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ADVANCED PROCESS DATA ACQUISITION, AUTHENTICATION, AND MANAGEMENT FOR CIVILIAN NUCLEAR FACILITIES

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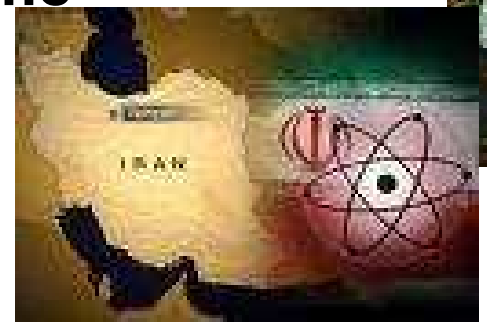
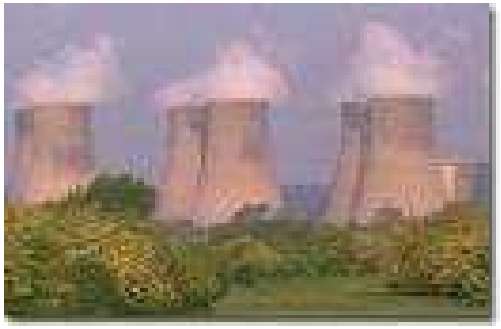
Summary

- **A new landscape poses new challenges to the international safeguards system**
  - **Changing landscape:**
    - Rapid growth of nuclear energy
    - Deployment of advanced facilities
  - **Challenges:**
    - Insufficient resources
    - Technical limitations
- **New tools and approaches may help answer these challenges**
  - **Process information**
  - **To be useful, many challenges need to be addressed**
  - **Should be approached in an integrated manner seeking to optimize utility for multiple applications**
- **Several areas of relevant research underway examining all elements of process data use**

New Landscape, New Challenges

- International safeguards system has been very effective
- Many challenges to the broader nonproliferation regime
  - Iran
  - DPRK





- "Nuclear renaissance" may place a significant burden on the safeguards system
  - More states
  - Advanced facilities and technologies

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Current IAEA Responsibilities Will Grow

- **Already more than 900 facilities in more than 70 states subject to inspection**
  - **Minimal expected growth in the IAEA's safeguards budget**
  - **Limited safeguards technology development**

Number of facilities under safeguards or containing safeguarded material

Facility type	Number of facilities (number of installations)			
	Comprehensive safeguards agreements[a]	INFCIRC/66[b]	Nuclear weapon States	Total
Power reactors	186 (223)	11 (14)	1 (1)	198 (238)
Research reactors and critical assemblies	141 (152)	7 (7)	1 (1)	149 (160)
Conversion plants	13 (13)	1 (1)	— (—)	14 (14)
Fuel fabrication plants	38 (39)	3 (3)	— (—)	41 (41)
Reprocessing plants	5 (5)	1 (1)	— (—)	6 (6)
Enrichment plants	8 (8)	— (—)	2 (4)	10 (12)
Separate storage facilities	67 (68)	3 (3)	7 (8)	77 (79)
Other facilities	82 (92)	1 (1)	1 (1)	84 (94)
Subtotals	**540 (600)**	**27 (30)**	**12 (15)**	**579 (645)**
Other locations	325 (423)	3 (30)	— (—)	328 (453)
Non-nuclear installations	— (—)	1 (1)	— (—)	1 (1)
Totals	**865 (1023)**	**31 (61)**	**12 (15)**	**908 (1099)**

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco and other comprehensive safeguards agreements.
[b] Excluding installations in nuclear weapon States; including installations in Taiwan, China.

International Atomic Energy Agency: IAEA Safeguards: Stemming the Spread of Nuclear Weapons

- **Facility operators will face increased safety, security, and operational requirements that they will need to find cost-effective ways to meet.**

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Building Confidence in the System

- Ability to collect sufficient relevant information in a timely fashion
- Ability to make sufficiently accurate measurements (especially in large, bulk facilities)
- Ability to make full use of all information through integration and analysis
- Ability to reduce the burden on inspectors
- Ability to reduce the burden on facility operators

Operational Data and Process Monitoring

- **Process Data:**
  - **Data collected by the facility operator (using facility operator-owned data acquisition tools) primarily, but not exclusively, to monitor critical facility operation characteristics such as safety and efficiency.**
- **Complement to traditional material accountancy approaches**

Integrated Elements Process Data Use

- ***Acquisition*** **of process data for material monitoring and accountancy (includes development of modeling tools, diagnostic tools, new or more accurate sensors, and improved or novel utilization of existing sensors)**
- ***Authentication*** **of acquired process data**
- ***Aggregation*** **of multiple, disparate data streams through the use of advanced information systems**
- ***Analysis*** **of acquired data using innovative statistical evaluations to draw meaningful, reliable, and transparent conclusions**
- ***Access*** **to data and analysis in a secure and managed environment to allow multiple stakeholders remote access to appropriate information**

Data security is a crucial component of all elements of process monitoring

Potential Contributions

- **Potential areas of contribution:**
  - **Strengthen of safeguards conclusions**
    - Improved accuracy and frequency; Reduce accountancy uncertainty
  - **Improve the increased transparency of civilian nuclear activities**
    - Improved flexibility to provide desired and appropriate data
    - The “check engine” light concept
  - **Cost savings (cost effectiveness; limited additional safeguards data acquisition tools)**
    - Authenticated sources may avoid need for duplicative sensors and data communications system
    - Incorporation into design critical

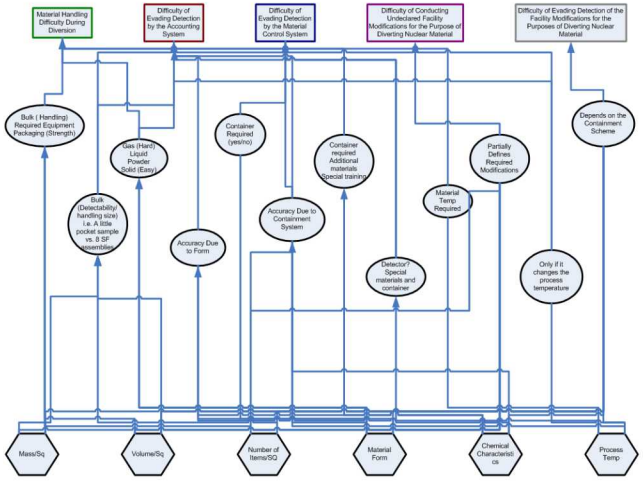
Limitations

- Safeguards:
  - Credibility of Information
  - Independence
  - Control of Equipment

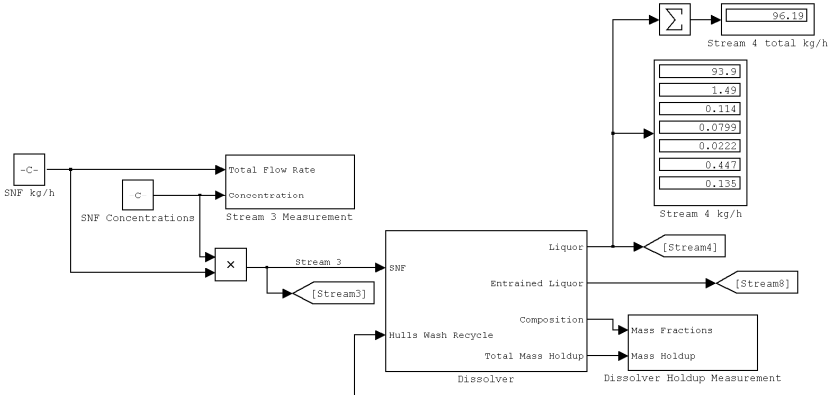
- Transparency
  - Credibility
  - Security
  - Protection of proprietary data

Sandia R&D: Acquisition

- **Identification of nonproliferation-relevant data acquisition opportunities**
  - **Proliferation assessment input development**
  - **Facility and process visualization and modeling**
  - **Process model of expected material flows to optimize optimizing sampling strategies**
  - **Advanced transparency framework using plant process data**



Proliferation Assessment Input Hierarchies



Front End Simulink Model

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Sandia R&D: Authentication

- **Ensuring that data originated from the intended source, was not changed in transit, and that it is not a repeat or delayed copy of previous data**
  - **Cooperative research effort with the European Commission to study the enhancement of data authenticity via an electronics platform for the secure transmission and recording of sensor data.**
    - Integration of secure sensors into operator plant control system

Critical integrated circuits using reflective particle tagging technology

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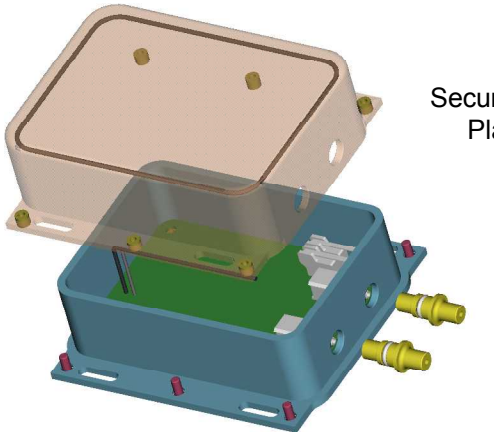
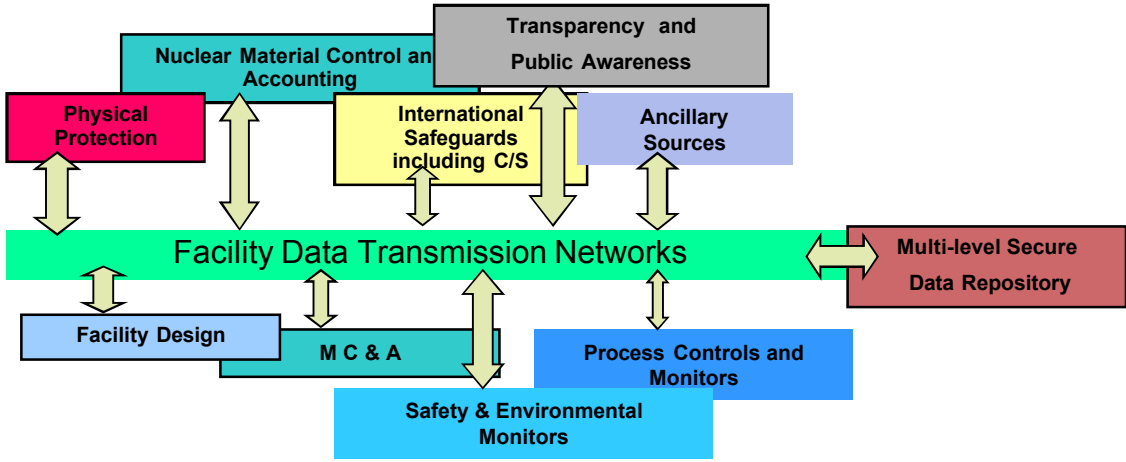
Sandia R&D: Aggregation

- **Management and aggregation of large data sets**
- **Secure Sensor Platform**
  - **Multiple sensor collection**
  - **Secure communication**
- **Advanced Facility Information System**
  - **Authentication, encryption, and tamper indication**
  - **Modular, flexible open architecture**



Secure Sensor Platform



Integrated Facility Information System Architecture

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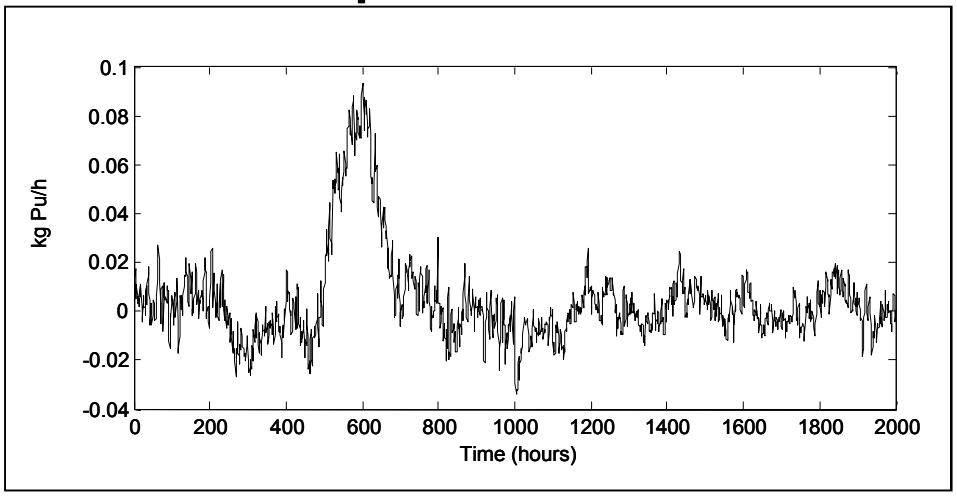
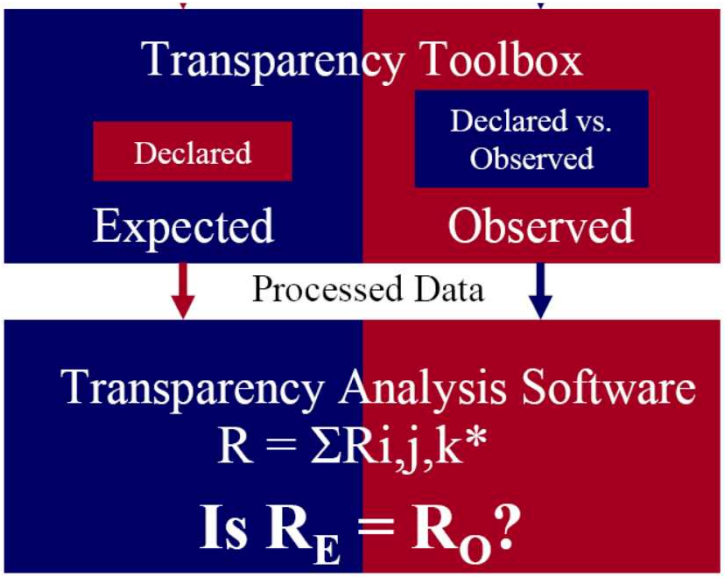
Sandia R&D: Analysis

- Critical step in translation of raw operations data
  - Must be transparent to be trusted
- In transparency applications, analytic techniques may be subject to negotiation
- Process modeling
  - Assess measurement results; set anomaly thresholds
- Transparency Framework
  - Quantify probability and consequence of diversion



Alarm thresholds: Response to diversion of 8 kg over 100 hours



*where i,j,k = step, process, plant

Comparison of measurements with design requirements

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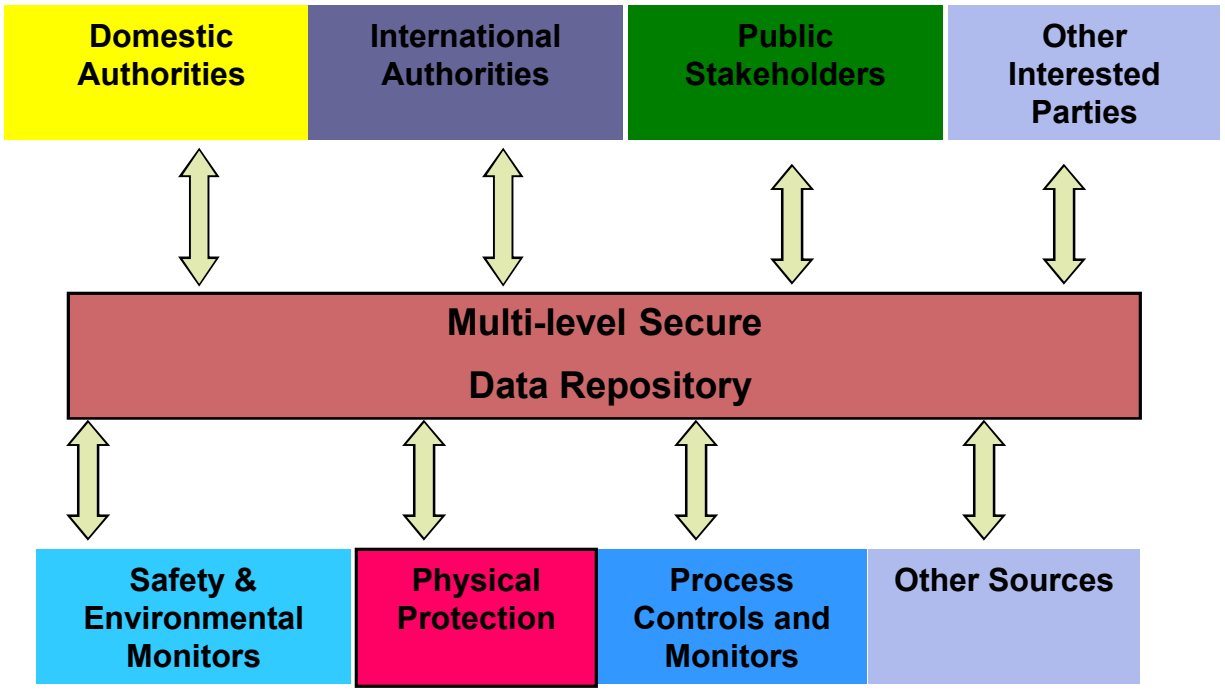
Sandia R&D: Access

- Secure, remote, managed access to stakeholders
- Closely related to authentication, aggregation, and data security
  - Public key encryption infrastructures



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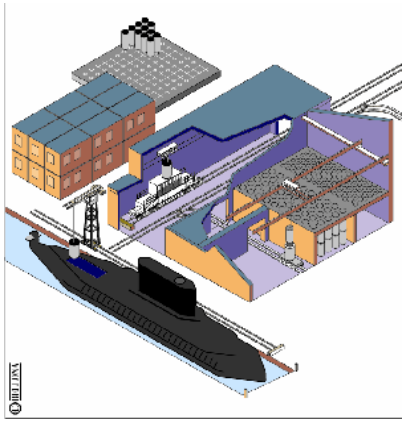
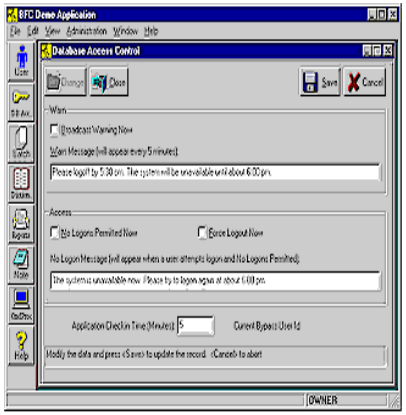
Integration Example:
Spent Fuel Storage System Knowledge Base

- Includes information on
- Design, operation, and technologies employed
- Techniques and results of tests on condition of SNF
- Results of performance and risk assessments
- Descriptive information and results of the transparency, safeguards, non-proliferation, and monitoring capabilities of the system to appropriate parties (and of protecting that information from those without proper authorization).





The goal is to provide access,, to information showing that the critical system requirements have been met, that the major functions and technologies have been implemented, and that the operations are conforming to the needs of the interested parties.

Acquisition, Authentication, Aggregation, Access, and Data Security

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Conclusion

- Operator-owned process data may be able to play an important role in strengthening the international safeguards system
  - Enhanced observational capabilities
  - Reduced operator and inspector burden
- Operator data also offers an opportunity to increase transparency of operations and activities
- However, to be valuable in either application, advanced approaches must integrate six elements:
  - Acquisition, Authentication, Aggregation, Analysis, Access, and Data Security
- Must be designed-in as part of systems approach if advantages are to be realized