CONSORTIUM FOR VERIFICATION TECHNOLOGY
TREATY VERIFICATION
CHARACTERIZING GAPS AND EMERGING CHALLENGES

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CVT POLICY RESEARCH THRUST

BACKGROUND

TWO WAYS OF APPROACHING THE VERIFICATION PROBLEM

Technology-focused and mission-focused approach;
CVT seeks to combine both; unique opportunities for synergisms
given diversity of 13 + 9 CVT partner institutions and groups

POLICY THRUST: A TREATY-ENABLING APPROACH

Emphasizes mission-focused dimension (as defined by existing and
expected future treaties); support and guide CVT technology developments
toward specific treaty applications; track emerging technologies

Source: www.engin.umich.edu (top) and news.kremlin.ru (bottom)
RELEVANT NUCLEAR ARMS CONTROL TREATIES

**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

**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 DISARMAMENT TREATIES**
Agreements that place limits on total number of nuclear warheads in arsenals would pose qualitatively new verification challenges
COMPREHENSIVE NUCLEAR TEST BAN TREATY
SEVERAL STUDIES HAVE EXAMINED CTBT VERIFICATION CHALLENGES IN GREAT DETAIL

National Academy of Sciences (2002 and 2012) or Dahlman et al. (2011)
WAVEFORM TECHNIQUES: SEISMIC AND INFRASOUND SIGNATURES
Paul Richards (Columbia), Milton Garcés (U Hawaii)

- Detect very low-yield explosions and discriminate against other sources
- Potential for improved event location and identification through the integration of infrasound with seismic monitoring

RADIONUCLIDE SIGNATURES
John Lee (U Mich), Abi Farsoni (Oregon State), Michael Schöppner (Princeton)

- Advanced detector technologies (higher energy resolution; lower MDC)
- State-of-the-art ATM, backward and forward
  Finding the origin of a release versus “catching the plume”

Source: Milton Garcés (top) and Radionuclide Station RN56, Russian Federation, www.ctbto.org (bottom)
DISTINGUISHING NUCLEAR EXPLOSIONS FROM EARTHQUAKES

Development of advanced methods (using all three components of recorded motion) to distinguish seismic signals from (very small) nuclear explosions from (very weak) earthquakes.

Ongoing CVT work by Paul Richards et al., Columbia University
CLOSING THE GAPS IN THE CTBTO RADIONUCLIDE MONITORING NETWORK

FISSILE MATERIAL CUTOFF TREATY
AND NUCLEAR NON-PROLIFERATION TREATY
FMCT VERIFICATION COULD BUILD ON NPT VERIFICATION AND IAEA SAFEGUARDS

NEW CHALLENGES IN SOME EXISTING URANIUM ENRICHMENT AND REPROCESSING PLANTS (for example, enrichment plants that were used for production of highly enriched uranium)

IAEA safeguards inspectors verification training exercise
Photo: IAEA Imagebank

Novouralsk enrichment plant, ~15 million SWU/yr
Photo: U.S. Department of Energy
FISSILE MATERIAL CUTOFF TREATY AND NUCLEAR NON-PROLIFERATION TREATY

GAPS AND CHALLENGES

REAL-TIME CHARACTERIZATION OF NUCLEAR MATERIALS
Sara Pozzi (U Mich), Zhong He (U Mich), Igor Jovanovic (PSU), Kim Kearfott (U Mich), James Baciak (U Florida)
- Determine mass, enrichment, and location of nuclear materials
- Possibility of combining instruments with information barrier

DETECTING CLANDESTINE FACILITIES (AND ACTIVITIES)
Paul Wilson (U Wisconsin); Al Hero (U Mich), Michael Schöppner (Princeton), and others
- Fuel cycle anomalies (CYCLUS)
- Data analytics
- Emission source terms and atmospheric transport modeling

Source: U Michigan (top) and Google Earth (bottom)
NEW INSTRUMENTS FOR ONSITE INSPECTIONS

CHARACTERIZING NUCLEAR MATERIALS

with real-time data processing and neutron-gamma discrimination capability

Stilbene crystals
Photo: LLNL

Sets of plutonium plates, measured at INL
Credit: Sara Pozzi, U Mich

Ongoing CVT work by Sara Pozzi and team at U Michigan
NEW INSTRUMENTS FOR ONSITE INSPECTIONS

LASER-INDUCED BREAKDOWN SPETROSCOPY

in-situ, in-air measurement of the atomic isotopic shift of uranium
(when combined with information barrier of particular interest for FMCT verification)

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Integrated interference profiles

Ongoing CVT work by Phyllis Ko Morgan and Igor Jovanovic at Penn State University
DETECTING CLANDESTINE PLUTONIUM SEPARATION ACTIVITIES WITH KRYPTON-85

GLOBAL VARIABILITY OF KRYPTON-85 CONCENTRATION
(as calculated with the Atmospheric Transport Model FLEXPART for the year 2010, daily emissions, 260,000 gridpoints)

NEXT-GENERATION NUCLEAR DISARMAMENT TREATIES
NEXT-GEN DISARMAMENT TREATIES

GAPS AND CHALLENGES

PROTECTING SENSITIVE INFORMATION

Clair Sullivan (Illinois), Dave Wehe (U Mich), and others

- Inherent information barriers: spectral/spatial, software/hardware
- Minimally intrusive verification approaches
- Confirming numerical limits (e.g. using new tagging techniques)

CONFIRMING AUTHENTICITY OF NUCLEAR WARHEADS

Richard Lanza (MIT), Francesco d’Errico (Yale), Alex Glaser (Princeton)

- Nuclear resonance fluorescence
- Neutron radiography and fission signatures

Source: Paul Shambroom (top) and U.S. Department of Energy (bottom)
INFORMATION BARRIERS

REMOVING SENSITIVE INFORMATION VIA HARDWARE AND SOFTWARE

(Successive-approximation-register analog-to-digital converter)

Measured spectrum from combined Cs-137, Co-60, Na-22, Bi-207 calibration sources; but only Cs-137 allowable.

Output spectrum preserves allowable energy information; all other spectral information appears as background.

Ongoing CVT work by Fred Buhler, David Wehe, and Mike Flynn at U Michigan.
MINIMIALLY INTRUSIVE VERIFICATION APPROACHES

Unique identifiers (UIDs) don’t necessarily have to be directly attached to treaty accountable items.
WARHEAD DISMANTLEMENT FACILITY & MANAGED-ACCESS SIMULATOR

DEVELOPMENT OF FACILITY ARCHITECTURES TO ENABLE TREATY VERIFICATION

Bird’s eye view of a notional dismantlement facility
Credit: Tamara Patton
WARHEAD DISMANTLEMENT FACILITY & MANAGED-ACCESS SIMULATOR

FULL-MOTION VIRTUAL REALITY SYSTEM WITH REAL-TIME RADIATION FIELDS
ONE LAST THING
WORKSHOP

“VERIFYING NUCLEAR ARMS-CONTROL TREATIES: GAPS AND CHALLENGES”

When: December 10–12, 2015 (2.5 days)
Where: Princeton, New Jersey, or Cambridge, Massachusetts

SESSIONS ON ALL RELEVANT TREATIES OR TREATY PROPOSALS

- Nuclear Non-Proliferation Treaty (NPT)
- Comprehensive Nuclear Test Ban Treaty (CTBT)
- Fissile Material Cutoff Treaty (FMCT)
- Next-generation Nuclear Disarmament Treaties