
Source: defenseimagery.mil


Source: Google


Source: Paul Shambroom


Source: IAEA

VIRTUAL ONSITE INSPECTIONS
FOR NUCLEAR ARMS CONTROL AND DISARMAMENT

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Program on Science and Global Security
Princeton University

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EXTERNAL ADVISERS

(NUCLEAR ARMS CONTROL EXPERTS WITH GOVERNMENT EXPERIENCE)



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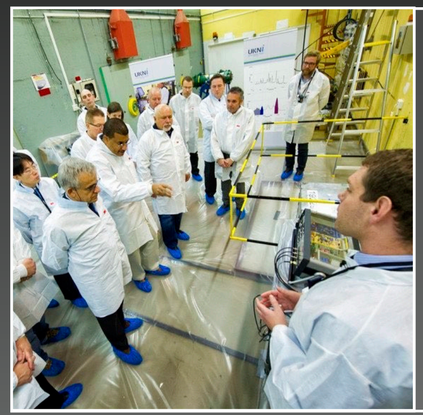
Stanford University
(Chief Negotiator, New START)



Keir Allen

AWE

TRADITIONAL & VIRTUAL ONSITE INSPECTIONS



PROS & CONS OF ONSITE INSPECTIONS

Onsite inspections remain the “gold standard” for IAEA safeguards and nuclear arms-control verification; inspections tend to be costly and are often considered intrusive, especially in an arms-control context

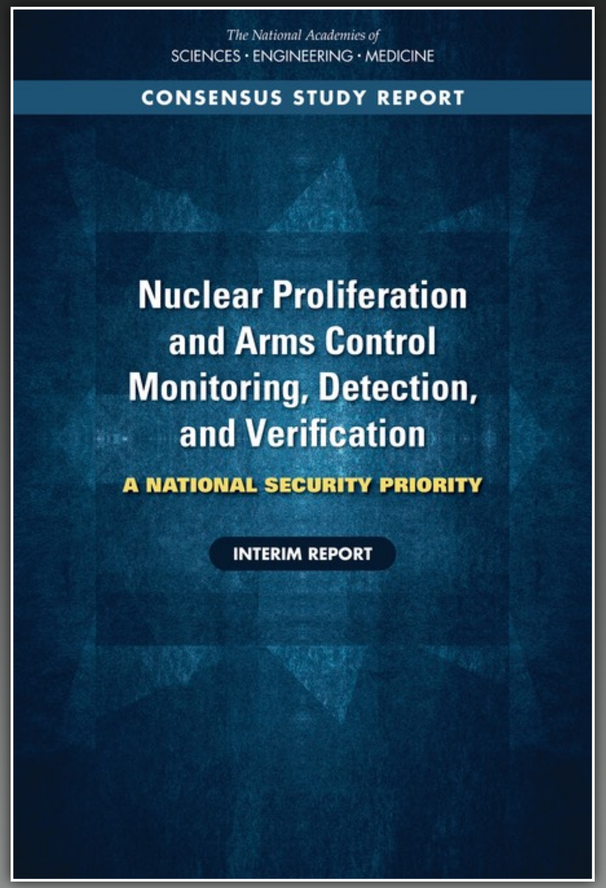


CAN WE (PHYSICALLY) “SEPARATE” HOST & INSPECTOR?

Many concerns could be addressed and resolved if inspectors were not “physically” present onsite; development of the concept could also facilitate engagement of new partners, and serve as a catalyst for discussions on the scope of future agreements and their verification

Source: ukni.info (top) and microsoft.com (bottom)

FINDINGS FROM A 2021 NATIONAL ACADEMIES STUDY



3.4 MDV FOR ARMS CONTROL

3.4.1 Capability Needs

...

*Treaties that include weapons in storage or weapons designed for shorter-range delivery systems are anticipated to require new MDV techniques. As a minimum, **such treaties would likely require access to storage areas either directly or remotely**, and confirmation of warhead count (either a baseline confirmation or through routine/challenge inspections).*

Jill Hruby, Corey Hinderstein, et al., Committee on the Review of Capabilities for Detection, Verification, and Monitoring of Nuclear Weapons and Fissile Material, National Academy of Sciences, Washington, DC, 2021, doi.org/10.17226/26088



Mk-21 reentry vehicles and W87 warheads in storage, F. E. Warren Air Force Base, Cheyenne, Wyoming, 1992
Credit: paulshambroom.com/nuke

SCENARIO IDEAS FOR A FIRST DEMONSTRATION



POSSIBLE BASELINE SCENARIO

Remote inspection of a storage room containing treaty-accountable items: confirm that the room is live and local, count containers, match UIDs to a declaration, and check integrity of seals



WHAT THE SCENARIO TESTS

Managed access, inventory verification, item identity, continuity of knowledge, substitution detection, and liveness



RED-TEAMING THE CONCEPT

Introduce limited scenario variations and red-teaming: Can we confirm a room is empty?
What happens if a container is hidden, a seal is broken, or the point cloud leaves an unresolved ambiguity?

Source: Paul Shambroom (middle), and Sascha Kreklau, Forschungszentrum Jülich (bottom)



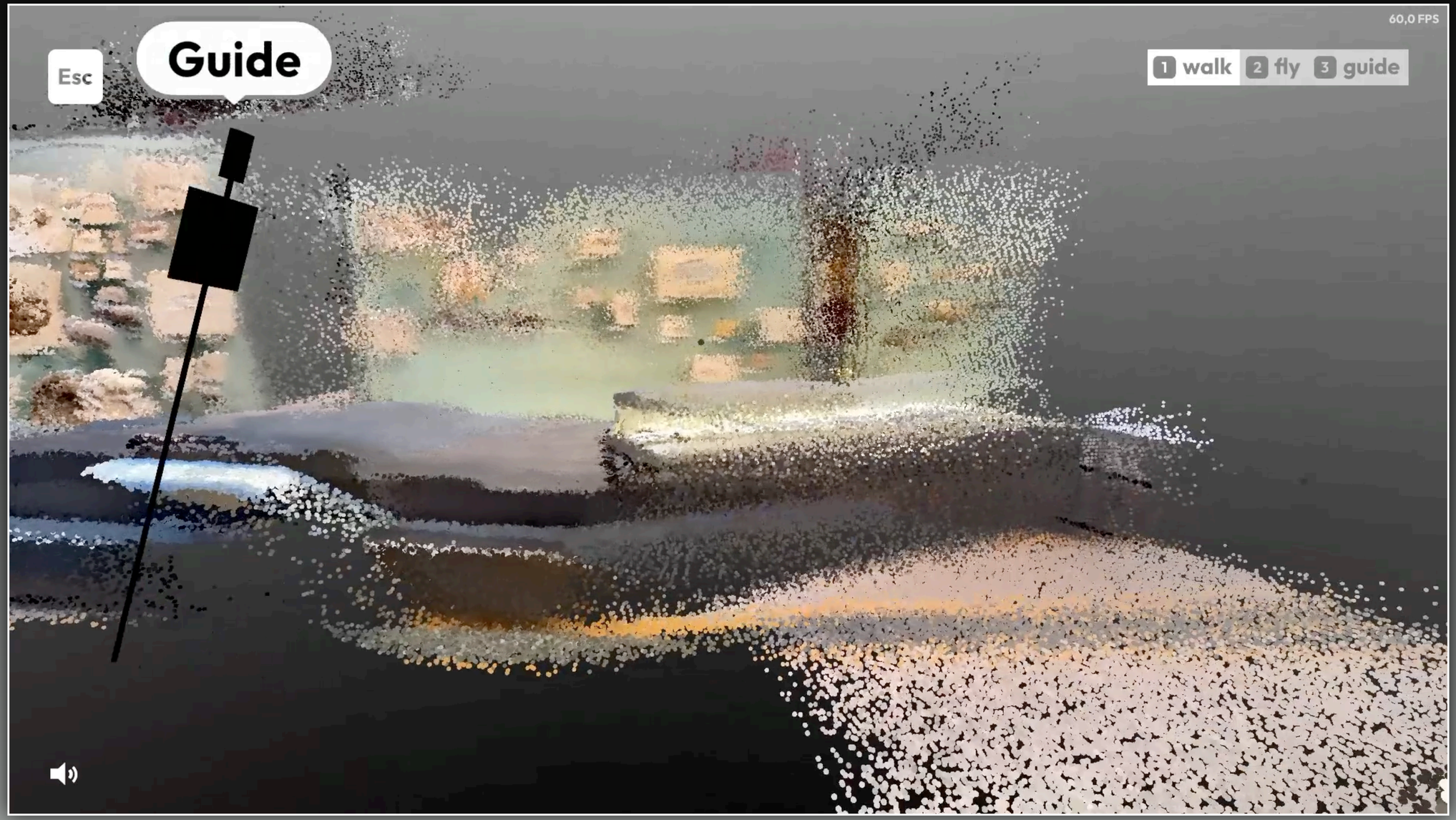
Inspection of a Very High-Resolution (VHR) satellite, 2024
Source: www.aerospacelab.com



A technician diagnoses an overheated CPU at a Google data center in Oregon
Source: datacenters.google/discover-more/photo-gallery

How Could This Possibly Even Look Like?

SCIENCE & GLOBAL SECURITY | ART+COM STUDIOS



Jussi Ängeslevä and Lukas Wirsching, ART+COM, artcom.de/en/?project=nuform-2020-2022

DEMO TIME



Mock Treaty Accountable Items on Princeton's VR Deck
Source: Authors



LiveVerify Apparatus (prototype)
Credit: Authors

Challenges & Next Steps

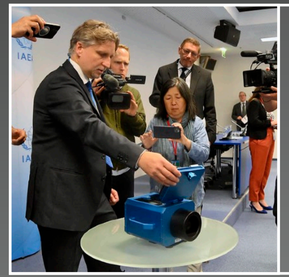
CHALLENGES FOR REMOTE INSPECTIONS

(PRELIMINARY & INCOMPLETE LIST)



DATA TRANSMISSION & INTEGRITY

How to transmit the footage to an offsite location, especially from the interior of a hardened and highly secured building? Can it be done in real-time?



SECURITY & PRIVACY

How to follow relevant activities without also capturing additional information that is considered sensitive but irrelevant for the task at at hand?



LIVE VERIFY & LOCAL VERIFY (Johnston and Warner, 2010)

How to ensure that the footage is recorded in real-time? How to preclude replay attacks?
How to ensure that the data is transmitted from the correct location?

Source: IAEA (top and middle)

“LOCAL VERIFY”



SX1 tag / Orbit One

OLD: ACTIVE TAGS THAT USE GPS

Battery-powered Global-RFID tags transmit GPS and sensor data via a constellation of low earth orbit satellites, enabling users to know an asset’s exact location and status at all times

Many uses cases; cargo-tracking, high-value assets — presumably mostly defense-related



NEW: TRACKING ANYTHING, ANYWHERE

In September 2026, EarthTraq demonstrated tens-of-meters RF geolocation from orbit with a four-satellite cluster; tag does not require GPS, resistant to spoofing and jamming; works indoors

Two additional missions are planned for early 2027

Source: rfidjournal.com (top) and earthtraq.space; Ian Bates for the nytimes.com (bottom)

CONCEPTUAL TOUCHSTONES

SELECTIVE VISIBILITY

Inspection relies on trained ways of seeing: which visual details does verification need, and which can be degraded or hidden?

- Goodwin (1994). **Professional vision.** American Anthropologist, 96 (3), 606–633
- Kraut, Fussell, & Siegel (2003). **Visual information as a conversational resource in collaborative physical tasks.** Human-Computer Interaction, 18 (1–2), 13–49
- Gergle, Kraut, & Fussell (2013). **Using visual information for grounding and awareness in collaborative tasks.** Human-Computer Interaction, 28 (1), 1–39

WARRANTED CONFIDENCE

Confidence comes from agreed working procedures, not the transmitted visuals alone

- Lee & See (2004). **Trust in automation: Designing for appropriate reliance.** Human Factors, 46(1), 50–80
- Rini (2020). **Deepfakes and the epistemic backstop.** Philosophers' Imprint, 20(24), 1–16
- Habgood-Coote (2023). **Deepfakes and the epistemic apocalypse.** Synthese, 201, 103

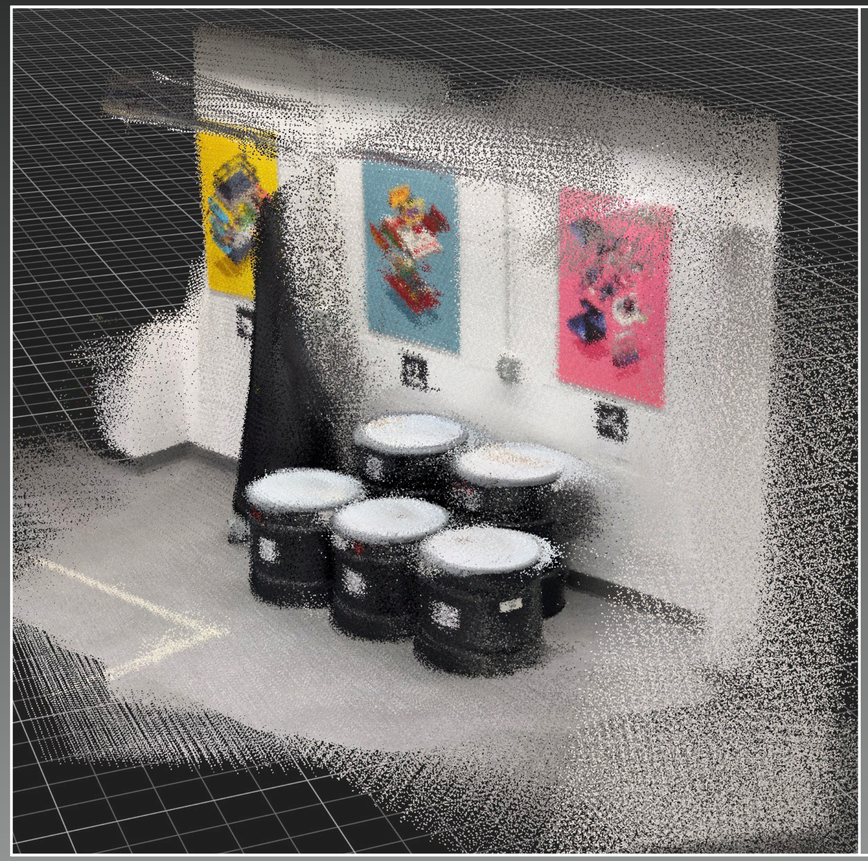
NARROW AGREEMENT

Jointly designed objects and methods let parties reach the same narrow finding despite different perspectives & priorities

- Star & Griesemer (1989). **Institutional ecology, "translations" and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–39.** Social Studies of Science, 19 (3), 387–420
- Galison (1997). **Image and logic: A material culture of microphysics.** University of Chicago Press

DID THE INSPECTION WORK?

THINKING THROUGH QUESTIONS FOR REMOTE INSPECTORS



DRAFT QUESTIONS FOR A POST-INSPECTION SURVEY

1. *How confident are you that the host's declaration is accurate? (scale of 1-5, plus free text)*
2. *Where, if at all, did the inspection process leave an ambiguity you could not resolve?*
3. *What additional access or capability would most increase your confidence?*
4. *...*


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