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Data Authentication for the Nondestructive Assay of Spent Fuel

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Context

- We support the Next Generation Safeguards Initiative Spent Fuel (NGSI-SF) project to develop advanced nondestructive assay (NDA) instrumentation for spent reactor fuel
  - All project work by U.S. national laboratory participants is funded by the U.S. National Nuclear Security Administration (NNSA)
  - Sandia has responsibility for the data authentication task
- SKB also collaborates with the NGSI-SF project
  - In particular, SKB has been providing field test opportunities at Clab for prototype instruments: Passive Gamma, DDSI, DDA…

Why are we here?

- This visit differs from others by the project team
  - We are not here to do (or plan for) measurements at Clab
  - We are looking ahead to the possibility for a deployed safeguards instrument to support spent fuel encapsulation (e.g., at CLINK)
- Our goals
  - We wish to understand better the *operational environment* for routine use, both physical and procedural
  - We wish to understand better the *stakeholder requirements* for routine use, both interests and constraints
  - Encourage communication with SKB about helping design controls for the CLINK facility

Motivation: Safeguards by Design

- During their development, NDA systems for spent fuel assemblies (SFAs) are “attended” systems
- Their use in an eventual routine application would likely be as “unattended” systems, either
  - Fully automated, e.g., as part of a robotic system
  - Operated by the facility

- The “data authentication” task poses the question:

What (else) is necessary for a safeguards inspectorate to trust the information from the spent fuel NDA system(s) when operated in unattended mode?

Unattended (or remote) operation: What does an inspector need to know?

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- The measurement information is indeed from the NDA instrument
- The information pertains to the particular SFA in question
- The information has not been altered since the measurement was performed
- All measurement conditions were in fact as reported
- No complicating factors were present
- Continuity of knowledge for this SFA can be maintained reliably

All of this must be assured by the unattended system
without any reliance on trust

Trust cannot be a factor in accepting the truth of the measurement results

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- Technical security measures (such as data authentication and tamper indication) ensure the faithful reporting of measurement results
  - No accidental corruption
  - No malicious manipulation
- Other measures may be necessary to establish the truth of the measurement results
  - Instrument calibration
  - Instrument diagnostics

- NOT an acceptable basis for accepting the results:
  - “These are the numbers I was expecting…”

Assumptions: Routine Use

- The instrument must be capable of operating in *unattended mode*
- The measurement will be essential to the IAEA Safeguards objective for *independent verification of* material accountancy declarations
- Other entities also have an interest in the measurement results
  - Operator (SKB)
  - National Authority (SSM)
  - Regional Authority (Euratom)
- Encapsulation: the measurement is likely the *last* one that will be possible for each particular SFA

Joint use greatly complicates unattended measurements

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- A new potential threat now exists within the secure perimeter: the other party
- At least two issues:
  - Another party may be able to *manipulate* the information
  - Another party is able to *know* the same information
- For cryptographic authentication of digital data
  - Public key cryptography is necessary: only one secret key able to "sign" the data; multiple public keys able to validate the signature
  - Key management is critical: only the trusted source of the data should know the secret key
  - Ideally, the private/public key pair is generated within the trusted source itself
- All parties must accept that the instrument is secure/impartial

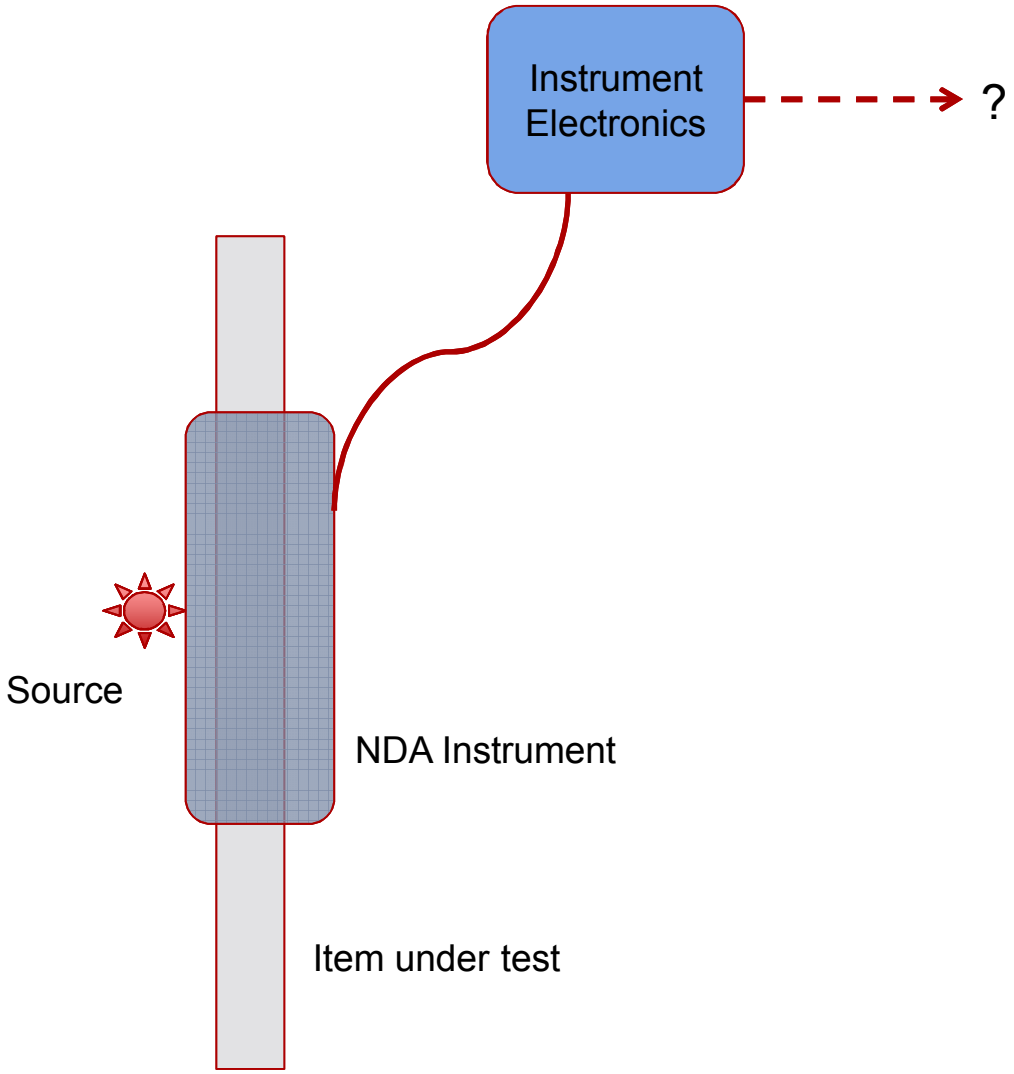
Joint use (continued)

- IAEA requirements for joint use are governed by internal policy paper 20
- Operator would need to declare a SFA *before* the measurement results could be shared
  - (the SFNDA measurement results could not inform the operator declaration)
  - Mailbox system for operator declarations?
- After measurement
  - How does the IAEA verification conclusion affect the encapsulation process? Must the operator wait for a go / no-go indication from IAEA? From Euratom?
  - How do the measurement results affect the operator decisions concerning that SFA? What options does the operator need?

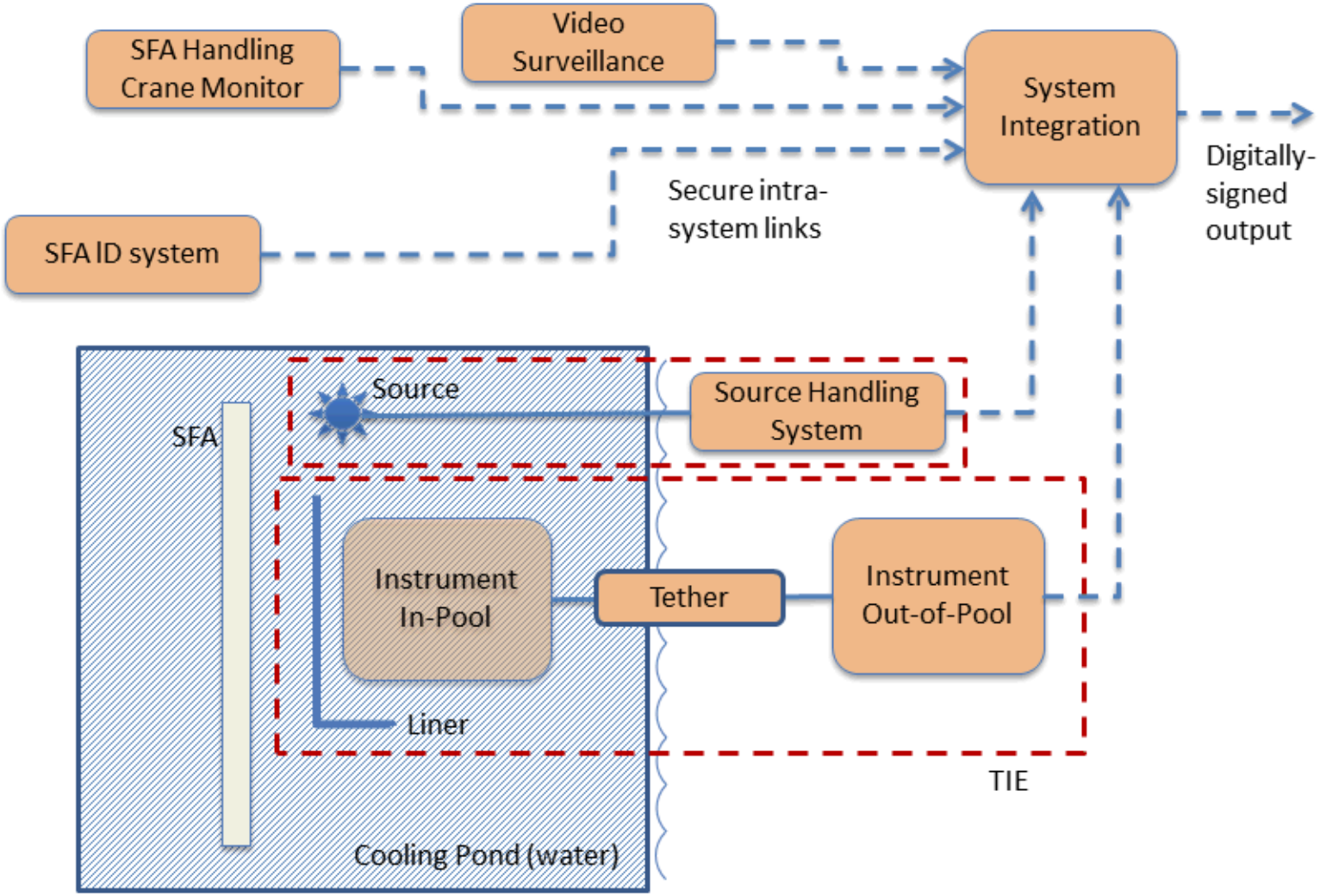
Generalized measurement scenario

Factors:

Interrogating source (if required)
Position of that source (if required)
Item being measured
Position of that item
Environment
Instrument configuration
Instrument integrity
Instrument-measured data
Timing



Notional system configuration



The notional system is only a guess: What is *actually* necessary or planned?

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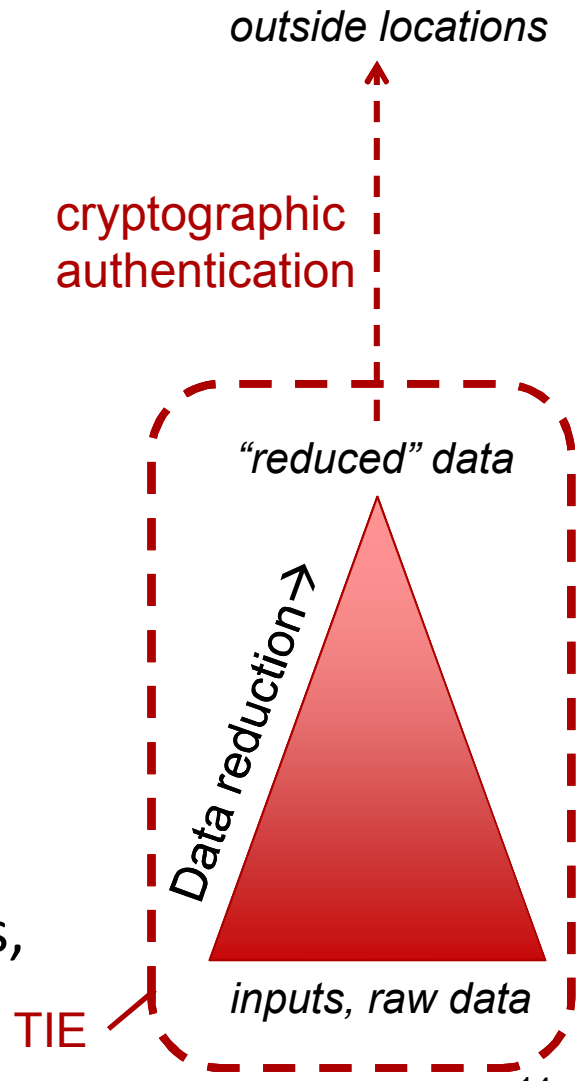
- The physical layout and design of the facility
- What is the process of moving SFAs from wet storage to encapsulation?
  - Where does the process permit temporary storage of assemblies?
  - What are the conditions that allow a SFA to proceed to encapsulation?
  - What is the system that maintains a continuity of knowledge of SFAs?
- How are SFAs identified?
  - By the operator
  - By the safeguards inspectorate
- How are both normal and off-normal events handled?
  - SFA that might be returned to storage?
  - Situation where the SFNDA instrument isn't working?
  - Other situations that might be anticipated?

Procedural considerations

- What is the role for the safeguards measurement in the encapsulation process?
  - Information only; encapsulation proceeds regardless of the results
  - Measurement results dictate the next steps for the operator
- What are the requirements/expectations for the measurement data and results?
  - Immediate use only (e.g., pass/fail partial defect verification)
  - Archive forever (e.g., historical record of repository content)
  - How are measurement data analyzed & abstracted to yield “results”?
- Are measurement data and/or results shared?
  - Joint use by IAEA and Euratom
  - With the operator as well?

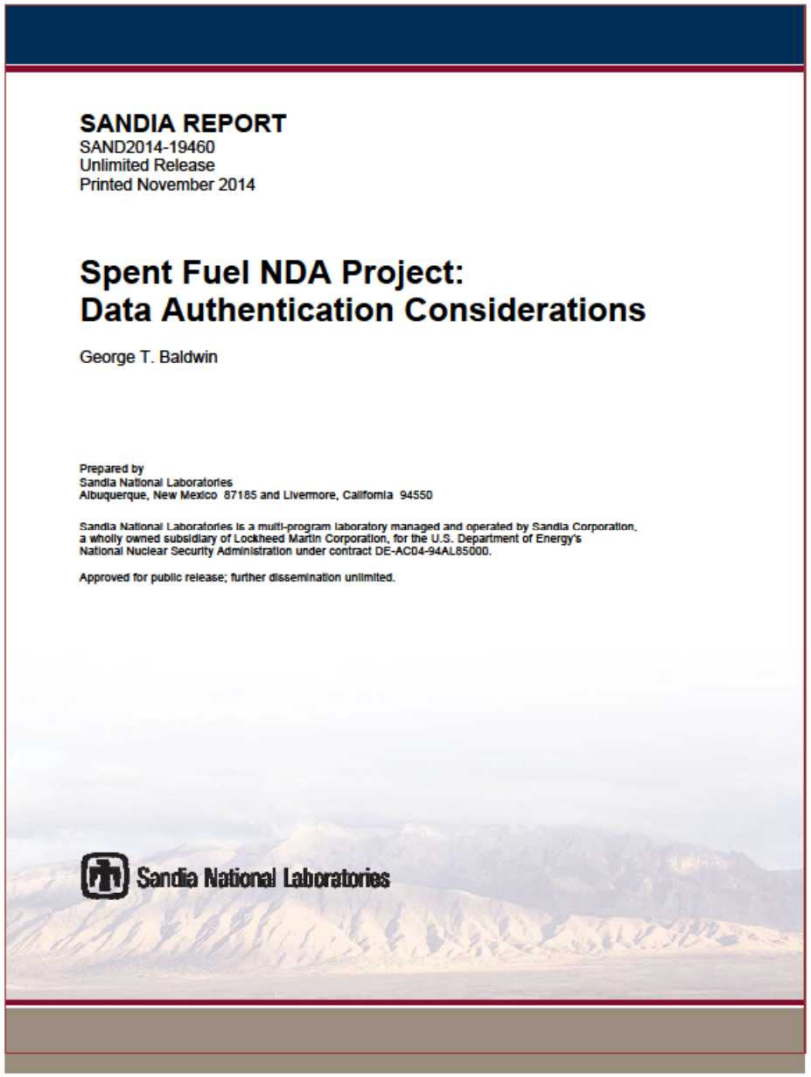
Data Reduction

- Various data streams may be consolidated to generate a measurement result
  - May be automated or done manually
- Where does that consolidation take place?
  - Within a tamper indicating enclosure (TIE)…
    - At the measurement station? Elsewhere at the facility?
    - Offsite?
- When does that consolidation take place?
  - In real time?
  - At the discretion of the inspectorate
- If multiple parties are to receive the results, do all receive the same information?



Recommendations from our initial report

- Develop use cases for these measurements
- Develop readily-verifiable tamper indicating enclosures for submerged NDA instruments to be used in unattended mode
- Define the individual ancillary instruments needed for systems implementation.
- Develop the system implementation for automated, unattended measurements
- Operate the NDA instrument continuously: self-monitoring to detect and deter tampering and report state of health.



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Spent Fuel NDA Project:
Data Authentication Considerations

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Task 12: Data Authentication
Revised FY15 Milestones/ Deliverables

1) Finalize, and validate with stakeholders, the equipment and information security requirements for the NGSI-SF project

- Work with stakeholders to define the use cases
- Compare and contrast data authentication issues for the various NDA technical options

~~2) Explore potential solutions to ensure information security of instruments for unattended operation.~~

~~3) Downselect/rank among technical options and draft a proposed approach for the project.~~

~~4) Review the proposed approach with stakeholders (IAEA, Euratom, SKB, SSM, LANL, and possibly others) and revise as necessary.~~

5) Write a concluding, summary report with recommendations.

Conclusions

- The “data authentication” task effectively takes a systems engineering approach to evaluate what is required to trust information from NDA instrument
- At this stage, we wish to
  - understand the concept for routine operation
  - identify the trust issues that will inform system requirements
- These issues still need better definition, which requires stakeholder engagement
- Results from the data authentication task can inform
  - NDA instrument selection
  - Instrument engineering design
  - Implementation procedures
  - Safeguards approach