O4.5-696

Harnessing Satellite Imagery Analysis for CTBT Verification

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Open Nuclear Network, a PAX *sapiens* programme

OPEN NUCLEAR NETWORK
Nuclear Risks Matter

Presentation Date: 10 September 2025

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

About Open Nuclear Network

MISSION: Reducing the risk of nuclear weapons use.

MONITOR: Tracking developments contributing to the escalation of nuclear risks.

ANALYSE: Producing actionable reports and research to inform decision-makers.

FORECAST: Injecting foresight and prediction methodologies into the nuclear debate.

ENGAGE: Building trusted partnerships and strategic outreach to advance dialogue and reduce nuclear risks.

OPEN NUCLEAR NETWORK
Nuclear Risks Matter

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Overview

I. Satellite Imagery as a Monitoring & Verification Tool

II. Monitoring Nuclear Test Sites

III. Integrating Satellite Imagery with IMS & OSI

IV. Conclusion

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

O4.5-696

I. SATELLITE IMAGERY AS A MONITORING & VERIFICATION TOOL

OPEN NUCLEAR NETWORK
Nuclear Risks Matter

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

O4.5-696

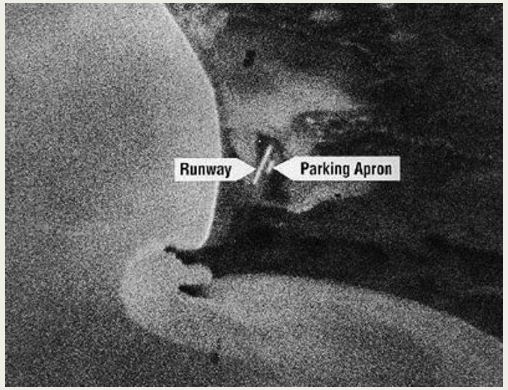
Satellite Imagery Utility

<u>Uses of Satellite Imagery</u>

- Provides non-intrusive and shareable visual data
- Enables geolocation and incident assessment
- Supports infrastructure and object monitoring, change detection and verification efforts
- Enhances transparency of on-the-ground situations, strengthening public awareness and confidence

<u>Driving Factors</u>

- Increased availability, accessibility and quality of imagery due to the growing commercial sector
- Rapidly developing technology



Mys Shmidta Air Field 1960

Mys Shmidta Air Field 2009

OPEN NUCLEAR NETWORK
Nuclear Risks Matter

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Key Analytical Techniques

High/medium-resolution optical imagery

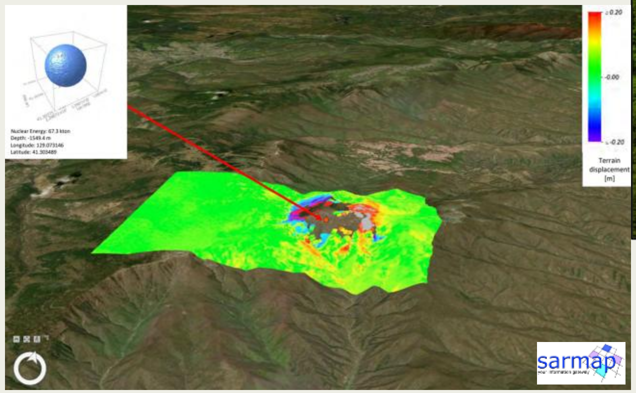
- Area monitoring and geolocation
- Detailed image interpretation, change detection

Multispectral/Hyperspectral/Thermal infrared

- Extracting additional information about surface properties
- Identifying heat emissions due to human activity

Synthetic aperture radar

- Wide area monitoring
- Very precise change detection
- Assessment of surface deformations



Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

O4.5-696

II. MONITORING NUCLEAR TEST SITES

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Key Monitoring Applications

Monitoring before a nuclear test

- Identifying and assessing test sites' infrastructure changes
- Surface deformation/excavation
- Detecting specific observables (such as drilling towers, cables, road networks, mining debris)

Monitoring after a nuclear test

- Surface deformation:
  - subsidence cratering and spallation, rockslides, avalanches
  - destruction of vegetation
- Unusual human activity (e.g. to pinpoint possible locations for OSI)

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Limitations

- Ambiguity in interpreting activities (multiple possible explanations and limited historical data for temporal comparisons)
- Technological development may introduce new measurement equipment and testing procedures, changing expected indicators
- Difficulty in detecting less observable low-yield underground testing
- Limited confidence due to sensor constraints, lack of supporting data and uncertainty in distinguishing normal from abnormal activity

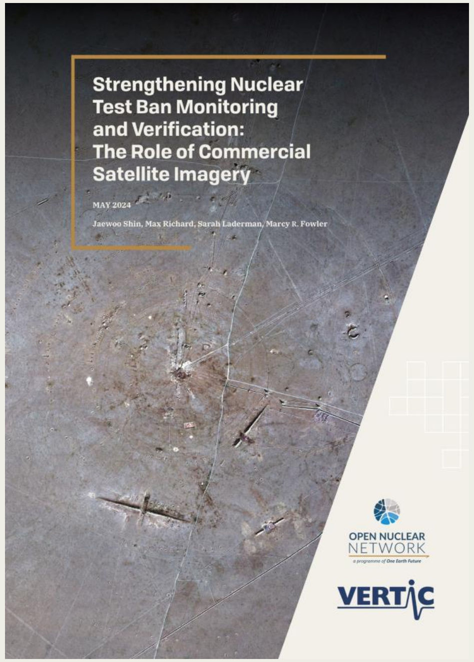
Harnessing Satellite Imagery Analysis for CTBT Verification

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

O4.5-696

Open Nuclear Network's Assessments (2024)

Punggye-ri (DPRK)	• Maintenance • ~ 1 re-excavated tunnel that could be available for potential future tests
Lop Nur (PRC)	• Maintenance and modernization, site expansion • ~ 5 tunnels for potential tests
Novaya Zemlya (RF)	• Maintenance and modernisation • ~ 6 tunnels for potential tests
NNSS (US)	• Maintenance, modernisation, expansion • Several tunnels and facilities for subcritical tests and other experiments, potential test readiness



OPEN NUCLEAR NETWORK
Nuclear Risks Matter

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

O4.5-696

III. INTEGRATING SATELLITE IMAGERY WITH IMS & OSI

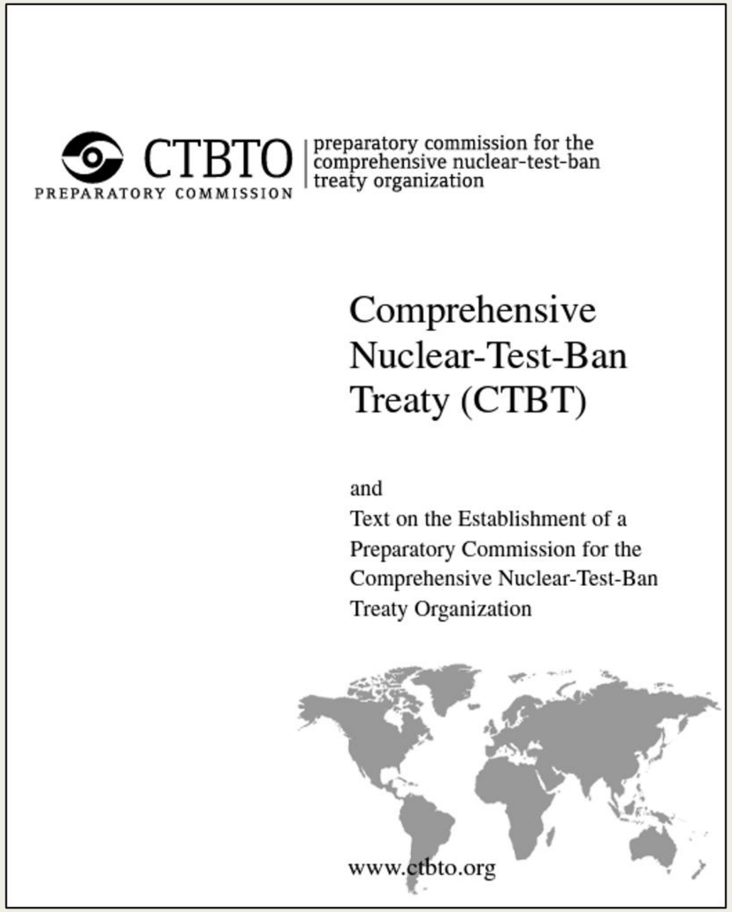
OPEN NUCLEAR NETWORK
Nuclear Risks Matter

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Satellite Imagery for CTBT After Entry into Force

CTBT Art. IV, Par. 11:

“Each State Party undertakes to cooperate (…) in the improvement of the verification regime, and in the examination of the verification potential of additional monitoring technologies such as electromagnetic pulse monitoring or satellite monitoring, with a view to developing, when appropriate, specific measures to enhance the efficient and cost-effective verification of this Treaty (…)”


CTBTO PREPARATORY COMMISSION | preparatory commission for the comprehensive nuclear-test-ban treaty organization

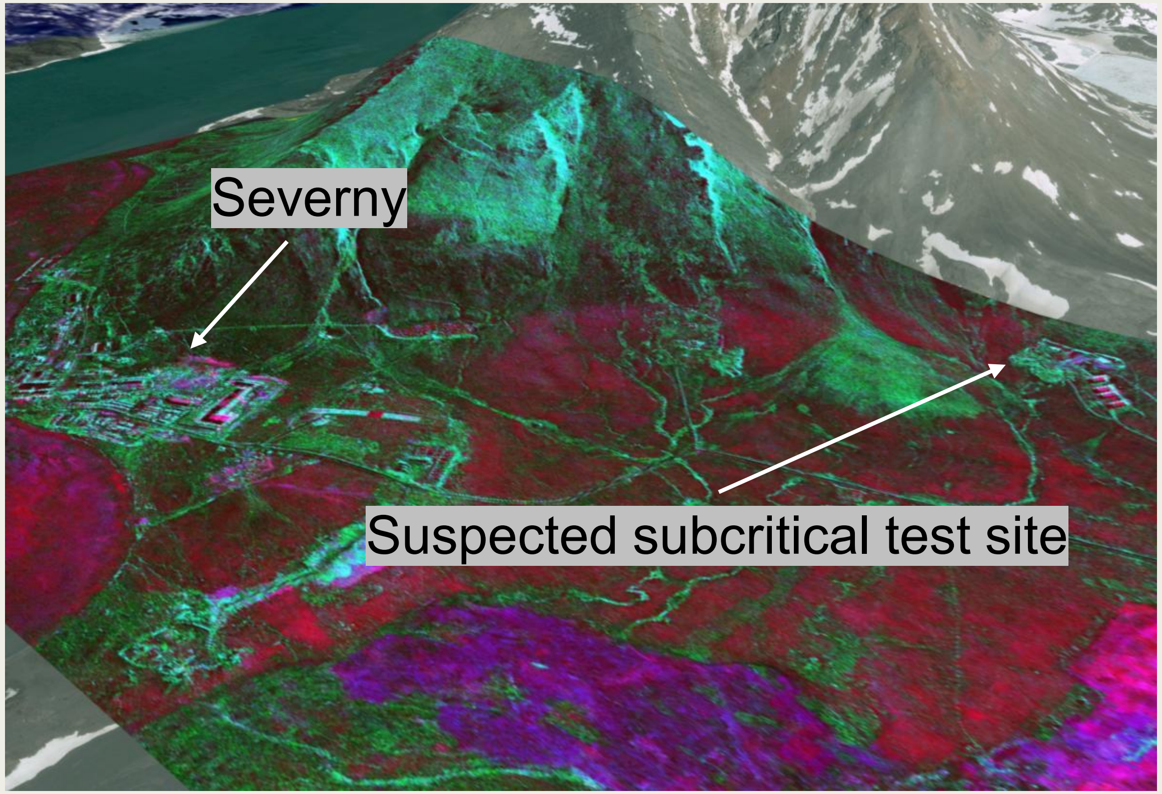
Comprehensive Nuclear-Test-Ban Treaty (CTBT)

and
Text on the Establishment of a Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization

www.ctbto.org

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Example: Launch phase



Multi-temporal SAR composite of the Novaya Zemlya test site (RF) draped over Google Earth terrain model

73.374 N, 54.763 E
14 acquisitions Dec 2023-Mar 2024

- Could help detect changes and surface deformations with precise location, complementing IMS data with clear visual evidence
- Could provide visual and, hence, intuitively understandable information for discussion during the consultation and clarification process
- Could serve as additional evidence for requesting on-site inspections

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Example: Pre-inspection phase

Overview of Lop Nur (PRC) with highlighted possible new test area (in red)

Sentinel-2 via ESRI World Imagery (ESRI, European Commission, European Space Agency, Azure).

- Could help characterise different areas of the test site to give a general understanding of the place and delineate possible testing zones
- Familiarises the inspection team with site features (already envisioned since IFE 2014)
- Supports logistical planning, highlighting key areas for inspection (already envisioned since IFE 2014)

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Example: Inspection phase

Punggye-ri (DPRK) with signs of personnel activities and restored entrance to a test tunnel

41.277 N, 129.087 E
1 January 2024

- Could help the team's orientation and navigation at the potential explosion site
- Could prepare the team for the overflight activity and the expected presence or absence of objects and equipment

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

Example: Post-inspection phase

P-Tunnel at NNSS (US) with movement of equipment after the chemical explosion on 18 October 2023

37.229 N, 116.152 W
21 October 2023 (left), 19 November 2023 (right)

- Could add data for reporting with both analytical and visual value
- Could enhance understanding of what happened, where and how

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

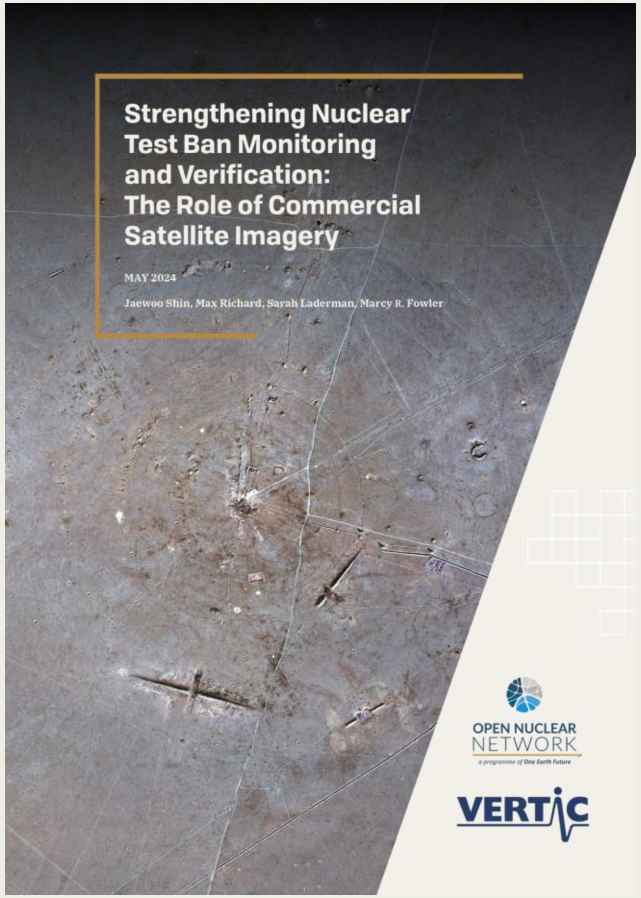
Conclusions

- Growing number of commercial satellites and rapidly developing analytical approaches can provide reliable, non-intrusive, shareable, and actionable CTBT-relevant information
- Supports transparency and verification efforts
- Valuable for CTBTO inspections: site characterisation and post-test analysis
- Lessons can be learned from monitoring experiences by States, IOs and researchers
- Nuclear test sites are actively maintained and modernised

Harnessing Satellite Imagery Analysis for CTBT Verification

Jaewoo Shin, Nikita Degtyarev, Marcy R. Fowler, Sarah Laderman

O4.5-696



Scan QR Code for full report

Website:
www.opennuclear.org

E-mail:
onn@paxsapiens.org

Twitter/X:
@OpenNuclear

LinkedIn:
https://at.linkedin.com/company/opennuclearnetwork

OPEN NUCLEAR NETWORK
Nuclear Risks Matter