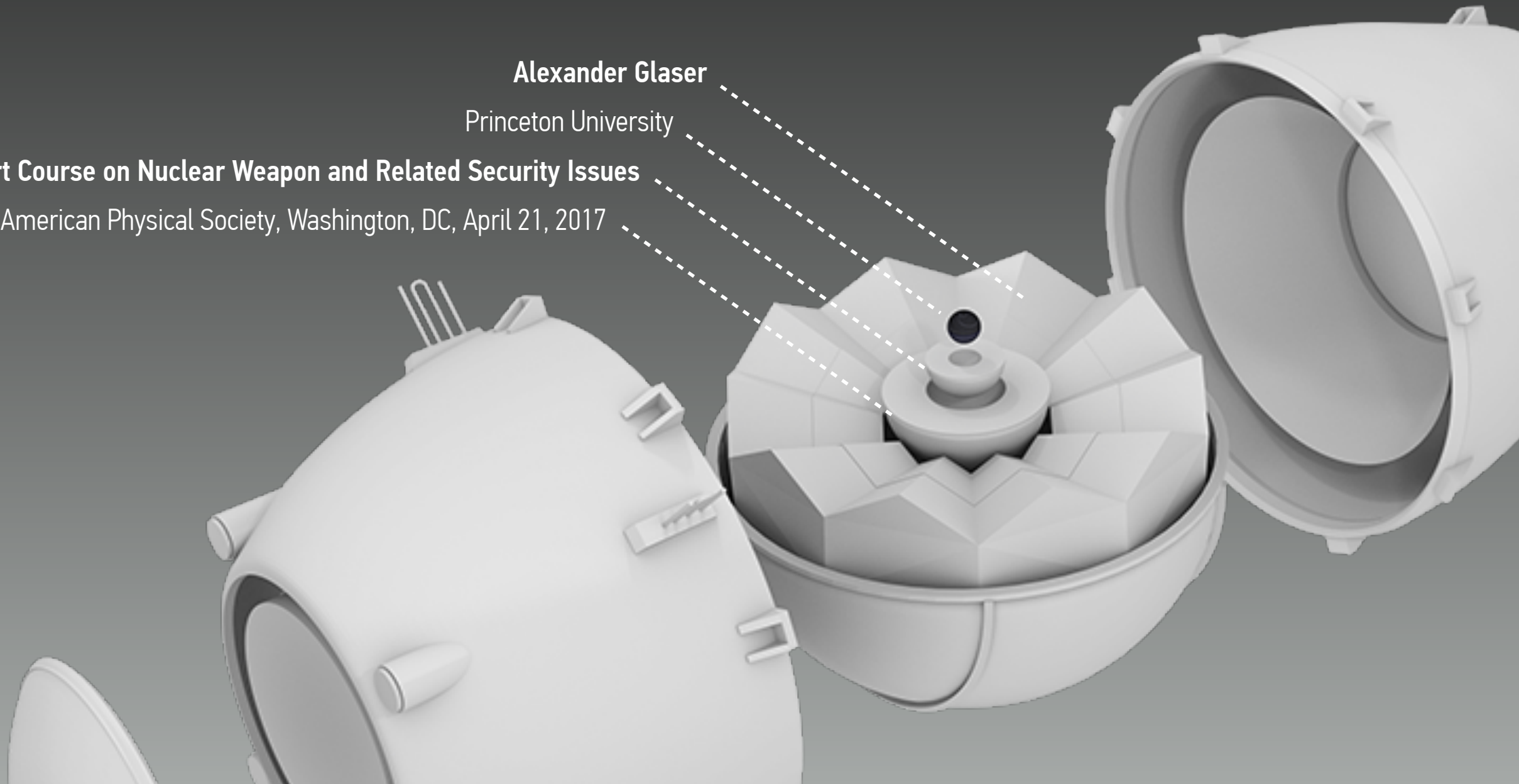
VERIFYING LIMITS ON THE STOCKPILES OF NUCLEAR WEAPONS

Alexander Glaser

Princeton University

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

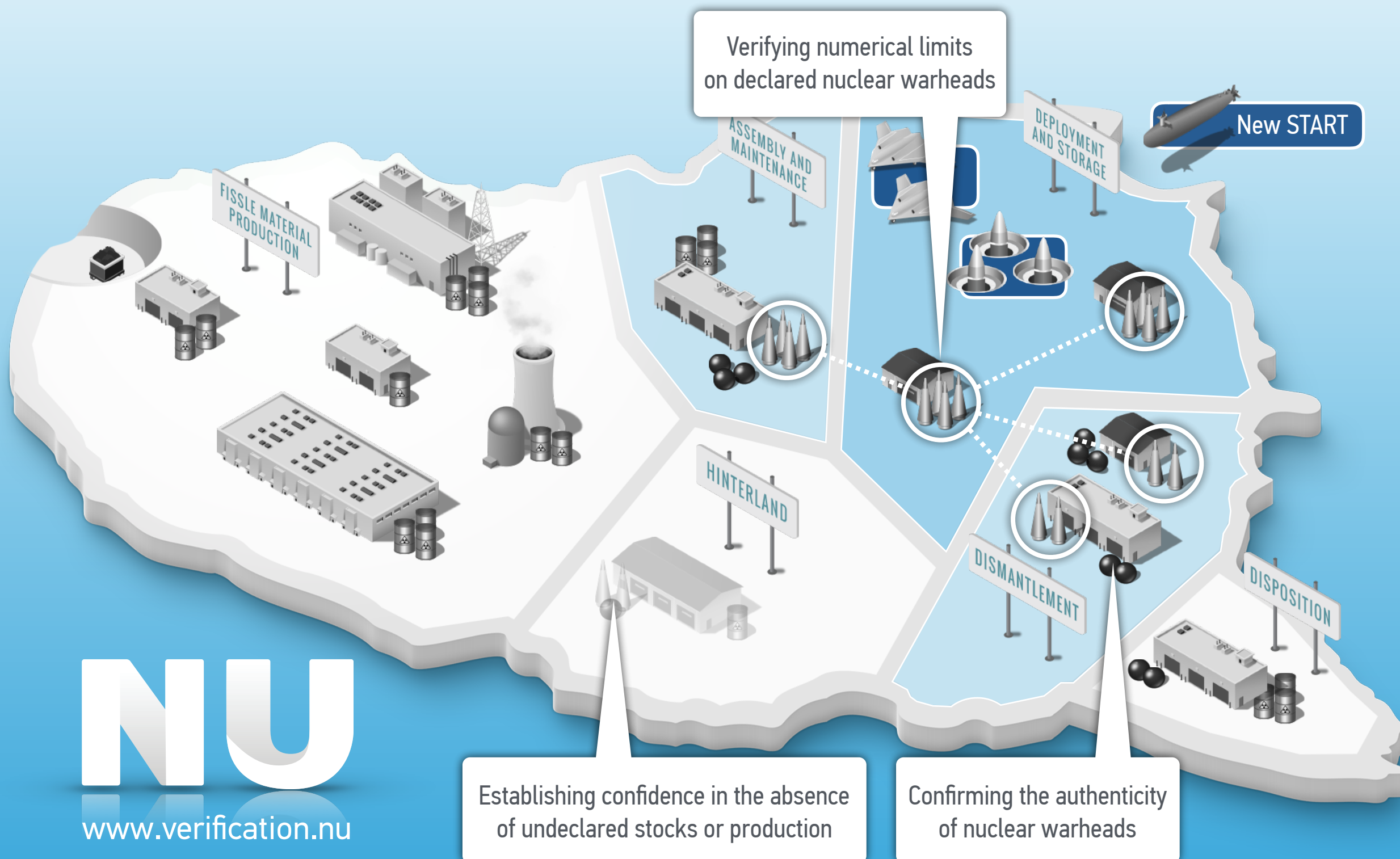
MAPPING NUCLEAR VERIFICATION



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www.verification.nu

VERIFICATION CHALLENGES OF DEEP REDUCTIONS



COUNTING WARHEADS

TAGGING

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

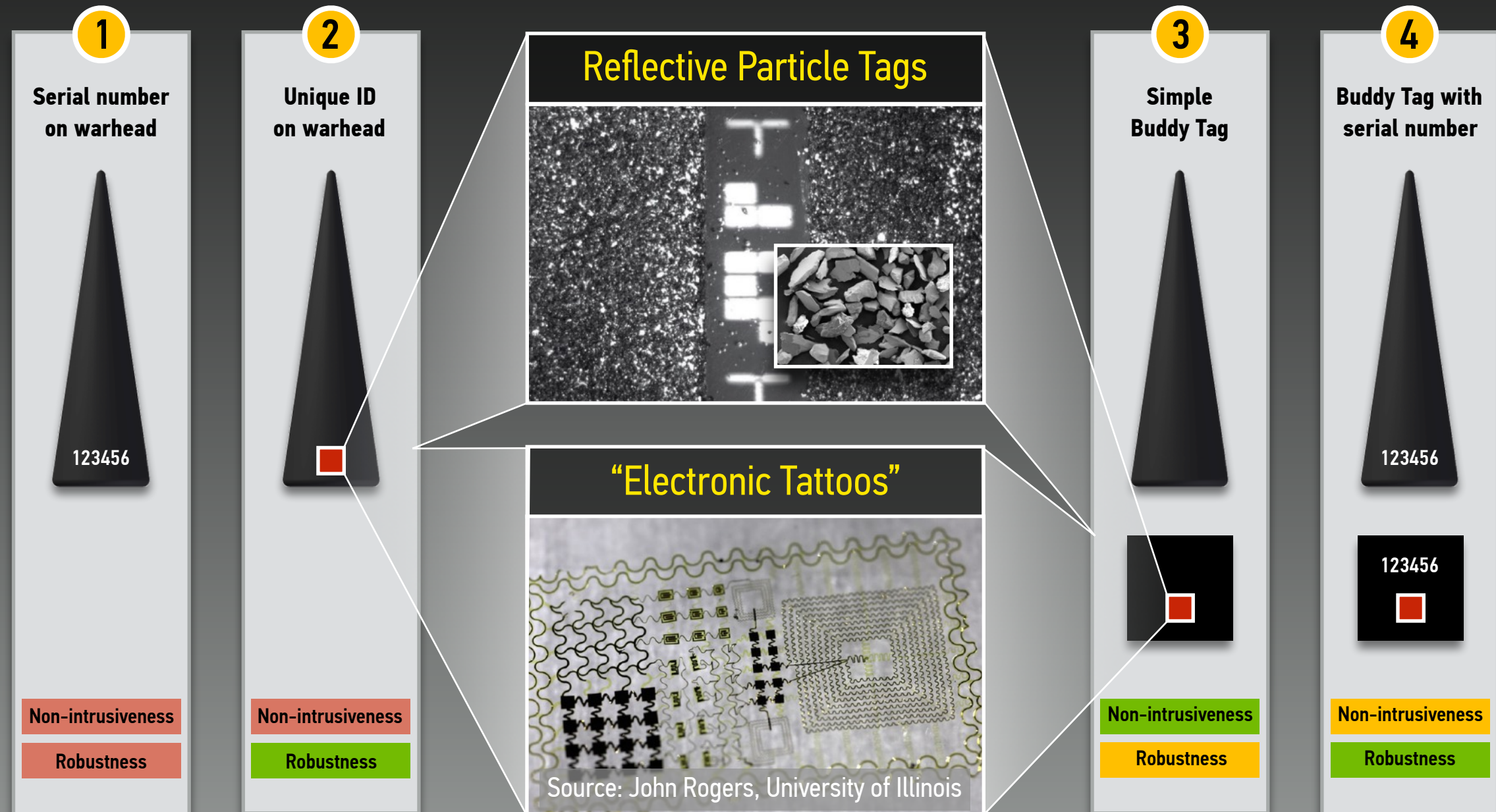


Source: www.automoblog.net

Steve Fetter and Thomas Garwin, “Using Tags to Monitor Numerical Limits in Arms Control Agreements”
in Barry M. Blechman, ed., *Technology and the Limitation of International Conflict*, Washington, DC, 1989, pp. 33–54

VERIFYING NUMERICAL LIMITS OF DECLARED NUCLEAR WARHEADS

WARHEAD TAGGING OPTIONS



Reflective particle tag concept: A. Gonzales, *Reflective Particle Tag for Arms Control and Safeguards Authentication*, Sandia National Laboratories, 2004

Original buddy tag concept: S. E. Jordan, *Buddy Tag's Motion Sensing and Analysis Subsystem*, Sandia National Laboratories, 1991

HASHED DECLARATIONS

ITEM 01: 67d97802b84a6db872aacc400a0f5eaecebc52012503111891b0d1e89711605
 ITEM 02: b3c22af3a5f9ecc51c5cf6b4604e2bef191e4ceb305c6ef4a9589206e0bd7e62
 ITEM 03: 0b277554264c8d00e81fb4b0af3f39f753146c8881ce093d7d45e8212cce95ac
 ITEM 04: 4161814ef03933b605958325ca0aa3a3d9d2106f8f79b2c28cec5e75ea70266b
 ITEM 05: f5c53f5c375c22f6e20554d5d7488f1cc678caa4fdc50aca77057c4755d7b12b
 ITEM 06: fb28390a1b3db5db0fb44534a8a8c8716dccf64aa41828658b5fcadaf82b37c8
 ITEM 07: 368bfb3e543c11dec2511b38e59dd4dadf7eb0ed87d3128d8f3f13c0b37073c5
 ITEM 08: a1e89078ac797a3cfc8423965ca966645b62e2e212597e81b9c2a2e041778fd4
 ITEM 09: f7618c3fead199ec24dcdbf6854d993330a8870c9e6a313d15d8fd988877f813
 ITEM 10: 2abd37560821d1e5007a26c3ec0e25a16c46dcea5258605e0a2ef207ecf98520
 ITEM 11: 9280cac30c39ea62daf66f082f2a574ae865308be5bb49cce11dabebf26a6a8c
 ITEM 12: f7467d431353ce15dfe0dc6395e9e6a8806afd3222467ffb5eb1105bfa90bb31
 ITEM 13: 023cc75fce0d55eb9cce5aa4b9f79d20d3da555c98048abfcc147c797a8db642
 ITEM 14: 4108821ea003aaceefdb8c2d86126c33a5315b62043b36d5e612bc831e446896
 ITEM 15: 340bcbda4afb3409f2d750f0a3ac029270a27e727c83650d8b6417d8153765a2
 ITEM 16: bca49804e0b0da52df8f533d91d680e26818752111538dea4401277bc6cfa2e3

Declaration in hashed form (with one entry per item)

ITEM 01: 67d97802b84a6db872aacc400a0f5eaecebc52012503111891b0d1e89711605
 ITEM 02: b3c22af3a5f9ecc51c5cf6b4604e2bef191e4ceb305c6ef4a9589206e0bd7e62
 ITEM 03: **8edd164eb3fd9116 SITE C :: W99 :: TIME 12345678 a562c8ffefbc2fb**
 ITEM 04: 4161814ef03933b605958325ca0aa3a3d9d2106f8f79b2c28cec5e75ea70266b
 ITEM 05: f5c53f5c375c22f6e20554d5d7488f1cc678caa4fdc50aca77057c4755d7b12b
 ITEM 06: fb28390a1b3db5db0fb44534a8a8c8716dccf64aa41828658b5fcadaf82b37c8
 ITEM 07: 368bfb3e543c11dec2511b38e59dd4dadf7eb0ed87d3128d8f3f13c0b37073c5
 ITEM 08: **25b78703bcbdcfa7 SITE C :: W99 :: TIME 12345678 0e62292b6c2f98a3**
 ITEM 09: **184702dc19247c56 SITE C :: W99 :: TIME 12345678 6f2efeb7be00fc82**
 ITEM 10: 2abd37560821d1e5007a26c3ec0e25a16c46dcea5258605e0a2ef207ecf98520
 ITEM 11: **c02d3fee2ad8a77a SITE C :: W99 :: TIME 12345678 dfa54d7edc14494b**
 ITEM 12: f7467d431353ce15dfe0dc6395e9e6a8806afd3222467ffb5eb1105bfa90bb31
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 ITEM 14: 4108821ea003aaceefdb8c2d86126c33a5315b62043b36d5e612bc831e446896
 ITEM 15: 340bcbda4afb3409f2d750f0a3ac029270a27e727c83650d8b6417d8153765a2
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Declaration with entries for Site C revealed

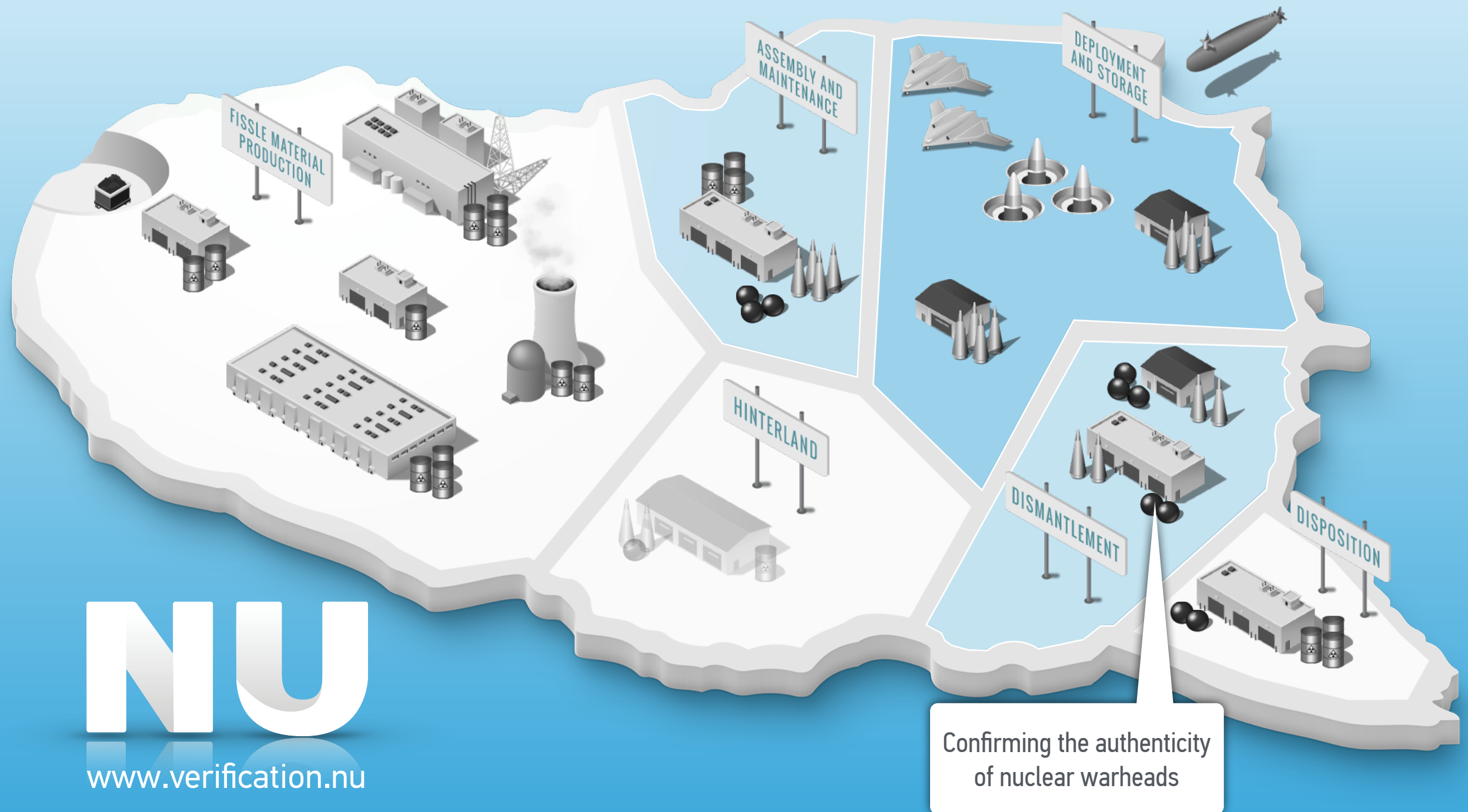


Adapted from:

Monitoring Nuclear Weapons and Nuclear-Explosive Materials
 National Academy of Sciences, Washington, DC, 2005

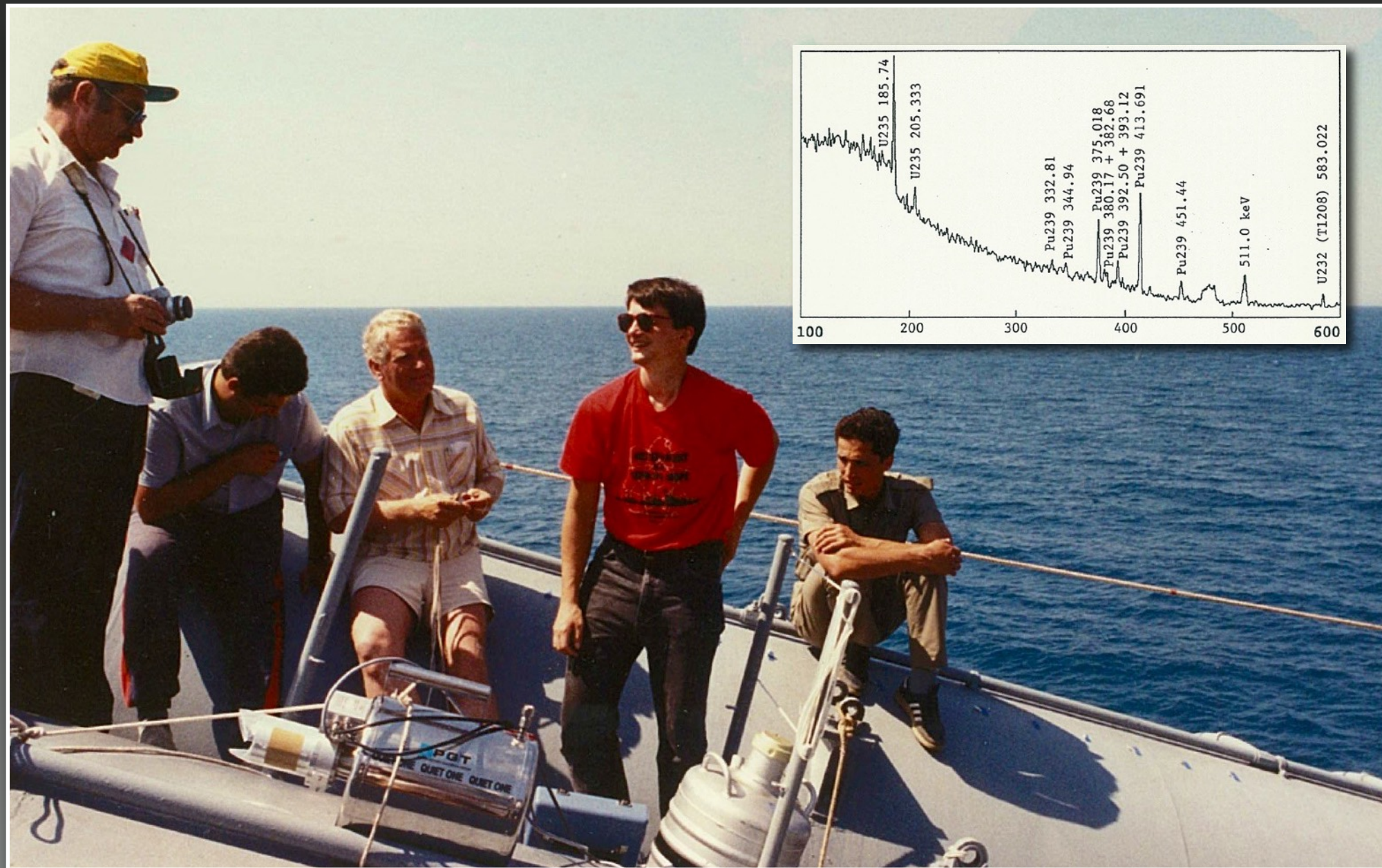
CONFIRMING THE
AUTHENTICITY OF WARHEADS

VERIFICATION CHALLENGES OF DEEP REDUCTIONS



NUCLEAR WEAPONS HAVE UNIQUE SIGNATURES

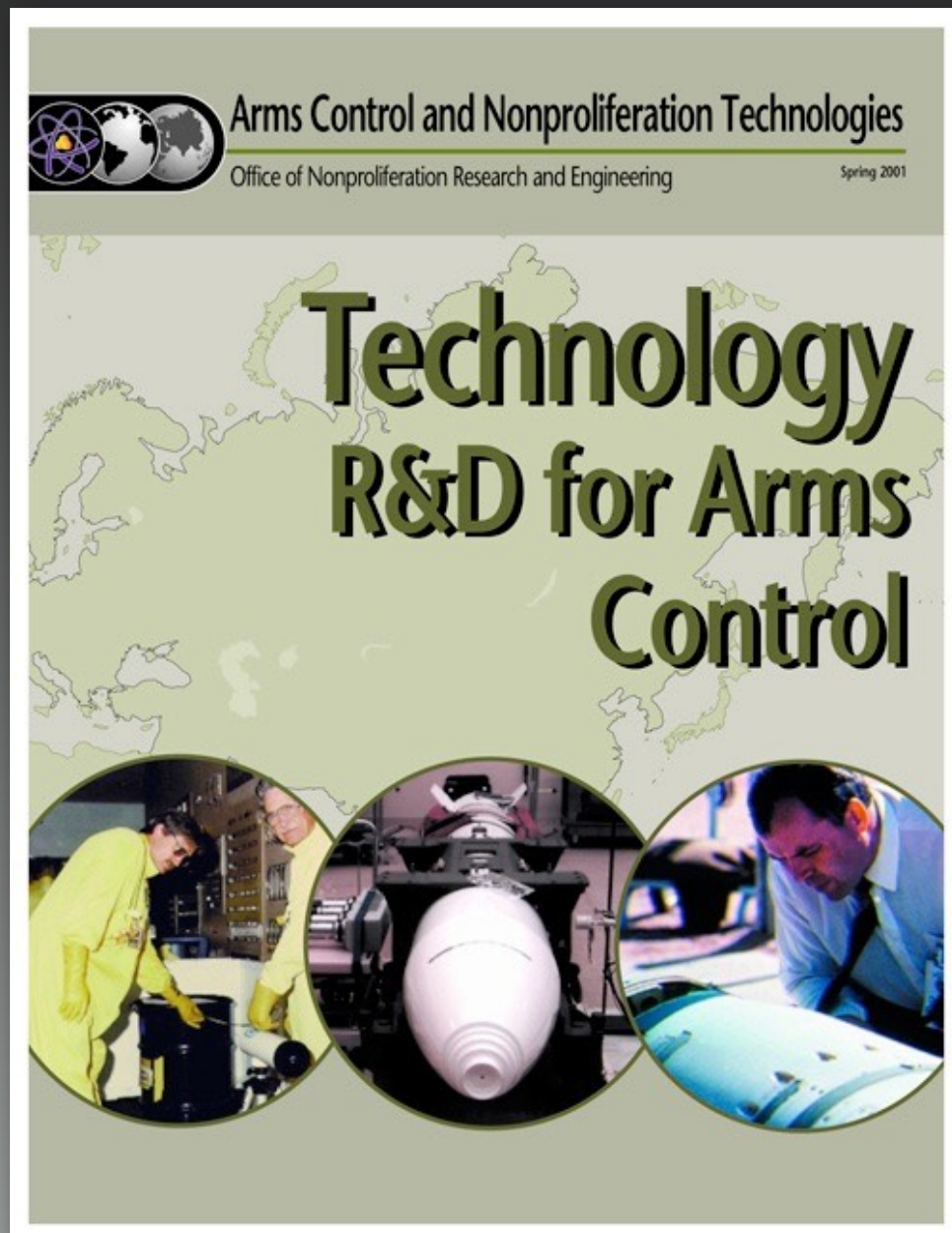
BUT THEY ARE SENSITIVE AND CANNOT BE REVEALED TO INSPECTORS



U.S. Scientists on a Soviet Cruiser in the Black Sea, 1989

NUCLEAR WARHEAD VERIFICATION

KEY CONCEPTS OF (PROPOSED) SYSTEMS



edited by D. Spears, 2001

ATTRIBUTE APPROACH

Confirming selected characteristics
of an object in classified form
(for example, the presence/mass of plutonium)

TEMPLATE APPROACH

Comparing the radiation signature
from the inspected item with a reference item
("golden warhead") of the same type

INFORMATION BARRIERS

Technologies and procedures that
prevent the release of sensitive nuclear information
(generally needed for both approaches)

WARHEAD AUTHENTICATION AND VERIFIED WARHEAD DISMANTLEMENT

IMPORTANT PRECEDENTS EXIST AND FUTURE WORK CAN BUILD ON THEM



Inspection System developed as part of the
Trilateral Initiative during a demonstration at Sarov
Source: Tom Shea



2nd Prototype of the Information Barrier
developed as part of the UK-Norway Initiative
Source: Ole Reistad et al.



Trusted Radiation Identification System (TRIS)
developed by Sandia National Laboratories
Source: U.S. Department of Energy

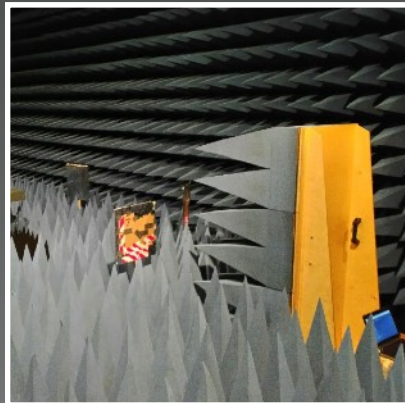
WHAT'S NEXT?

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)

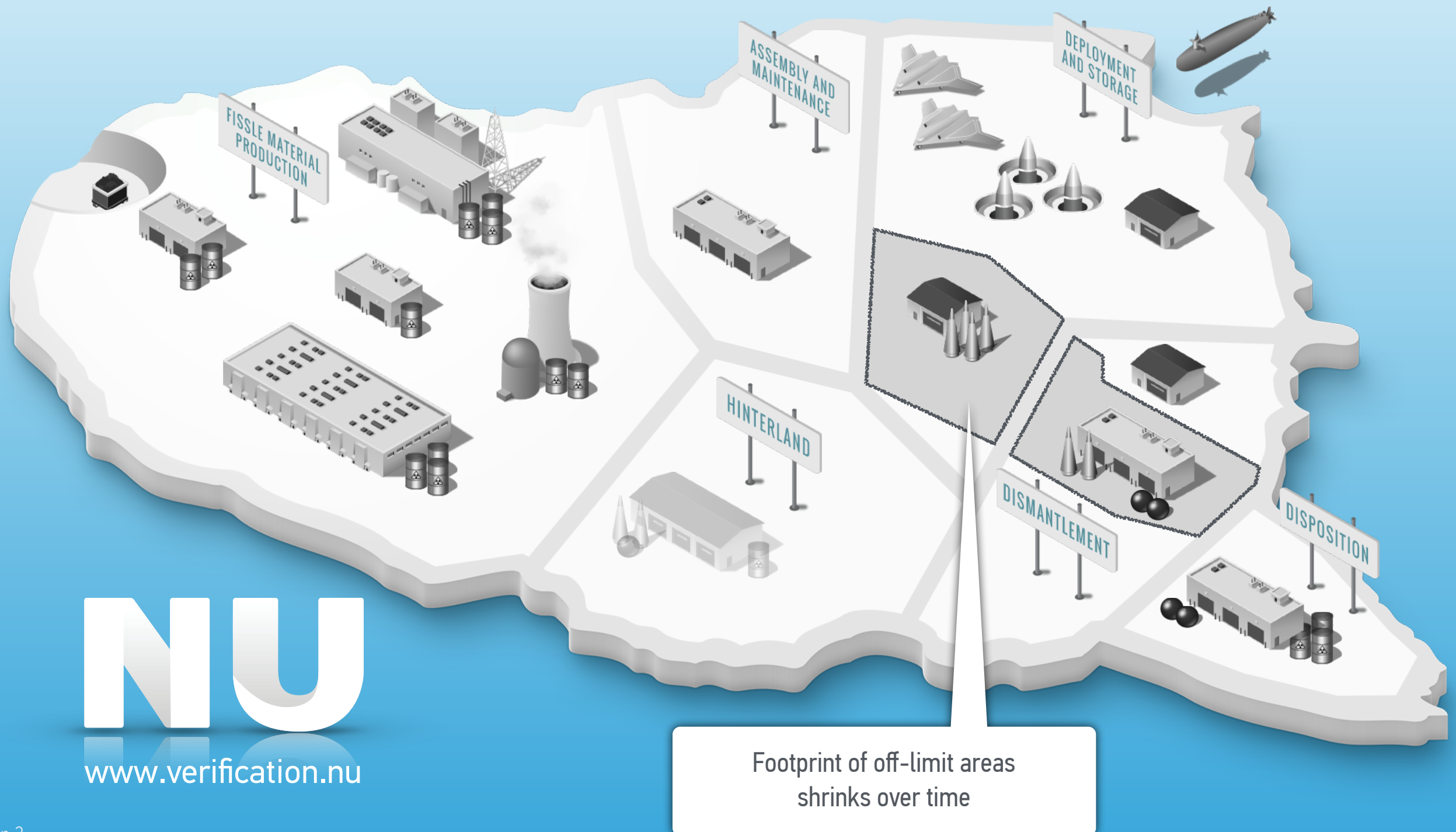


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“DEFERRED VERIFICATION”

Pavel Podvig, *New Approaches to Transparency and Verification of Fissile Material Stocks*, UNIDIR, Geneva, 2017



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

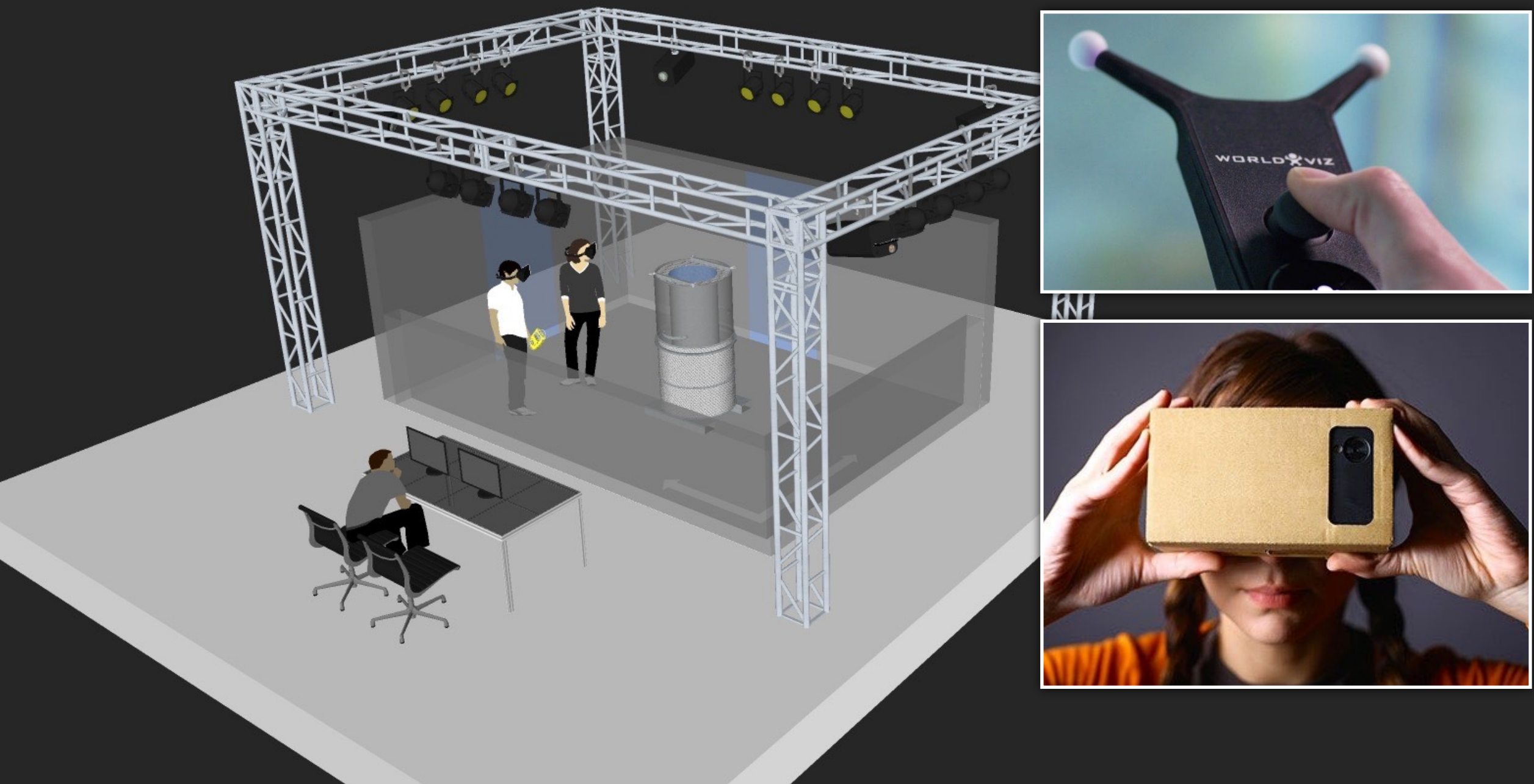




Photo: Mikhail Klimentyev/AP

