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Monitoring and Verifying Warheads: Going Beyond U.S.-Russian Efforts

Future Directions for Arms Control Verification Technologies

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Key Assumptions
Driving Technology Requirements

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- Nuclear weapons dismantlement will be the most technology intensive verification challenge.
- Indicators exist for potential next steps along path toward disarmament, ***but*** they do not point to a near-term requirement for verifiable dismantlement.
- Based on U.S.-Soviet and U.S.-Russian past practice, technology will most likely by utilized when verification by other means is either difficult or impossible.

Experience Exists for Delivery Vehicle Verification

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- Confirming delivery vehicle type and verifying the absence of delivery vehicles at declared sites
  - Relatively straightforward and
  - Special tools likely not required.
- Verifying the elimination of delivery vehicles
  - Also relatively straightforward (based on experience with START and Cooperative Threat Reduction Program)

Nuclear Weapons Verification Is more Complicated

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- Nuclear warheads are much smaller items of inspection than delivery vehicles, and warheads could be collocated at sites with deployed or stored conventional warheads.

- If items are assumed to be nuclear weapons, unless shown otherwise, verification challenges exist, but are more easily addressed than if confirmation of nuclear weapons is required.

- Verifying absence requires means to distinguish nuclear weapons from non-nuclear weapons.
  - Foundation exists based on START and New START approach

- Assuming this involves equipment being stored under multi-party access control, tamper indicating enclosures (TIEs) are necessary.

Verifying Elimination of Nuclear Weapons Is Most Challenging

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- Implies dismantlement of nuclear weapons and destruction or disposition of components such that weapons cannot be readily remanufactured.
- Requires verification of presence of nuclear weapons, which poses different challenges from verification of absence.
- Nuclear weapons do not lend themselves to an elimination process that is analogous to one for delivery vehicles
  - Continuity of knowledge throughout a series of processes required
- Verifying the disposition of fissile material removed from a nuclear weapon may be required, which could mean long-term monitored storage of material, or verification of material processing into a form unsuitable for weapons.

Potential Next Steps: Verification of Non-Deployed Nuclear Warheads

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- New START Treaty may be the last U.S.-Russian arms control treaty that limits only deployed strategic weapons.
- Next step is to address total stockpiles – including strategic and non-strategic, deployed and non-deployed warheads.
- Verifying limits on non-deployed stockpiles of nuclear warheads will pose new challenge.
  - Once declarations are made, the parties will likely want to ensure that items being monitored are nuclear warheads
  - Technology-based approaches may be required to verify nuclear weapons under this scenario, although timing is unknown
  - Minimally intrusive option could involve verification of randomly sampled number of warheads at sites where nuclear weapons are deployed

Moving beyond U.S.-Russia Paradigm

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- Involves states that do not have history and experience of traditional nuclear weapons arms control implementation.
- Working with other states may mean that limitations and associated verification are less complex and intrusive than what the U.S. and Russia might consider in a bilateral context.
  - May require a “least common denominator” approach with respect to the types of limitation and verification that prove achievable, due to security and other considerations of parties involved
- However, important work done by other states already in considering challenges and approaches for verification.

Use of Technology-based Means of Verification

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- Most likely to be pursued when other approaches are deemed unacceptable due to time, cost, or intrusiveness, or non-technology based means do not exist.
- Perception of increased efficiency or reduced intrusiveness alone will not likely result in utilization of technology.
- Possible exception is jointly developed technology
  - Process of joint development ensures that each side fully understands the technology, thereby facilitating authentication of the equipment
  - Helps to ensure that the technology provides a specific and agreeable approach to address a particular problem

Categorization of Technology Requirements

- Technology requirements are categorized into:
  - Near-term (present to 4 years)
  - Mid-term (4 to 8 years)
  - Long-term (> 8 years)

Near-Term Requirements

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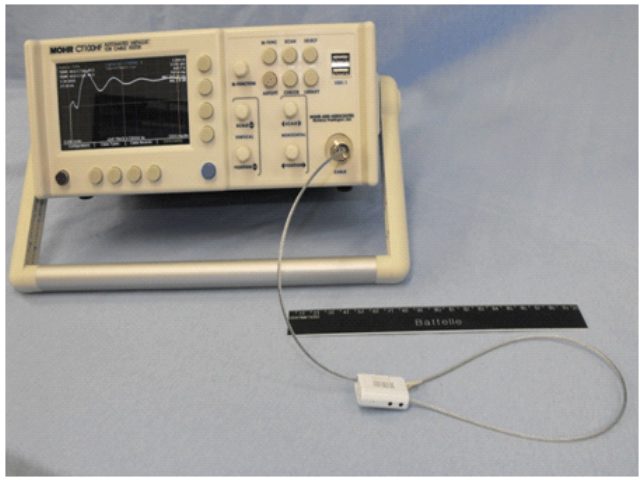
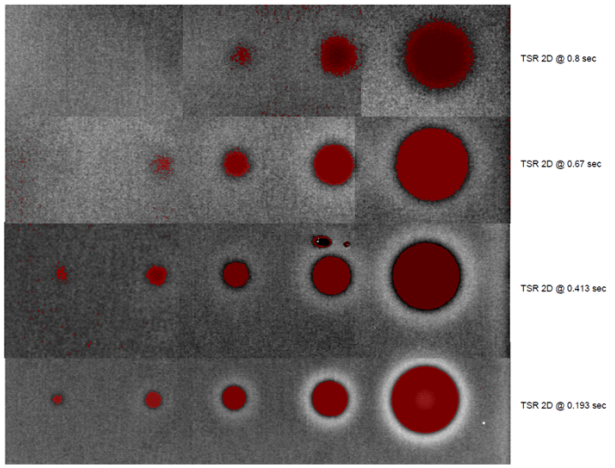
- Next generation radiation detection equipment (RDE) to distinguish non-nuclear objects from nuclear weapons.
  - Equipment and approaches that rely less on calibration sources
  - Potential utilization of gamma radiation measurements in addition to neutron measurements used for START and New START
- Tools and processes for authenticating equipment used to verify non-nuclear objects and weapons
  - Work has been and continues to be conducted in this area with regard to both authentication of hardware and software, but additional capability and experience is needed

Near-Term Requirements (cont.)

- Development of tamper indicating enclosures as well as new means for detecting tampering.
  - Equipment used to verify non-nuclear objects and for other purposes is likely to be stored under multi-party access control
  - Examining advanced techniques for detecting tampering, including the use of time-domain reflectometry (TDR) and flash thermography



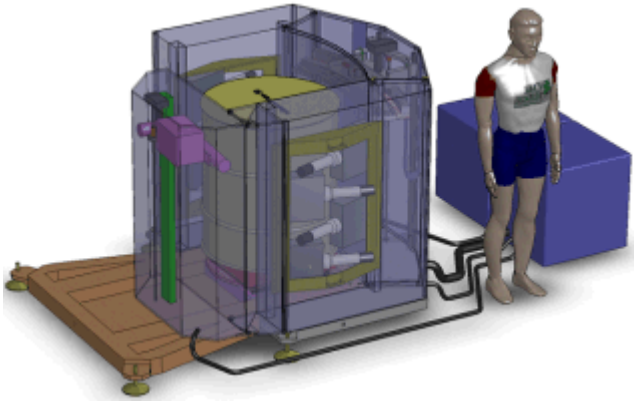
Standard configuration for TDR examination of wire loop seals.



Thermographic signal reconstruction (TSR) map of rear wall defects in an aluminum panel at 0.2 to 0.8 seconds postflash

Mid-Term Requirements

- Tools for verifying the presence of nuclear weapons
  - In addition to passive radiation measurement techniques, the development and evaluation of active measurement techniques should continue to be explored, including:
    - Methods for high explosives verification
    - Highly enriched uranium verification
    - Imaging, while balancing information protection requirements

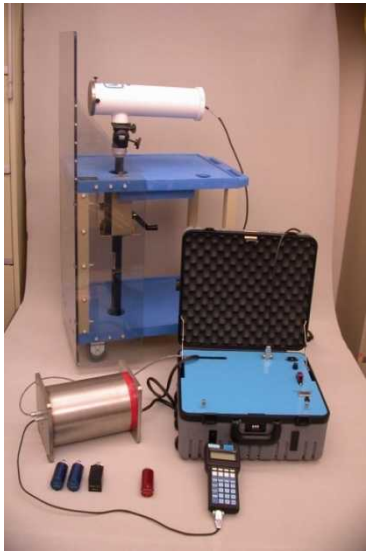


Conceptual design for Fieldable Nuclear Material Identification System (FNMIS)

Mid-Term Requirements (cont.)

- Information barriers (IBs) to protect sensitive information during warhead verification measurements
  - IBs provide deliberate protection for sensitive information through a combination of hardware, software, and human procedures
  - IBs may be based on either attributes or templates, and the development of both continues to be supported

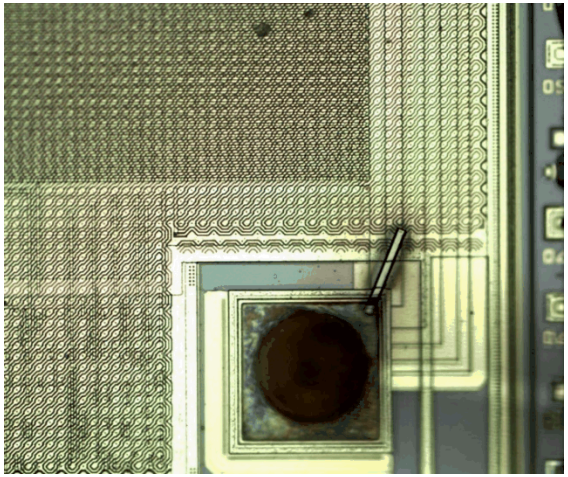
Next Generation Attribute Measurement System (NGAMS)



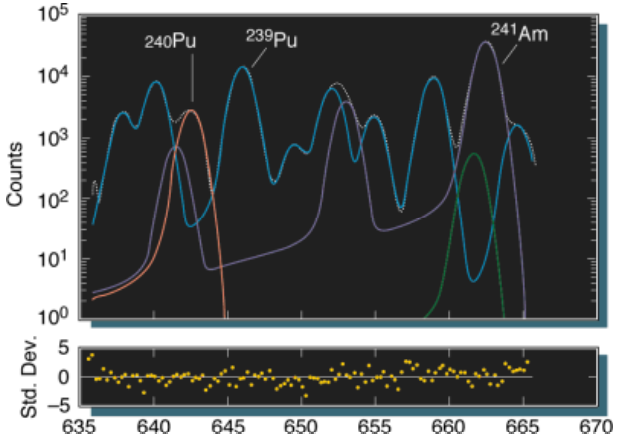
Trusted Radiation Identification System (TRIS) [template system]

Mid-Term Requirements (cont.)

- Tools for authenticating equipment used for verifying the presence of nuclear weapons
  - Both authentication of hardware and software



Authentication of integrated circuits



Increasing ability to authenticate attribute determination code Pu600 via conversion to C

coverity

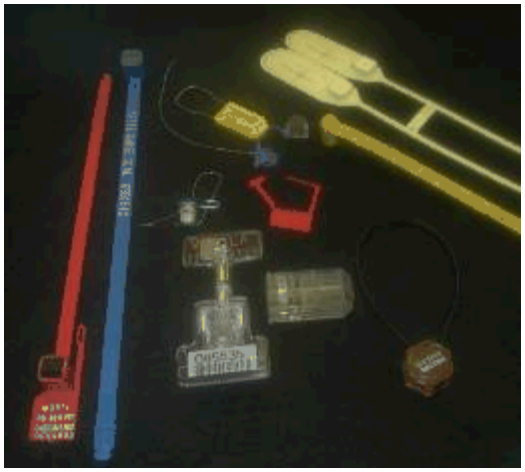
IDA Pro

ROSE

Commercial and National Lab software used to analyze converted Pu600 code

Mid-Term Requirements (cont.)

- Tools to facilitate continuity of knowledge for long-term storage through dismantlement
  - Development of tamper indicating devices (TIDs) to maintain confidence over time that items within a sealed container or room have not been altered or removed. Examples include:
    - Optically stimulated luminescence (OSL)
    - Radiofrequency (RF) tags



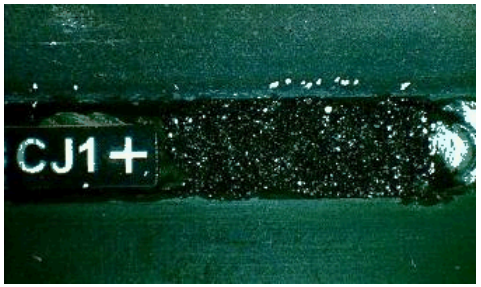
Candidate plastic seals for application of OSL taggant

OSL TID Reader

Totally passive ultrawideband (UWB) radiofrequency (RFID) tag

Mid-Term Requirements (cont.)

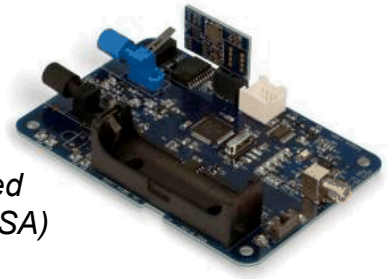
- Additional tools for continuity of knowledge
  - Development of unique identifiers (UIDs) to confirm the identity of items over time



Reflective Particle Tag (RPT)

Application of ultrasonic intrinsic tag (UIT) for advanced item monitoring

  - Development of advanced unattended and remote monitoring systems such as the Next Generation Remote Monitoring System (NGRMS)



Remotely Monitored Sealing Array (RMSA)

Tiny Gamma Spectrometer (TGS)

Long-Term Requirements: Technology Integration

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- Verification of dismantlement and disposition
  - Continuity of knowledge for weapons in long-term storage and through the dismantlement and disposition process
  - Techniques discussed previously, especially when integrated into a system, can be used to detect, characterize and track nuclear materials throughout the stages of the nuclear weapon lifecycle, including through processing and disposition of nuclear components
  - Robust and secure tagging and TID capabilities will be particularly important components of an overall system