



VERIFICATION CHALLENGES FOR THE NEXT DECADE

WHAT NUCLEAR VERIFICATION CAN (AND CANNOT) TEACH US FOR SPACE AND AI

Alexander Glaser

Program on Science and Global Security
Princeton University

Exploratory Workshop: Open Source and Strategic Verification

Stanford University, October 21–22, 2026

Revision 0.2

Why Nuclear Verification Is So Hard

(and what to do about it)

DEALING WITH SECRECY



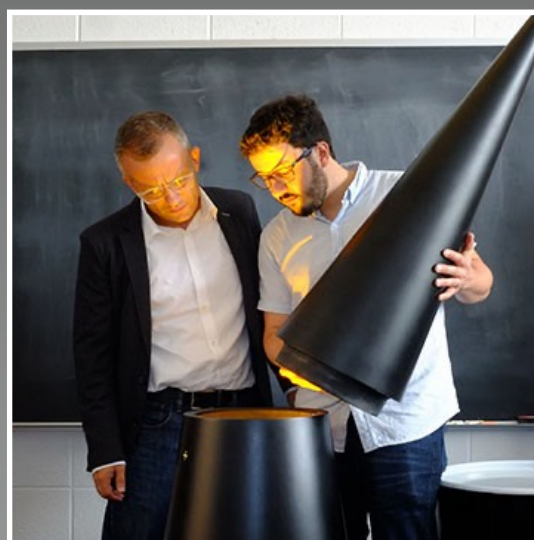
PROTECTING THE SECRET

Many government-sponsored efforts have focused on development of dedicated hardware
For example, information barriers for warhead confirmation measurements



REINVENTING THE PROBLEM

Never acquire sensitive information to begin with; explore (radically) different technologies and approaches
For example, confirming the absence of a treaty accountable item at a given location



REVEALING THE SECRET

Requirement to protect sensitive information is typically the main reason for complexity of the task
For example, mass and isotopics of fissile material in a nuclear weapon

Source: Author (top and bottom) and Ruhr-Universität Bochum (middle)

Guiding Principles for Good Verification Technologies

SOME (PROPOSED) GUIDING PRINCIPLES

FOR GOOD VERIFICATION TECHNOLOGIES



SIMPLICITY

A single numerical value is usually better than a complex radiation spectrum; demonstrating the absence of something is more straightforward than confirming the exact nature of a classified item



NON-INTRUSIVENESS

Future arms control efforts may involve weapon states that are less familiar with bilateral or multilateral inspections; importance of “on-ramps” for them, i.e., approaches and procedures that do not require major commitments upfront but can provide a foundation to build on later

Source: Pavel Podvig (top) and U.S. Department of Defense (bottom)

Which Technical Problems
Are Worth Solving?



Mk21 reentry vehicles and containerized W87 warheads at F. E. Warren Air Force Base, Cheyenne, Wyoming, October 1992

Source: Paul Shambroom, paulshambroom.com

CASE STUDY #1

REINVENTING ONSITE INSPECTIONS



PROS & CONS OF ONSITE INSPECTIONS

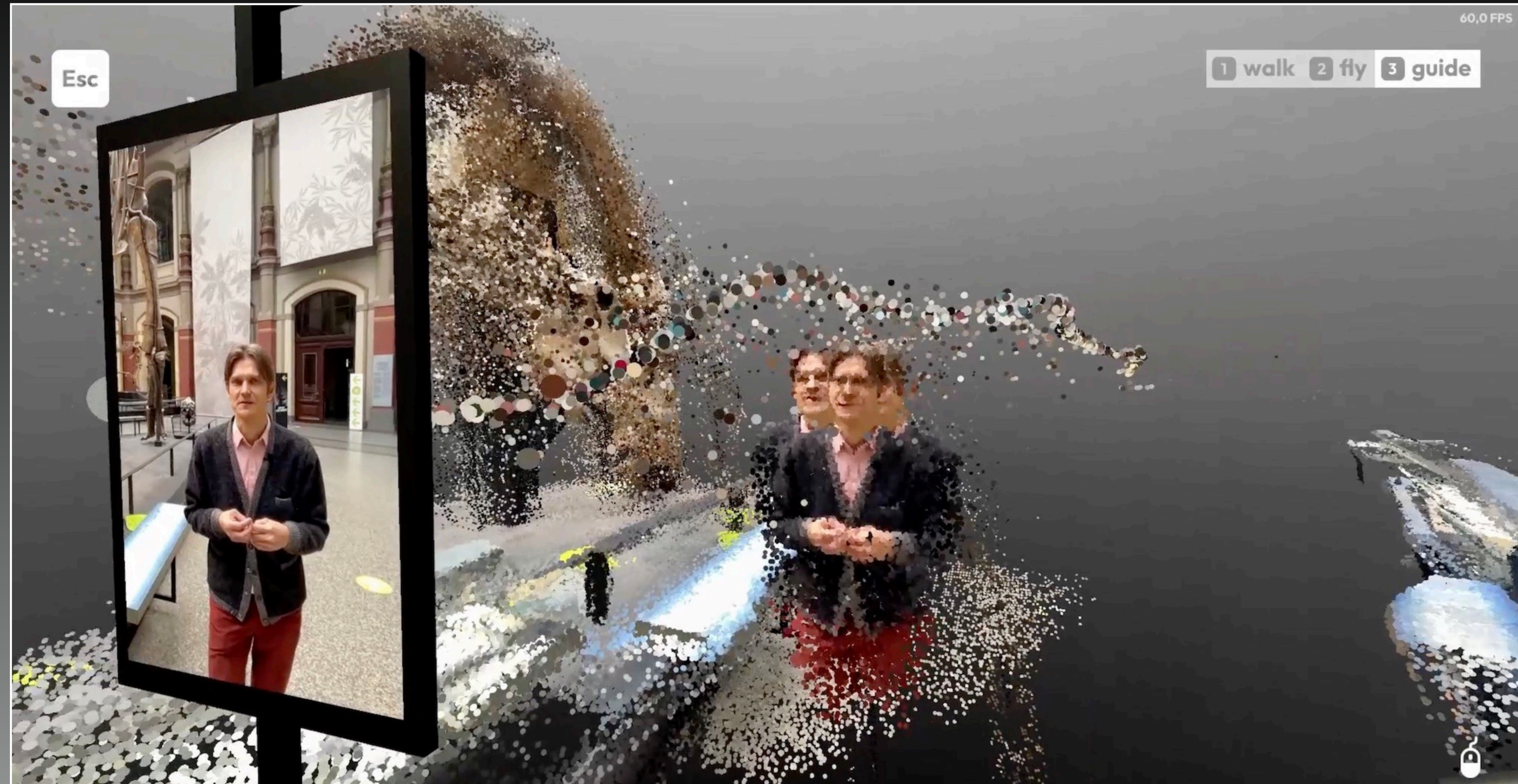
Onsite inspections remain the “gold standard” for IAEA safeguards and nuclear arms-control verification; inspections tend to be costly and are often considered intrusive, especially in an arms-control context



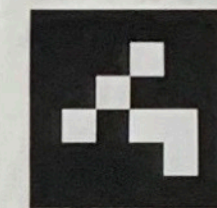
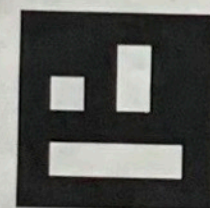
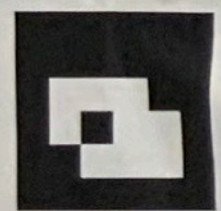
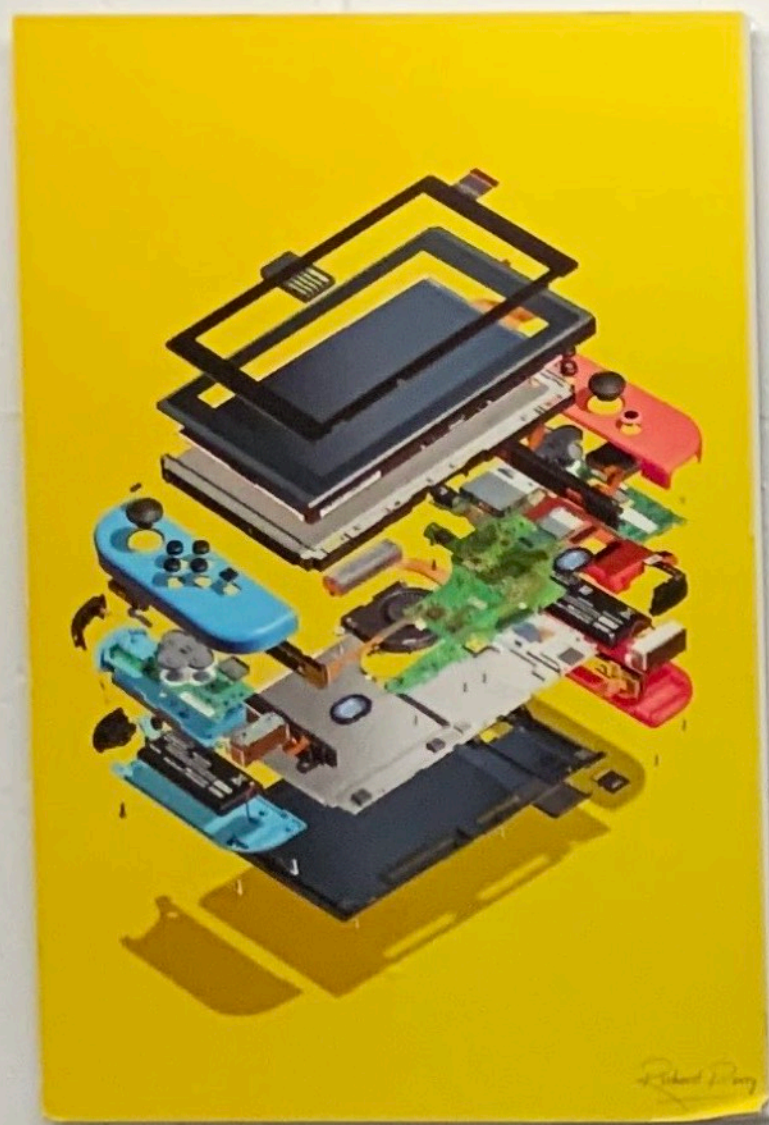
CAN WE (PHYSICALLY) “SEPARATE” HOST & INSPECTOR?

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: NuDiVe (top) and microsoft.com (bottom)



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



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



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

CASE STUDY #2

MONITORING ACTIVITIES AT “UNKNOWN” LOCATIONS



BEYOND DETECTION OF CLANDESTINE FACILITIES AND ACTIVITIES

Treaty accountable items may be known to exist, but their location is unknown, uncertain, or secret

For example, future arms control agreements could limit or ban altogether the presence of certain weapons systems in specified geographic areas



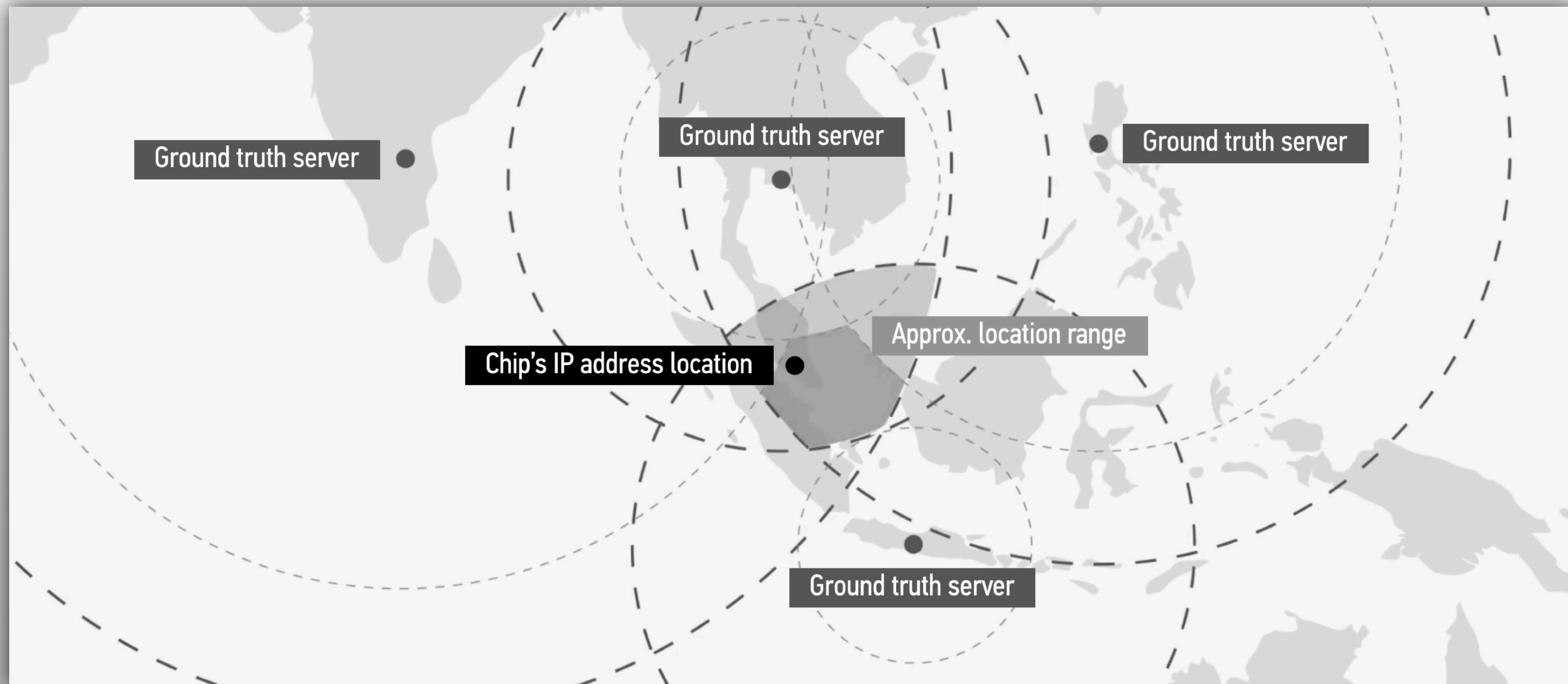
LOCATING ANY OBJECT ANYWHERE ON EARTH — WITH OWNER'S CONSENT

The ability to locate an item anywhere on the planet in near real-time is an exciting new capability that can take advantage of state-of-the-art technologies

For example, tags that work in GPS-denied environments, communicating with dedicated satellites

Source: KCNA (top)

GEOLOCATING HARDWARE



Geolocating a GPU based on the round-trip time of signals sent by ground-truth servers

Adapted from: www.geocomply.com/location-verification-for-export-controls



Donald J. Trump  
@realDonaldTrump

Space Force



3.29k ReTruths 15.2k Likes
5/18/26, 2:46 AM

Donald J. Trump  
Donald Trump • 12h

[View Truth Details](#) >



 448

 2.11k

 9.49k



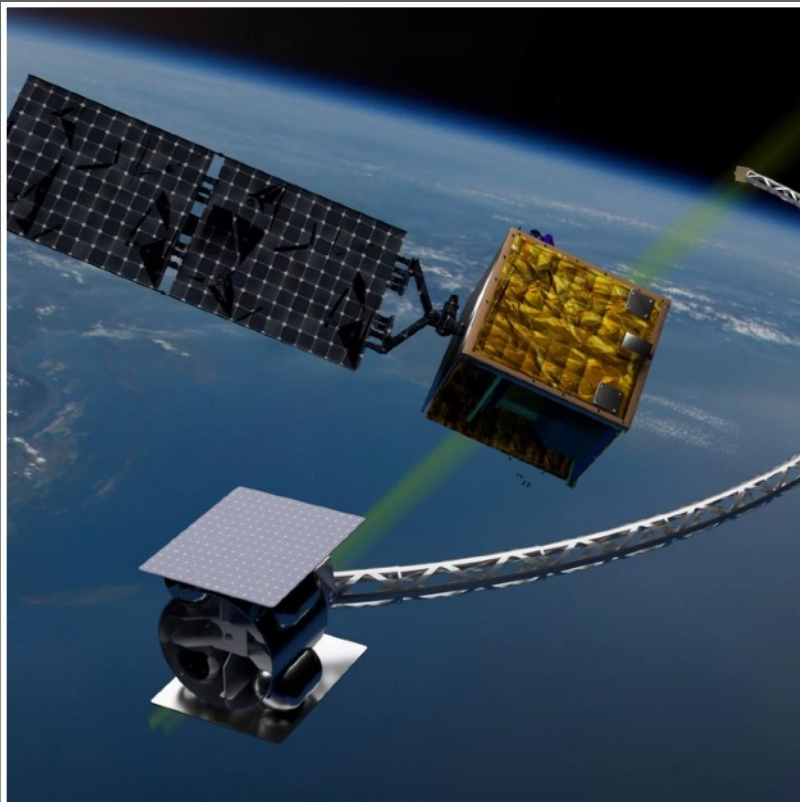
CASE STUDY #3

CONFIRMING COMPLIANCE IN OUTER SPACE



NUCLEAR PAYLOADS AND THE NEED FOR MORE TRANSPARENCY

Space launches that include nuclear payloads (for power generation or propulsion) could further increase geopolitical tensions, especially when there are concerns about the peaceful nature of these missions and compliance with the Outer Space Treaty

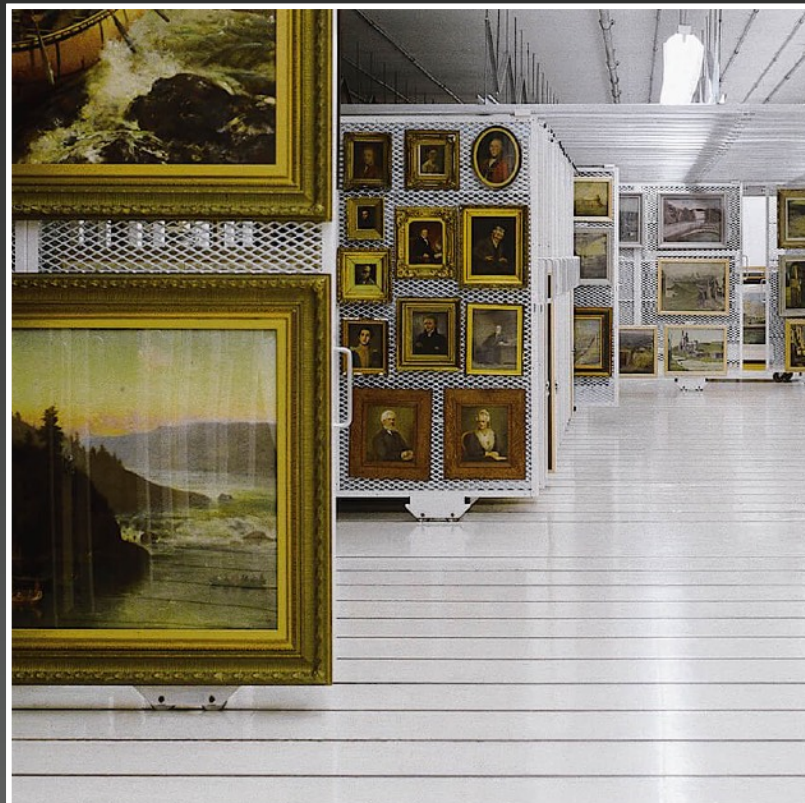


STRENGTHENING THE 1967 OUTER SPACE TREATY

New technical developments could (finally) allow for verification of the Outer Space Treaty
Pre-launch or post-launch inspections could provide confidence in the civilian nature of planned missions involving fission power or other nuclear systems

Source: esa.int (top) and thinkorbital.com (bottom)

WHERE DO WE GO FROM HERE?



LEVERAGING NEW TECHNOLOGIES

Emerging technologies may enable new verification approaches for the nuclear and other relevant domains; can showcase concepts that would be too costly for commercial markets but are justified for high-stakes security applications



ENCOURAGING (BOTTOM-UP) DEMONSTRATION EXERCISES

Can involve verification experts from think tanks, academia, or civil society; would also benefit from partnerships with companies looking to take a proactive role in promoting arms control (including in outer space) or in demonstrating the ability to monitor constraints on AI deployment

Source: Montel (top) and Pavel Podvig (bottom)



Earthset captured through the Orion spacecraft window, April 6, 2026
www.nasa.gov/image-detail/art002e009288/