## RELEVANT NUCLEAR ARMS CONTROL TREATIES AND AGREEMENTS

| **NUCLEAR NON-PROLIFERATION TREATY** | Bans the acquisition of nuclear weapons by non-weapon states and commits the five weapon states to nuclear disarmament; verified by IAEA safeguards |
| **BILATERAL/MULTILATERAL NONPROLIFERATION AND ARMS-CONTROL AGREEMENTS** | Protocols negotiated to ensure compliance with specific agreements, for example: the Joint Comprehensive Plan of Action (JCPOA, July 2015) and the Plutonium Management and Disposition Agreement (PMDA, 2000/2010) |
| **COMPREHENSIVE TEST BAN TREATY** | Bans all nuclear explosions in all environments and would be verified by extensive verification mechanisms (International Monitoring System, CTBTO) |
| **FISSILE MATERIAL (CUTOFF) TREATY** | At a minimum, treaty would ban fissile material production for weapons purposes; Issue about treaty scope: Would it also cover existing stocks? |
| **NEXT-GENERATION NUCLEAR ARMS-CONTROL AND DISARMAMENT TREATIES** | Agreements that place limits on total number of nuclear warheads in arsenals would pose qualitatively new verification challenges; this could also include verification of the TPNW (“Ban Treaty”) |
VERIFICATION CHALLENGES AND GAPS

MAJOR AREAS OF RESEARCH

- Timeliness at large enrichment and reprocessing plants
- Verifying numerical limits on declared nuclear warheads
- Proliferation of advanced enrichment technologies
- Monitoring nuclear warheads in storage
- Reconstructing historic fissile material production
- Establishing confidence in the absence of undeclared stocks, production, or other clandestine activities
- Confirming the authenticity of nuclear warheads
CVT Postdoc Malte Göttzsche receives a fellowship to establish a new research group on nuclear verification at the Aachen Institute for Advanced Study in Computational Engineering Science (AICES), Germany

wws.princeton.edu/news-and-events/news/item/g%C3%B6ttzsche-awarded-1-million-fellowship-study-nuclear-archaeology
www.aices.rwth-aachen.de/en/about-aices/about/institutes/nuclear-verification-disarmament
UNDERSTANDING NUCLEAR VERIFICATION TECHNOLOGIES AND APPROACHES IN CONTEXT

**ROBUSTNESS**
How difficult is it to defeat or circumvent the technology?

**NON-INTRUSIVENESS**
How intrusive is deployment and use of the technology?
_for example, does it interfere with operations; is sensitive information put at risk?_

**SIMPLICITY**
How easy is it to deploy and use the technology?
_for example, passive systems are generally preferable to active ones_

Source: IAEA (top), defenseimagery.mil (middle), author (bottom)
NON-INTRUSIVE MONITORING & INSPECTIONS
INSPECTIONS FROM A DISTANCE
(MONITORING OF TREATY-ACCOUNTABLE ITEMS IN LONG-TERM STORAGE)

Plutonium Storage, Pantex Plant, Amarillo, Texas
Dismantling the Bomb, DigiComTV, 2010

MAGTAG blanket containing randomly oriented magnets cover each weapon container; a magnetometer in the magazine detects changes in the magnetic field

S. Philippe, M. Kütt, M. McKeown, U. Rührmair, and A. Glaser, The Application of Virtual Proofs of Reality to Nuclear Safeguards and Arms Control Verification
57th Annual INMM Meeting, July 24–28, 2016, Atlanta, Georgia.

MAGTAG, Los Alamos National Laboratory, 2000
verification.nu/technology/magtag

CONSORTIUM for VERIFICATION TECHNOLOGY
“INSPECTOR BOT”

(ROBOTICS AND MACHINE LEARNING FOR NON-INTRUSIVE INSPECTIONS)

Autonomous Mobile Robots for Managed Access Inspections, Princeton University and Princeton Plasma Physics Laboratory (PPPL)
Seed funding from U.S. Department of State, V-Fund, 2017-2019

Robotics Group, Naomi Leonard
Closeup of detector and information barrier with simulated radiation spectrum and shielding material handled by user.
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www.verification.nu