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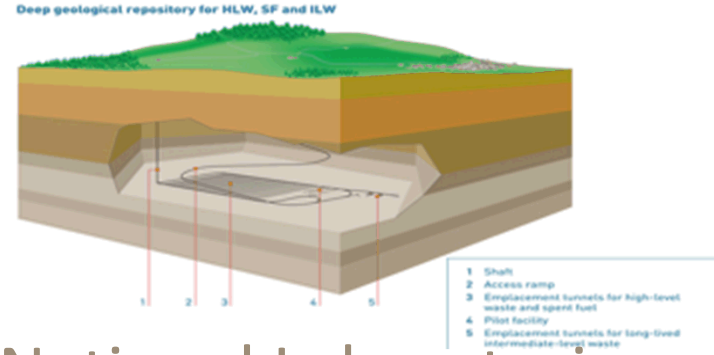

Safeguards at Sandia National Laboratories

International Safeguards and Engagements

INMM Southwest Chapter Meeting

Taos, NM

Risa Haddal

May 19, 2016

U.S. DEPARTMENT OF ENERGY | NNSA

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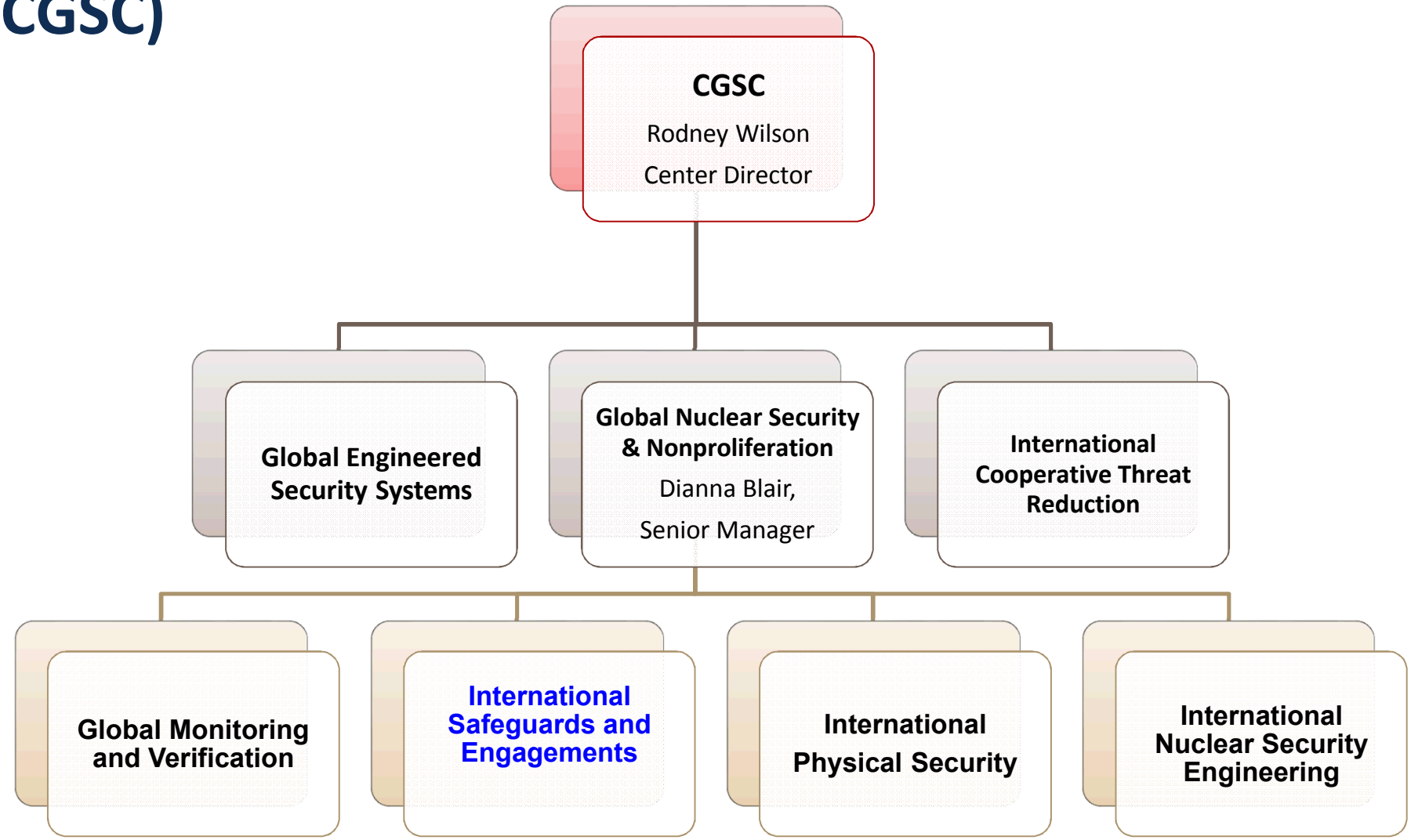
Overview

- Programs and Current Safeguards Work
- SNL Expertise and Contributions to Safeguards
- International Cooperation
- R&D
- IAEA Support
- Future Collaboration
- Discussion

SAND:

Center for Global Security and Cooperation (CGSC)



Current Safeguards-Related Work

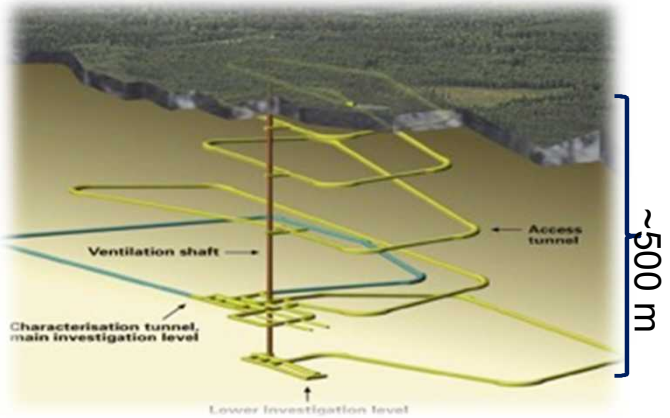
- Cooperation with technically advanced nuclear safeguards partners, i.e., South Korea, France, Germany, Euratom, Argentina, Brazil

- **Enhanced Data Authentication System (EDAS):**
  - Field trial completed in March 2015
  - Demonstrated utility of secure branching in operational nuclear facility;
  - Identified any unforeseen implementation or application issues; and
  - Confirmed whether approach is compatible with operator concerns and constraints.

- **Remotely Monitored Sealing Array (RMSA):** Complete, IAEA procuring
  - Seal integrity/status reported via authenticated/encrypted wireless transmission to a central "translator"
  - Seals units are optimized for low power consumption, last 4-5 years on battery
  - Plastic fiber optic seal cable is easy to install and terminate
  - Incorporates advanced tamper indication and communications capabilities
  - Low life-cycle cost

Current Safeguards-Related Work Continued

- **Technology Development**
  - Ceramic Seal
  - Standoff Video
  - Spent fuel NDA – data authentication
  - Mobile Computing for On-Site Inspections



- **DOE/NNSA Policy, Concepts and Approaches: Geological Repository Safeguards**
  - C/S for Repositories
  - Long-Term Information Management
  - Deep Borehole

- **DOE/NNSA International Nuclear Safeguards Engagement Program (INSEP)**
  - France/Germany: INSEP Regional Lead
  - ABACC: inspector training on C/S
  - Japan: C/S training
  - Argentina: maintaining CoK spent fuel in wet storage
  - ROK: Joint Fuel Cycle Study (JFCS)
  - Euratom: EDAS

SNL Expertise in Critical Aspects of International Safeguards

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Equipment and Information Security

- Safeguards authorities must be able to trust the information it collects and ensure it is suitably protected.
- Key elements: authentication, encryption, tamper indication and system design

Remote and Unattended Monitoring

- IAEA increasingly relies on information collected by unattended safeguards instruments at facilities worldwide
- With proper security, much of the information can be communicated to the IAEA remotely by internet, satellite, or telephone

Vulnerability Assessments (VA)

- Before technologies and systems can be certified for routine Safeguards use, they must survive rigorous independent testing

Containment and Surveillance (C/S) technologies

- Safeguards relies heavily on maintaining "Continuity of Knowledge"
- C&S technologies indicate tampering with nuclear materials or processes

SNL Expertise in Critical Aspects of International Safeguards Continued

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Geological Repository Safeguards

- C/S methods: Essential to the safeguards approach for geological repositories!
- Long-term information management (LTIM)
- Deep Borehole
- Seismic detection and satellite imagery to help assure integrity of repository isolation zone
- Challenges: C/S methodology; unique canister i.d.; retrievability/reversibility
- SNL experience: Waste Isolation Pilot Plant (WIPP) and Yucca Mountain; Application of Safeguards to Repositories (ASTOR) Experts Group

Data Analytics

- Analyzing large amounts of heterogeneous sensor data to discover patterns, trends and anomalies

On-Site Inspection and Managed Access

- Readiness procedures and host/inspector training

Other

- Extensive science and engineering base: chemical analysis, electrical engineering, computer science, materials science, cryptography, and many others

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International Nuclear Safeguards Cooperation

SAND: 2015

South America Cooperation

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Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC)

- Past: Secure Video Surveillance System (SVSS) for unannounced safeguards inspections
- Support for inspector training in containment & surveillance (C/S)

Autoridad Regulatoria Nuclear (ARN) - Argentina

- Current: New application for spent fuel C/S
- Past: Secure safeguards regulatory network
- Future: C/S application for spent fuel management (pending)

Comissão Nacional de Energia Nuclear (CNEN) - Brazil

- Past: Joint assessment of antineutrino monitoring of reactors for safeguards
- No current activity.

East Asia Cooperation

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Republic of Korea

- Partners: Korea Atomic Energy Research Institute (KAERI), Korea Institute of Nuclear Nonproliferation and Control (KINAC)
- Current: Technology for Monitoring, Containment and Surveillance (C/S)
- Past:
  - Safeguards for Geological Repositories: Applications to Waste Forms from Electrochemical Processing of Spent Nuclear Fuel (AS41) (2013-2015)
  - Information Sharing Framework for Regional Nonproliferation Cooperation (Transparency) (2011-2013)
  - Regional cooperation in remote monitoring: established a secure link between SNL, Idaho National Laboratory, and KAERI

Japan

- Partners: Japan Atomic Energy Agency (JAEA), through cabinet ministry (MEXT)
- Current: C/S Training (June 2016)
- Past: Regional cooperation in transparency and remote monitoring
  - Information Sharing Framework for Regional Nonproliferation Cooperation (Transparency) (2011-2013)
  - Established, upgraded, and maintained a secure link between SNL and Joyo

European Cooperation



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Euratom

- Current: secure branching of operator instrumentation for safeguards inspector
  - "Enhanced Data Authentication System" (EDAS)
    - Inspector requires exact (but authenticated & encrypted) copy of the data; operator must be confident that EDAS could not interfere with existing system
  - Field trial of EDAS: March 2015; close-out June 2016

- Past: other collaborations with the European Joint Research Centre (JRC)
  - Wireless data transmission: investigated feasibility and security of radio frequency (RF) and other communication technologies for safeguards instrumentation in facilities
  - 3D sensing technologies: contrast different methods for application to safeguards

Complementary activities

- European Safeguards Research and Development Association (ESARDA) Associate Member (2015).
  - C/S, Safeguards Implementation, Verification Technologies & Methodologies

European Cooperation Continued



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France

- Current: No open Action Sheets, but SNL holds France Regional Lead position for INSEP/France Safeguards Cooperation.
  - 9th Annual PCG, September 2016, France
- Separate agreements with the Commissariat à l'Énergie Atomique (CEA) and the Institut de Radioprotection et de Sûreté Nucléaire (IRSN)

Germany

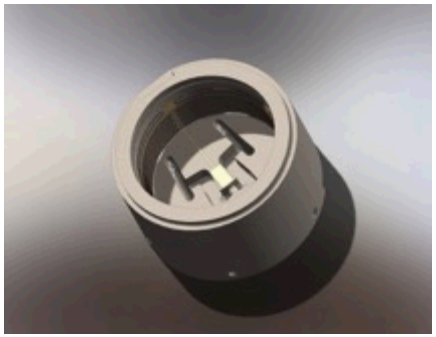
- Past: Action Sheet 1: Cooperation on lifecycle challenges of Electronic Optical Sealing System (EOSS)
- SNL holds Germany Regional Lead position for INSEP/Germany Safeguards cooperation.
- Exploring other areas of future safeguards cooperation.

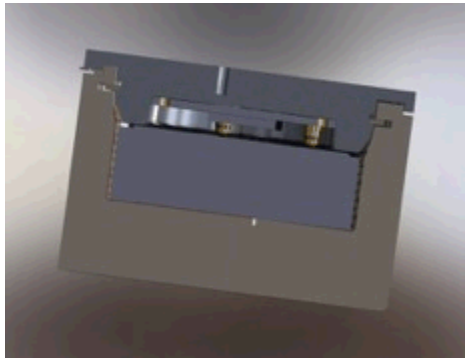
Technology Research & Development

SAND: 2015-

Ceramic Seal

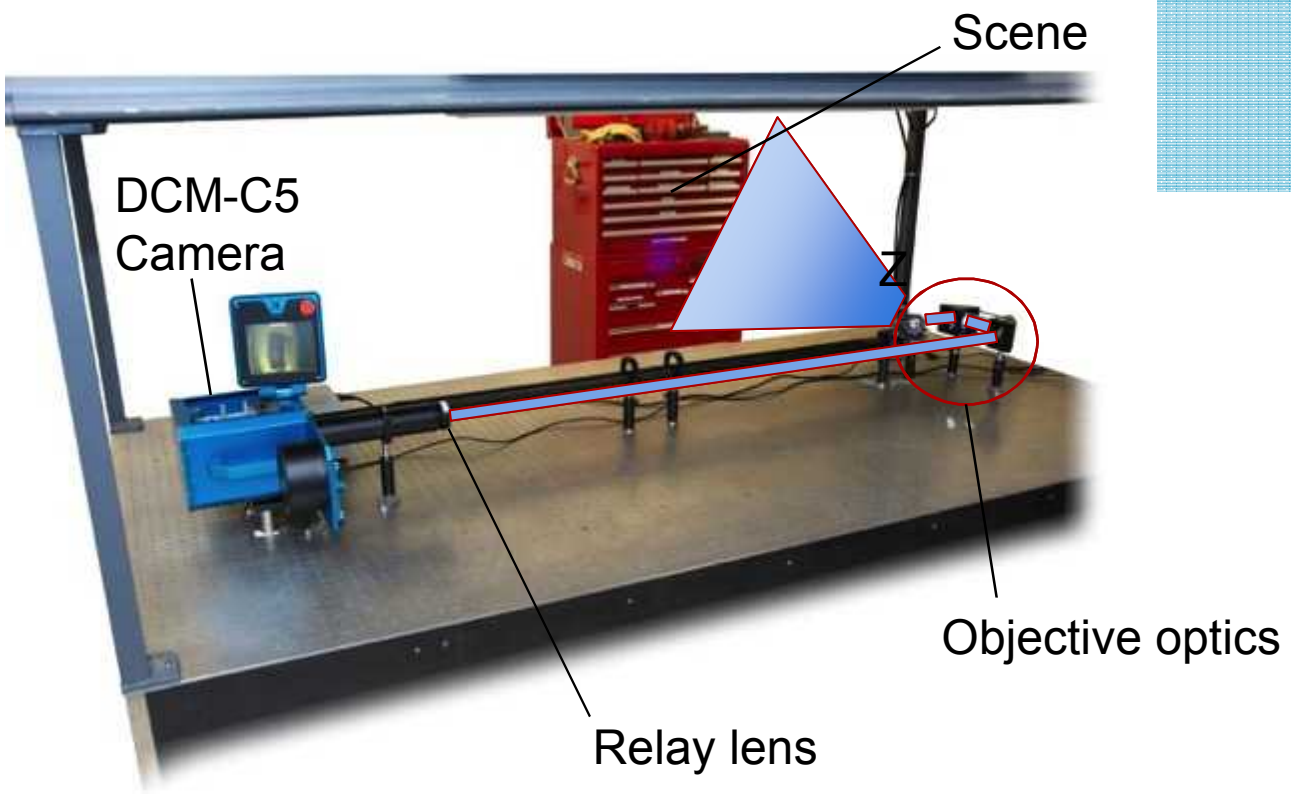
- Fabrication of seals for testing
- Development of handheld reader
- Development of interface capability to a sensor/data integration system
- Testing for operational readiness
- Field testing in representative verification trial in 2016

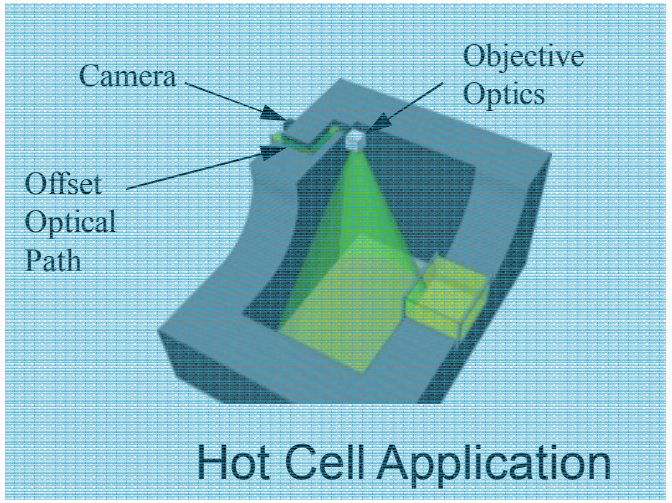




Demonstration of standoff video and in-scene authentication

- Minimize how much of a surveillance system is exposed to a hazardous environment
- Mirrors are used for the objective optics

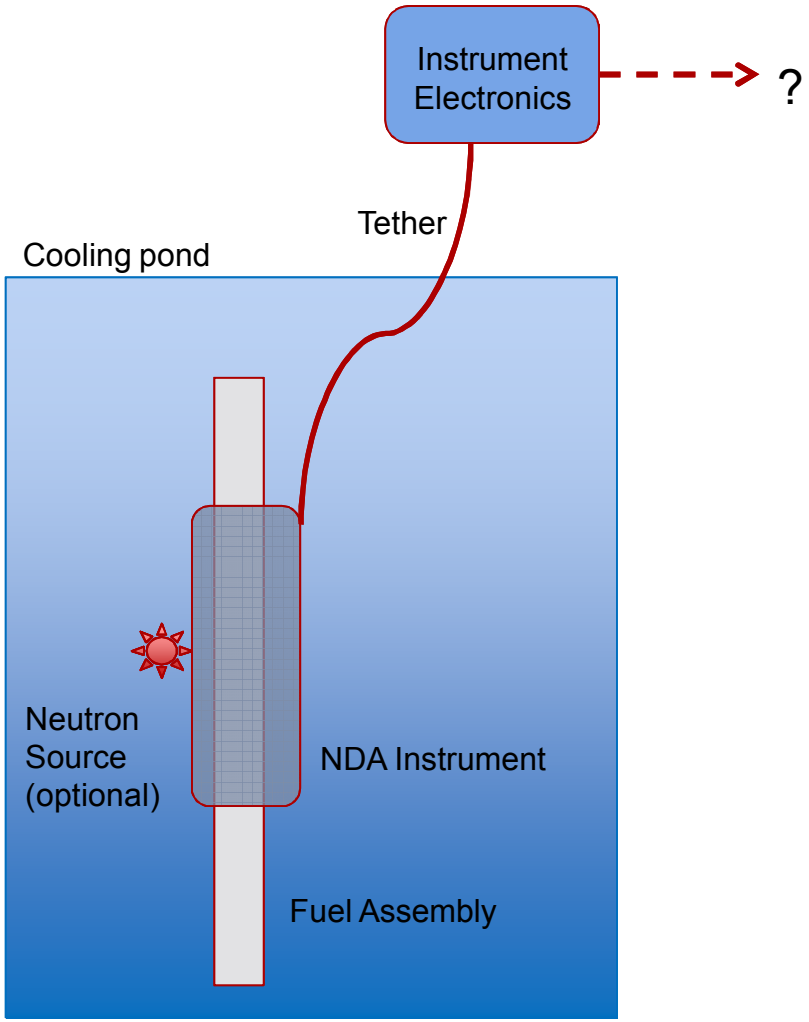




Authentication is by challenge/response:

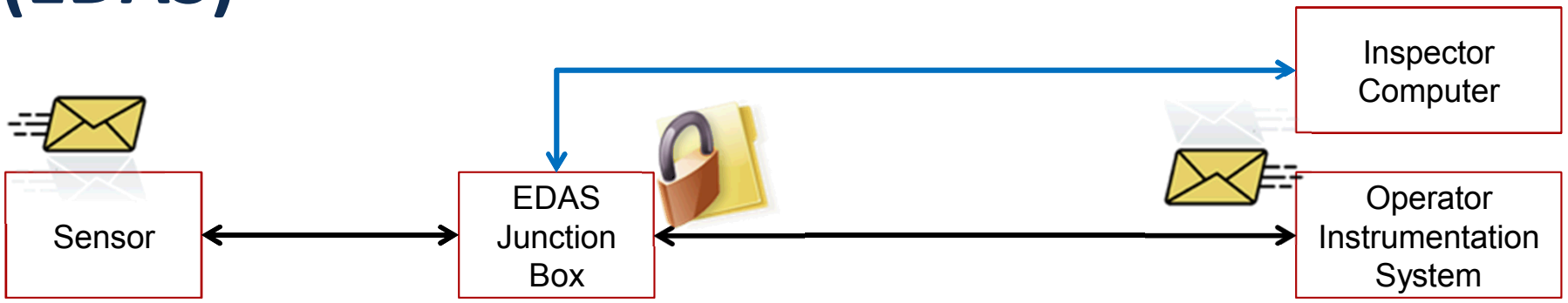
- LED light artificially cast into the scene
- The light varies in intensity, position, color, and timing
- Look for the expected “spots” in the image

Data authentication for the spent fuel (SF) nondestructive assay (NDA) project



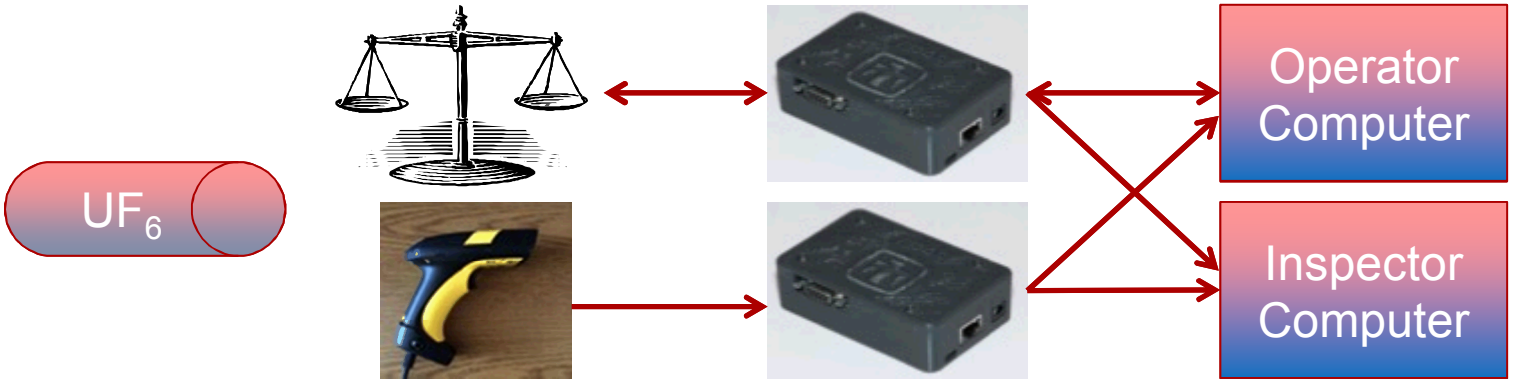
- NNSA has a large multilab effort to develop an NDA instrument to provide improved assay of SF
- All other labs are concerned with developing the technical capability—the science
- Sandia is tasked with "data authentication" for the project:
  - Assume the instrument works
  - *How could it be used in remote or unattended mode, possibly by multiple parties, and still be trusted?*

Enhanced Data Authentication System (EDAS)



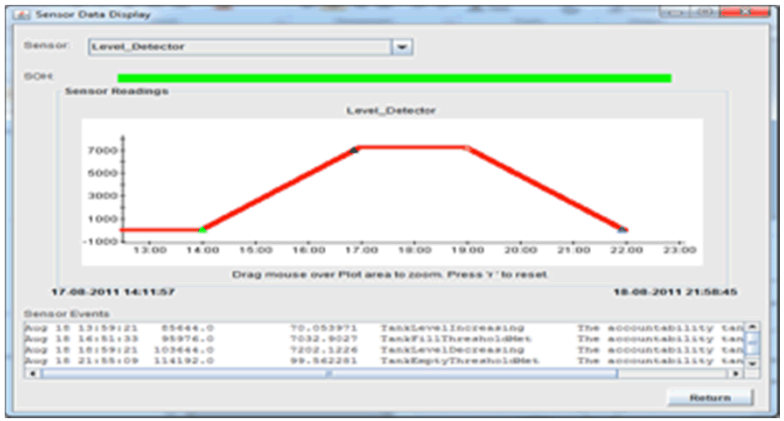
EDAS Field Trial

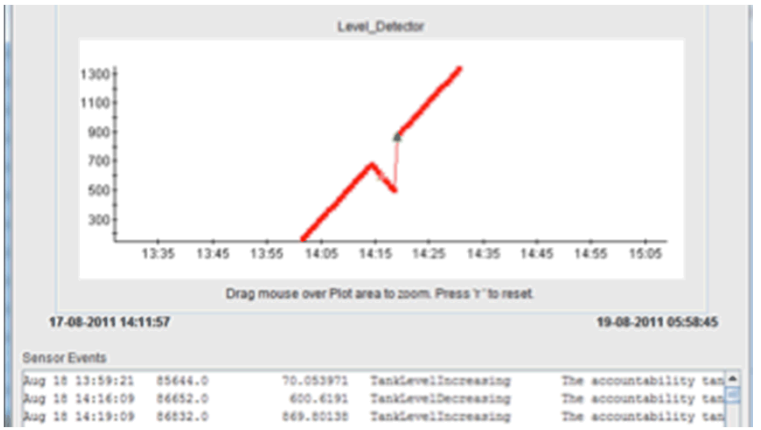
- Demonstrate secure branching under realistic operating conditions
- Identify any unanticipated issues with EDAS operation and installation
- Derive narrative of facility activity from multiple operator instruments



Advanced Analytics for Safeguards

- Knowledge Generation: state-based modeling of facility sensors to find discrepancies compared to operator declarations



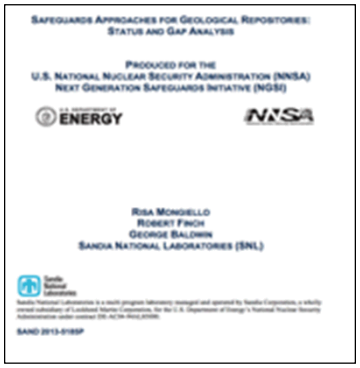


- Machine learning: find subtle patterns, trends, and anomalies in large amounts of heterogeneous sensor data

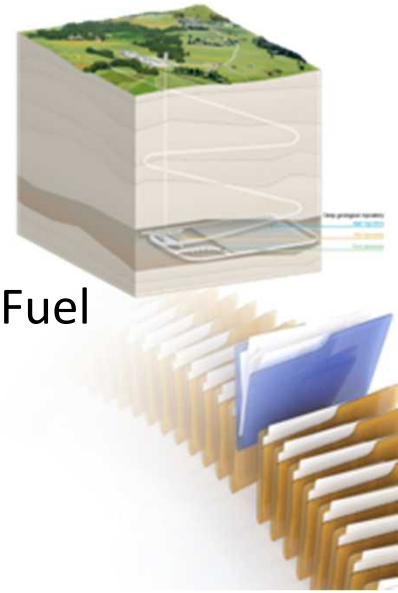
Geological Repository Safeguards

DOE/NNSA Next Generation Safeguards Initiative (NGSI)

Policy, and Concepts and Approaches (C&A) Subprograms



- 2016:
  - Long-Term Information Management Phase II
- 2015:
  - Long-Term Information Management Phase I
  - Containment and Surveillance (C/S) as the Primary Approach
  - Safeguards Implications for Deep Borehole Disposal of Spent Fuel
- 2014: SNL/LLNL joint study, Commercial Off-the-Shelf (COTS) Seismic Monitoring Technologies
- 2013: Gap Analysis



Other Work in Center

Global Monitoring and Verification Department

- Other projects in Center applicable to safeguards:
  - Sensors and systems using public key cryptography and certificates
    - Ultra low power cryptography board
  - New sensors: tiny gamma spectrometer, authenticated camera, door switch, and motion detector.
  - Data acquisition, inventory, and review system using standardized data protocols for safeguards sensors.
  - Advanced analytics research to find patterns, trends, and anomalies in large amounts of heterogeneous data.

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IAEA Support

Remotely Monitored Sealing Array (RMSA)

- Active loop seal for IAEA Safeguards application
  - Seal integrity and status reported via authenticated/encrypted wireless transmission to a central "translator"
  - Seals units are optimized for low power consumption and last 4-5 years on battery without replacement
  - Plastic fiber optic seal cable is easy to install and terminate
  - Incorporates advanced tamper indication and communications capabilities
  - Low life-cycle cost

- IAEA has approved RMSA for routine inspection use
- IAEA now commencing procurement (Canberra) and deployment
- SNL Principal Investigator:
  - Ross Hymel

RMSA pre-production prototype

Safeguards Collaboration

Past Collaboration

- **Electronic Optical Sealing System (EOSS): Action Sheet 1**
  - One-year effort to explore lifecycle challenges of EOSS
  - Identify possible upgrades to the seal
  - Collaborate on:
    - Assessing/identifying technical challenges and needs
    - Considering hardware/software adaptations for increased security of EOSS
    - Reviewing and revising suggested procedures for EOSS application during decommissioning in Germany
    - Recommendations
    - Final report

EOSS AS1 Continued

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FZJ:

- Collect and review current status of EOSS technical specs
- Identify safeguards applications in German safeguards program
- Develop prioritized list of needs
- Draft recommendations and first draft of final report
- Deliver recommendations to German Safeguards Program and IAEA

SNL:

- Conduct analysis of technical specifications
- Provide analysis and collaborate on final report

Technical Challenges of EOSS

- **Usability**
  - Multiple key sets used to communicate between EOSS seal and reader
    - Euratom unable to make independent conclusions regarding data authenticity
    - Authentication key stored at IAEA HQ
- **Data Authenticity and Integrity**
  - Triple Data Encryption Standard (3DES) not as secure as Advanced Encryption Standard (AES)
    - AES has variable bit strength (128 or 256 bits) – unbreakable by brute force for many decades
- **Data Confidentiality**
  - Seal uses 3DES or AES algorithms; 3DES is less preferable to AES.
- **Obsolescence**
  - Seal to be used for at least another 10 years.
  - Concern about parts and software obsolescence.

Recommendations

- **Usability and Data authenticity/integrity**
  - Implementation of asymmetric key cryptography (public/private key pairs) to improve key management.
  - Allow EOSS to have joint-use capability, e.g., IAEA and Euratom could have ability to verify authentication of data independently.
- **Data Confidentiality**
  - Implement AES encryption
- **Parts/Software Obsolescence**
  - Manufacturers should be consulted to provide guidance on how long seal can be supported.
  - Estimate seal number requirements

Questions

SAND: