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Arms Reduction Treaties and Attribute Measurement

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Abstract: This set of slides provides an overview of the drivers and current state of technology for arms control treaty verification systems. This overview includes the definitions of “authentication,” “certification,” “attribute,” “template,” and “information barrier” as well as a discussion of first, second and third generation attribute measurement systems. We include examples of U.S./Russian interactions and conclude with discussion of the concepts of joint design and random selection.

Arms Reduction Treaties and Attribute Measurement

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Generic Arms Reduction Treaty

- One side (the host country) makes a declaration concerning the numbers and/or disposition of treaty limited items (TLIs)
- The other side (the monitoring party) confirms that declaration
- This is easy to say, but ...

The Challenges

- Evaluate the material/object presented
(Measurement)
- Protect the host country's classified information
(Certification)
- Allow monitoring party to draw independent conclusions
(Authentication)

Measurement System

- Part of treaty verification regime
 - Protect the host country's classified information
 - Allow monitoring party to draw independent conclusions
-
- Information Barriers
 - Attribute measurement

Information Barriers (IBs)

Red: Potentially classified
Blue: Information Barrier
Green: Open

Template Comparison

- Compare each new item with template
- Proof that an item is unchanged
- May accommodate a shorter measurement time
- Maintain Continuity of Knowledge

- Do all treaty limited items fit the template?
- Template is probably classified
- How does one initialize the template?
- Only need to fool the system once—during the initialization

Attribute Measurement

- Measures agreed attributes of each item
 - Displays unclassified “yes/no” results
 - Each measurement is independent of previous results
 - System can be used with several types of TLIs with the same attributes
-
- Attributes are necessarily not very specific
 - Choice of attributes is very important
 - Not only must attribute be unclassified, but the reason to choose that attribute must also be unclassified

Attributes

Analysis
and
threshold
comparison

- Singles Rate: $S = F \epsilon M v_1 (1 + \alpha)$
- Doubles Rate: $D = F (fD/2) (\epsilon M)^2 \{v_2 + [(M-1)/(v_1-1)] v_1 (1 + \alpha) v_2\}$
- Triples Rate: $T = F (fT/6) (\epsilon M)^3 \{v_3 + [(M-1)/(v_1-1)] [3v_2 v_1 + v_1 (1 + \alpha) v_3] + 3[(M-1)/(v_1-1)]^2 v_1 (1 + \alpha) v_2\}$

The Challenges

- **Evaluate the material/object presented (Measurement)**
- Protect the host country's classified information (Certification)
- Allow monitors to draw independent conclusions (Authentication)

Measurement – Technical Feasibility

The Trilateral Initiative demonstration

- LANL/LLNL collaboration
- IAEA/Russian audience
- Small plutonium sources

The Challenges

- Evaluate the material/object presented
(Measurement)
- **Protect the host country's classified information
(Certification)**
- Allow monitors to draw independent conclusions
(Authentication)

Certification – Technical Feasibility

The Fissile Material Transparency Technology Demonstration (FMTTD)

- LANL/LLNL collaboration
- Russian audience
- Measurements on US weapon component

Only measurement of its kind ever performed.

The Challenges

- Evaluate the material/object presented
(Measurement)
- Protect the host country's classified information
(Certification)
- **Allow monitors to draw independent conclusions
(Authentication)**

Authentication Challenge

- Everything interesting (the object, the measurement system, and the data) has been hidden.
- If the host has a reason to cheat, ...
- **Why should the monitors believe the red/green lights?**

Authentication – Proposed Solutions

- Combination of methods
- Functional testing
- Validation techniques (reverse engineering)
- Construction techniques
 - Commercial off the shelf (COTS)
 - Custom
- Joint design
- Random selection

Authentication: Construction Techniques

The Next-Generation Attribute Measurement System (NG-AMS)

- LANL design
- U.S. labs audience
- COTS-based
- Small plutonium sources

Authentication: Joint Design

- Both parties develop design together.
- Both parties build systems from agreed design.
- Both parties are intimately familiar with both design and capabilities of measurement system.
- If the host certifies the measurement system and the monitor validates the validation system, then demonstrating the continued equality of the two systems (continuity of knowledge) is equivalent to authenticating the host system.

Authentication: Joint Design

The Attribute Measurement System for Neutrons and Gammas (AVNG)

- VNIIEF/LANL/LLNL collaboration
- Russian construction
- U.S. audience
- Multi-kg plutonium sources

Authentication: Random Selection

- Motivation – confidence that the measurement system (host) and validation system (monitoring party) are identical.
- Simple in concept
 - Several “identical” copies of a component or system are presented
 - One (or more) is randomly chosen for use in the measurement system
 - One (or more) is randomly chosen for validation
 - If the two are identical, validation of the “validation copy” is equivalent to validation of the measurement system
 - But the devil is in the details
- What about continuity of knowledge?

Authentication – The 3G-AMS

The third-generation attribute measurement system (3G-AMS) –
Our vision

- Multi-lab design and construction
- Designed for random selection
- “Independent” monitoring party
- Testing with realistic plutonium items

The Challenges – Current Status

- Evaluate the material/object presented (Measurement) – Done for Pu, ongoing for HEU
- Protect host country's classified information (Certification) – Toolkit exists
- Allow monitors to draw independent conclusions (Authentication) – Current challenge