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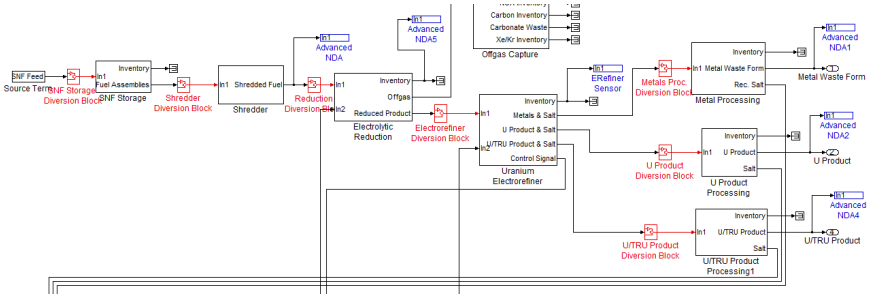

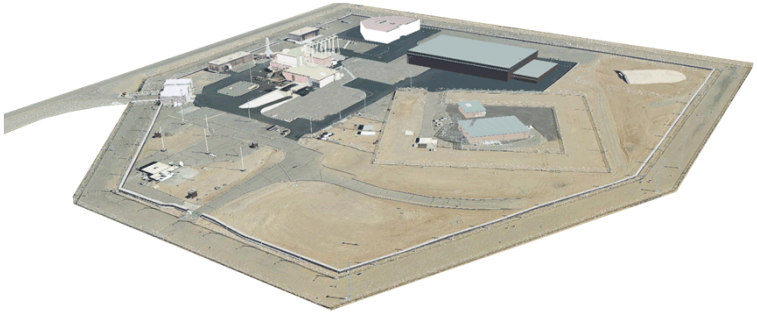

Safeguards and Security Integration for Fuel Cycle Facilities

Ben Cipiti, Felicia Duran, Jordan Parks, Dean Dominguez, Ethan Parks, Valorie Szlemko

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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Overview

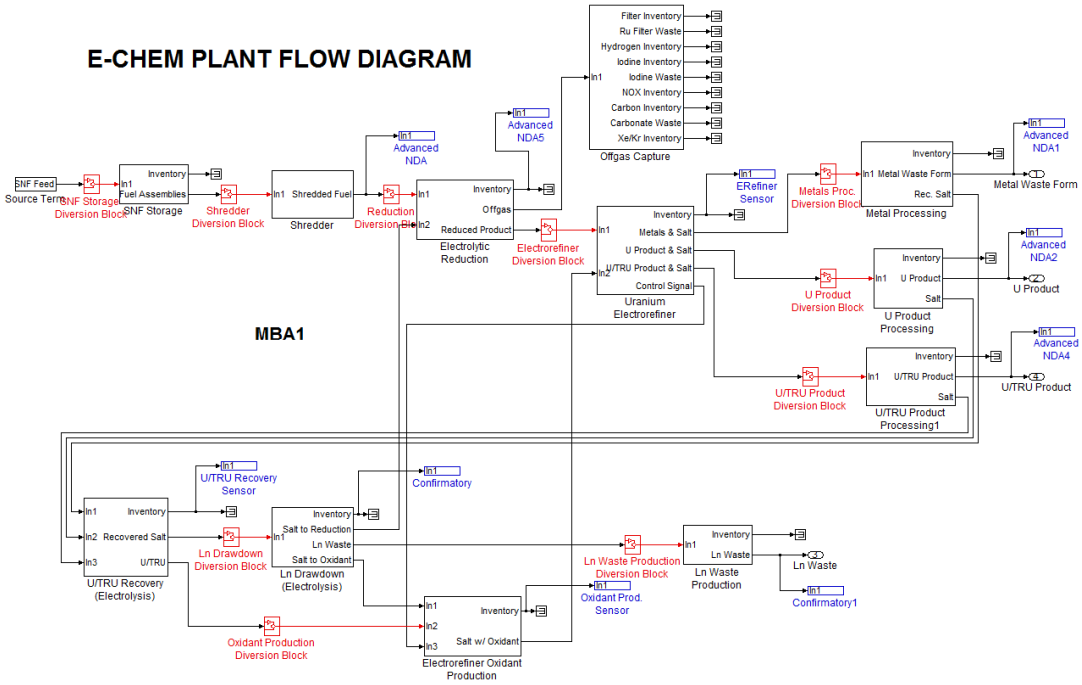
- Safety, Security, Safeguards, and Cybersecurity (3SC) should be taken into account early in the design process for nuclear facilities.
- Past work has been proposed fully integrated plant monitoring systems—however, full integration is not necessary and may create other problems.
- Rather, integration can be achieved by sharing only pertinent information to improve overall plant monitoring.
- This work has demonstrated the interface between safeguards and security for reprocessing as an example.

Basis for the Work

- Modern nuclear facility designs are extremely robust against outsider attack.
- Insider adversaries continue to be a concern though.
- Materials accountancy data (safeguards system) can provide more timely data for detecting material theft from an insider, and this data is more difficult for an insider to 'beat.'
- This work has examined the use of materials accountancy data from reprocessing plants to help protect against an insider diversion scenario.

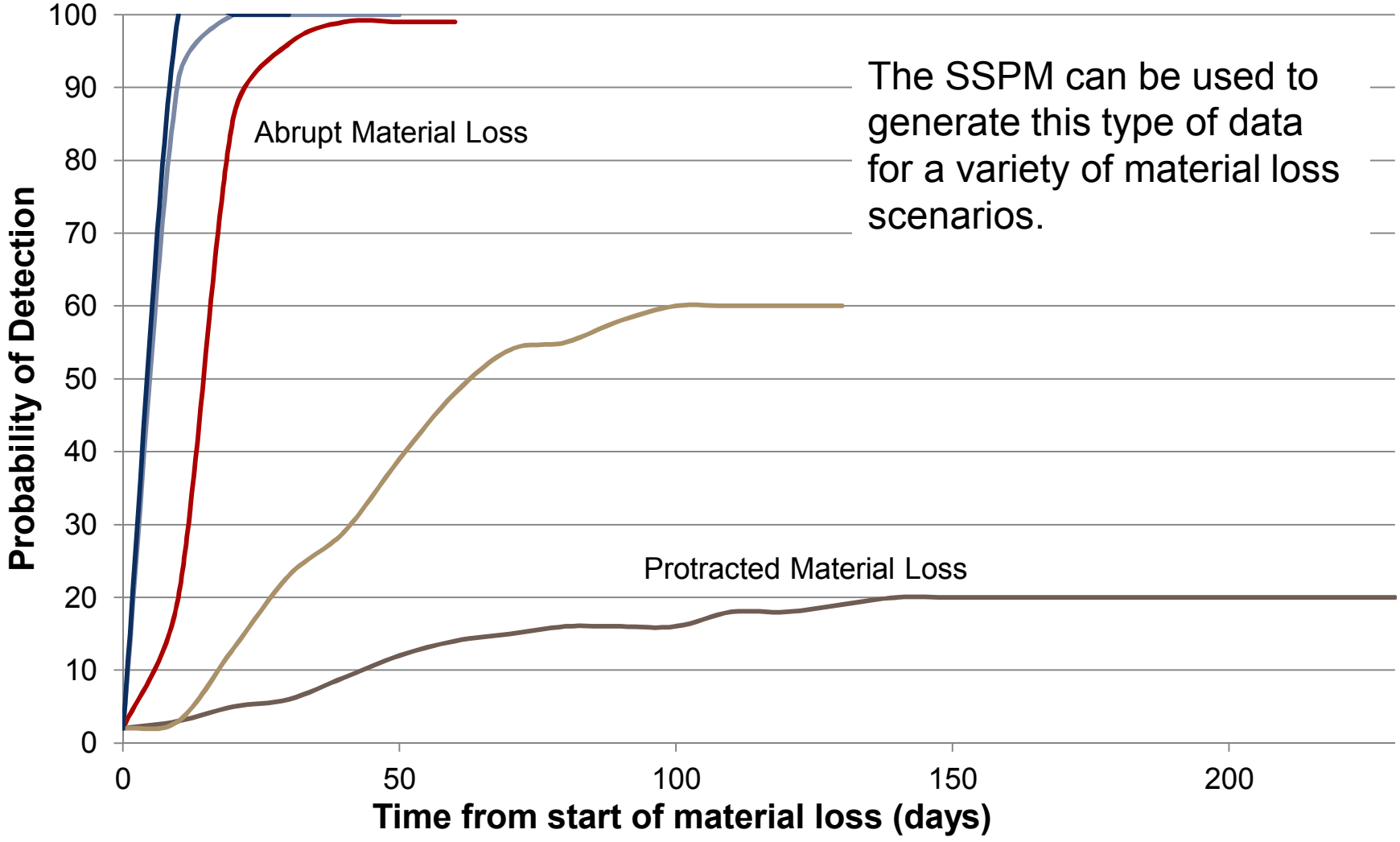
Separation and Safeguards Performance Model

- Designed for evaluating advanced safeguards concepts, improved measurement instrumentation, and diversion scenario analysis of reprocessing plants.
- Currently PUREX, UREX+, and E-Chem models have been built in Matlab Simulink. Material flows are tracked throughout the plant and measurements are simulated for safeguards.



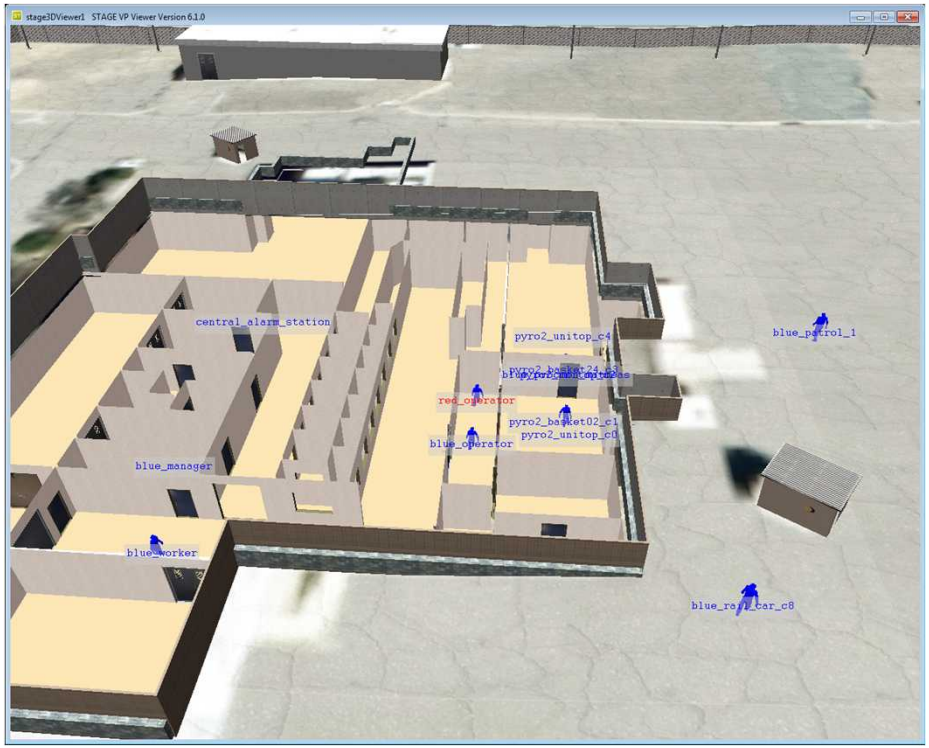
- Spent fuel source term library for user-defined runs
- Mass tracking of elements 1-99, bulk solid & liquid (or salt), heat load & activity
- Customizable measurement points with user-defined measurement error
- Automated calculation of inventory difference and error propagation in real-time.
- Alarm conditions, bias correction, and statistical tests
- User-defined diversion scenario analyses

Probably of Detection Timeliness

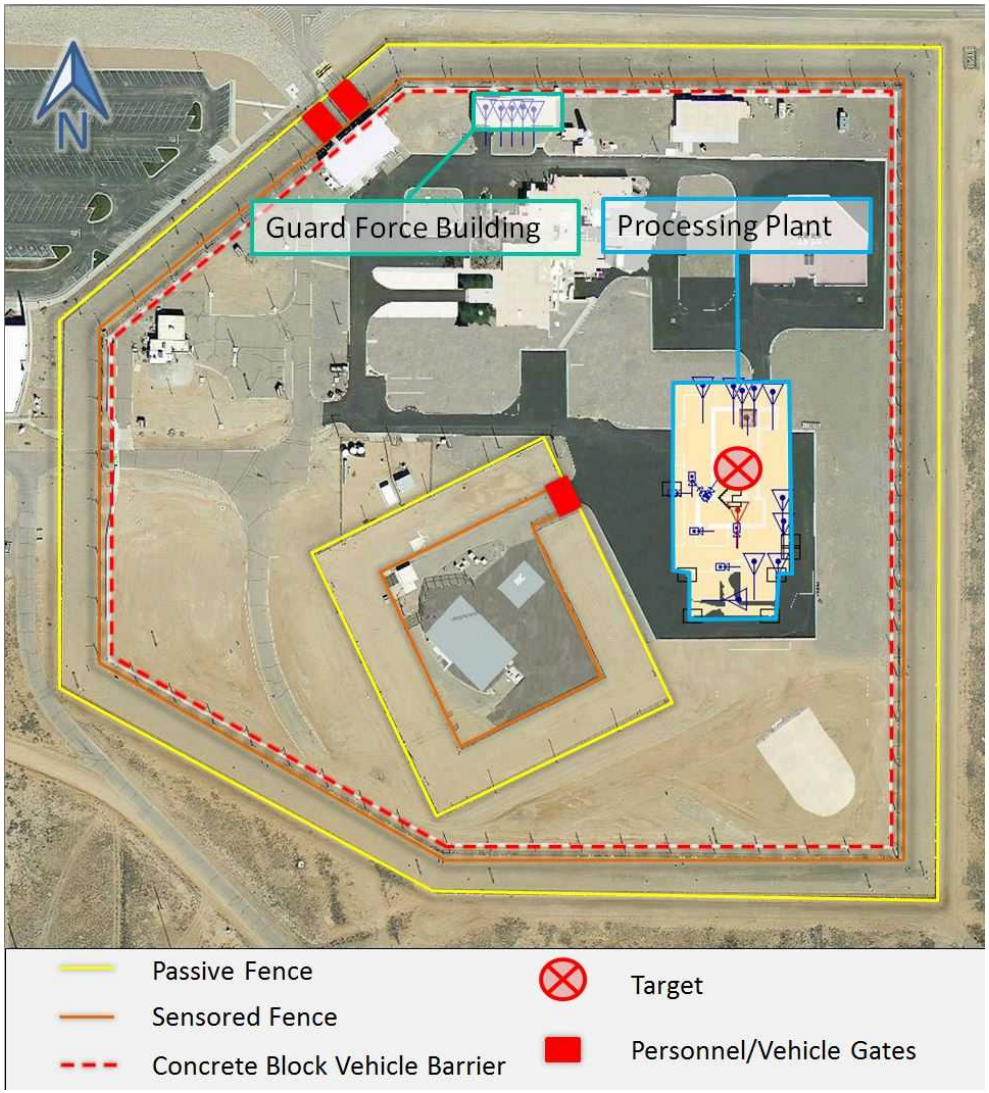


Presagis STAGE Software

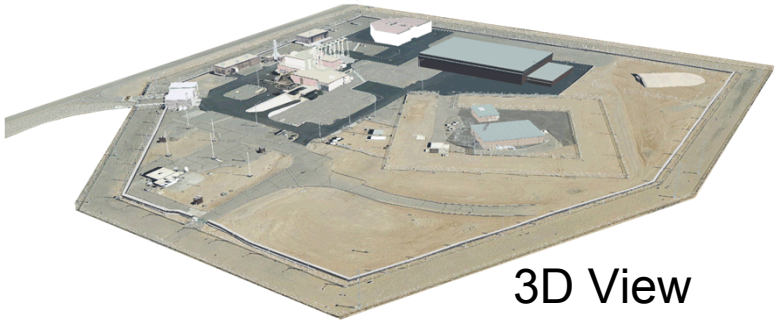
- STAGE provides a framework to create end-to-end scalable red team/blue team force-on-force combat simulations:
  - Probability-based Combat Model
  - Event-based entity missions
  - Performance-based databases
  - Logic based behavior
  - Ground navigation
  - Scripting support
  - 2D/3D environment
  - Road Networks
  - Batch Mode



STAGE Echem Model



- Facility layout is based on an existing model of the Integrated Security Facility at Sandia.
- A notional electrochemical processing plant facility was generated, and PPS elements were put into the model.
- Assumptions were made about guard force and number of responders.



3D View

Diversion Scenarios

- Both the SSPM and STAGE were used to model the same diversion scenarios.
  - The SSPM focuses on the detection of the material loss.
  - STAGE models the 3-D facility and path of material out of the facility.
- For all scenarios, a baseline scenario was run that only relied on the PPS elements to detect material removal.
- For all scenarios, an upgraded case was run that is additionally informed by materials accountancy data.

STAGE Modeling Notional Results

	Abrupt Theft 1	
	Baseline	Upgrade
No Detection	96%	0%
RF Win %	20.1%	20.1%
100% of Goal Quantity Removed	79%	79%
	Abrupt Theft 2	
No Detection	62%	0%
RF Win %	33.7%	43.3%
100% of Goal Quantity Removed	46%	0%
	Abrupt Theft 3	
No Detection	41%	0%
RF Win %	33.0%	43.3%
100% of Goal Quantity Removed	37%	0%
	Protracted Theft 1	
No Detection	15%	0%
RF Win %	42.0%	50.0%
100% of Goal Quantity Removed	11%	0%
	Protracted Theft 2	
No Detection	2%	0%
RF Win %	46.0%	49.0%
100% of Goal Quantity Removed	1%	0%

- For all protracted cases, the integration of MC&A completely prevented the insider from diverting a goal quantity.
- These results show how MC&A and PPS elements can work together to provide robust protection against insider diversion scenarios.

STAGE Modeling Discussion

- These results are notional, so actual facility designs and operations will yield different results.
- Detection very early in the scenario is vital to interruption and reduction of the amount of material removed.
- Process monitoring systems would likely be able to detect the abrupt loss of material, but we need to learn more about the use of process monitoring data.
- The integration of MC&A provides value in protecting against moderately protracted diversions.
- Very protracted diversions are likely to be detected by the PPS alone due to many opportunities to detect misuse.

Conclusions

- Modeling and simulation is being used to examine the interface between safeguards and security in fuel cycle facilities.
- The integration of safeguards data with a physical protection system has been shown to decrease adversary success in notional insider diversion scenarios.
- This example shows how pertinent data can be used to augment plant protection systems without complete integration of systems.