SAND2017-7109PE

Joint Fuel Cycle Study

Modeling and Simulation

Process Monitoring and Containment & Surveillance

Safeguards Technology for Nuclear Material Accountancy

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JFCS Overview at Sandia

- **Sandia's involvement with JFCS covers three areas, all of which are contained within the Safeguards and Security Working Group:**
  - Safeguards modeling and simulation
  - Process monitoring and containment and surveillance
  - Safeguards technologies and approaches for waste forms and termination of safeguards
- **Our focus has been more at the systems level to examine potential safeguards designs for future pyroprocessing plants.**
- **Ultimately these tasks provide input to non-proliferation acceptability for JFCS**

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AS-47: Modeling and Simulation for Safeguards and Security by Design

- **Safeguards Objective**
  - The goal of SSBD is to identify and develop the most effective and efficient ways to minimize the risks associated with potential material losses by considering nuclear material protection, accounting and control from the earliest stages of the design process.
  - The M&S activities help to tie together the safeguards and security system approach with performance data on the key parameters as generated from the Integrated Recycling Test (IRT) and other tests.
- **Key Metric**
  - The key metric generated will be overall measurement error which will be used to provide input to nonproliferation acceptability and scaling.

    ※ On the U.S. side, both an IRT and 10 MT/yr engineering scale model have been developed using the Separation and Safeguards Performance Model.
- **On the ROK side, the PYMUS model has been modified to represent a 30 MT/yr facility, and more detail on the unit operations and timing has been developed.**

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Mod/Sim Goals

- **Separation and Safeguards Performance Model (SSPM) Intermediate Scale Model**
  - The intermediate scale model (30 MT/yr) will be used as the basis for non-proliferation acceptability conclusions. It will incorporate the measurement uncertainty and other data from the tests at INL, and will generate the key safeguards metrics such as MUF and σ_{MUF}. The model will be used to explore other design options from a safeguards perspective.
  - We are developing multiple models to cover a range of potential design options.
- **The Pyroprocessing Material Flow and MUF Uncertainty Simulation (PYMUS+) Model**
  - KAERI is developing the PYMUS model in parallel that will be benchmarked with SSPM to ensure consistent results. Development of both models was agreed on so that sensitive results could be developed in-house without requiring sharing of sensitive data.
  - Various versions of PYMUS are also being generated.

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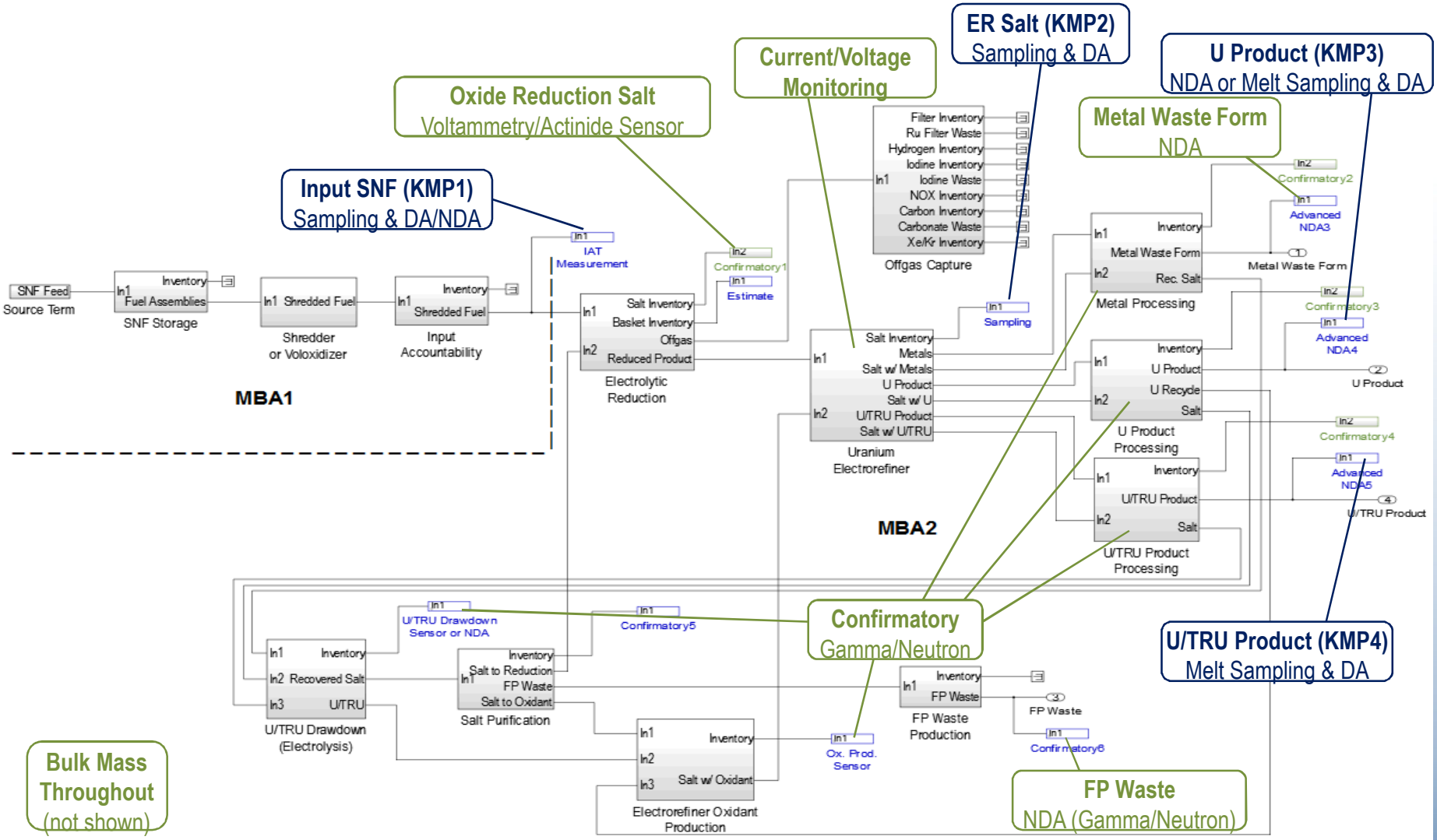
The Models Are Being Used to Develop Preliminary MC&A Designs



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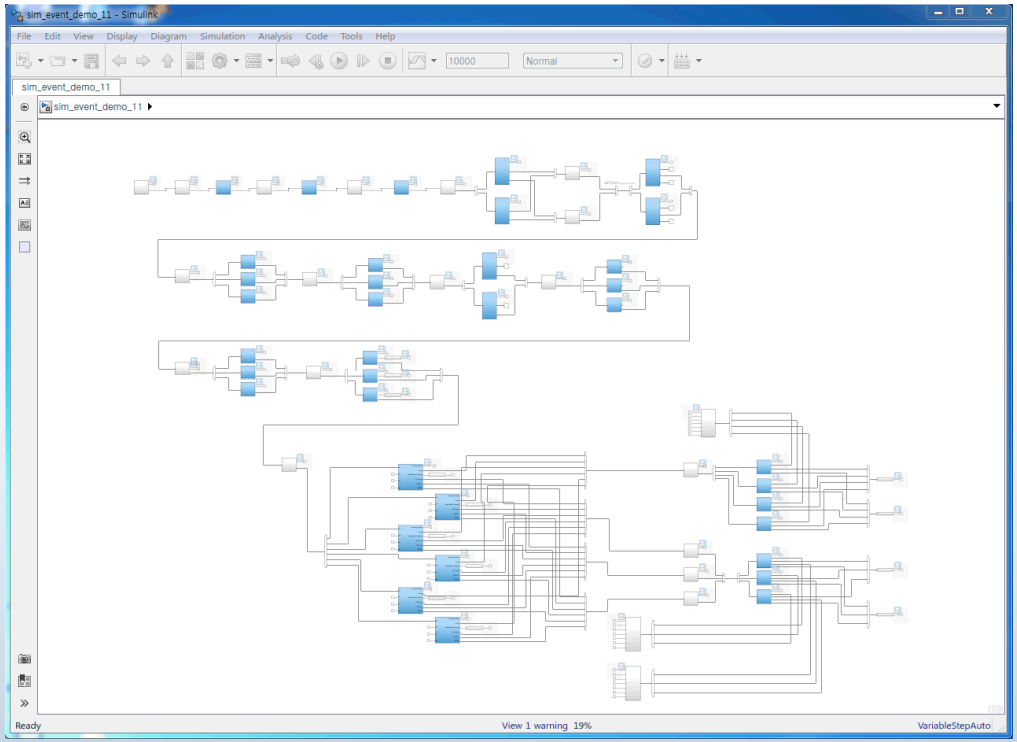
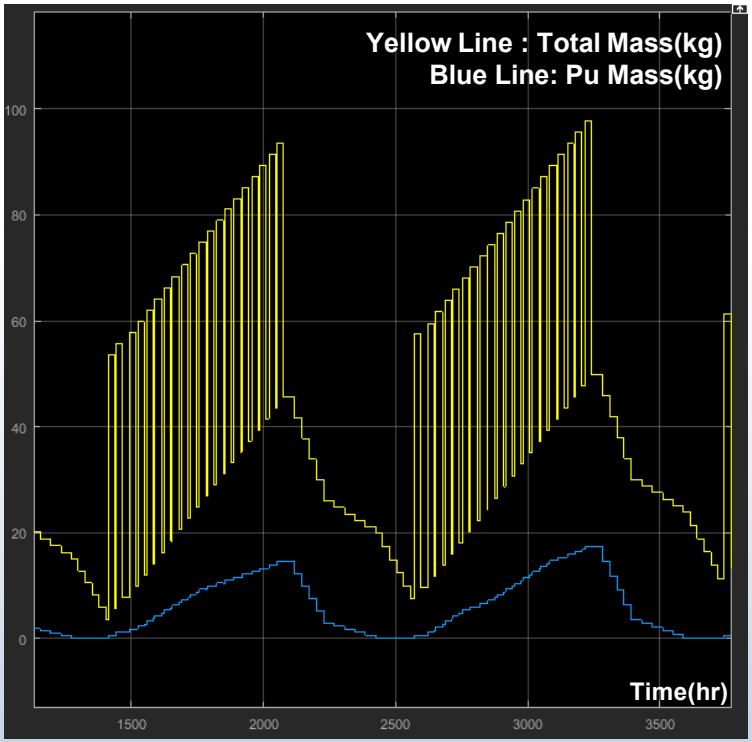
PYMUS+ Model Uses a Similar Approach



PYMUS+ Model



Example Mass Tracking

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AS-46: Monitoring, Containment and Surveillance (C/S) (signed October 2015)

- **AS-46 Safeguards Objective**
  - Explore and develop process monitoring (PM) and containment and surveillance (C/S) technologies for electrochemical recycling
- **Activities under action sheet 46:**
  - Process monitoring for safeguarding an electrochemical recycling plant
  - Technologies for containment and surveillance
  - System study for integrating safeguards technologies
- **Support IAEA equipment testing in IRT**

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AS-46: Monitoring, Containment and Surveillance (C/S)

- **Complementary PM and C/S measures might mitigate challenges for Nuclear Material Accountancy (NMA) for electrochemical recycling.**
  - Need to understand capabilities of PM and C/S technologies when applied to pyroprocessing facilities
  - Study underway
- **Study of PM & C/S technologies**
  - Identify appropriate PM and C/S technologies
  - Document test plan for selected PM and C/S technologies as part of the IRT and elsewhere, as appropriate

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AS-45: Safeguards Technology for Nuclear Material Accountancy
(signed October 2015)

- **AS-45 Safeguards Objective**
  - Design, fabricate and test safeguards measurement systems for uranium and U/TRU output products from the IRT
  - Understand characteristics of output products
    - Evaluate performance of safeguards measurement systems

- **Activities under AS-45**
  - Characterize output products
  - Design of safeguards measurement system(s) for output materials (U & U/TRU)
  - Design, test, and evaluate uncertainties of IRT safeguards-measurement systems


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AS-45: Safeguards Technology for Nuclear Material Accountancy

Safeguards for Electrochemical Waste

- **Safeguards Approaches**
  - Identify safeguards approaches for electrochemical waste streams & waste forms
  - Identify process effects that might influence safeguards approaches for wastes
- **Terminating Safeguards**
  - Identify requirements and challenges for terminating safeguards on electrochemical wastes
  - Measuring U/TRU concentrations in waste forms
    - Methods, detection limits, uncertainties

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Summary

- The partnership between NNSA, KAERI, and IAEA has remained strong.
- The JFCS meetings are highly technical, and significant progress is made in the meetings and bi-weekly telecons.
- The current tests at INL and existing work at KAERI represent a unique opportunity to gather safeguards data that is needed to make informed safeguards decisions—information on measurement uncertainties and process monitoring technologies will be highly valuable.