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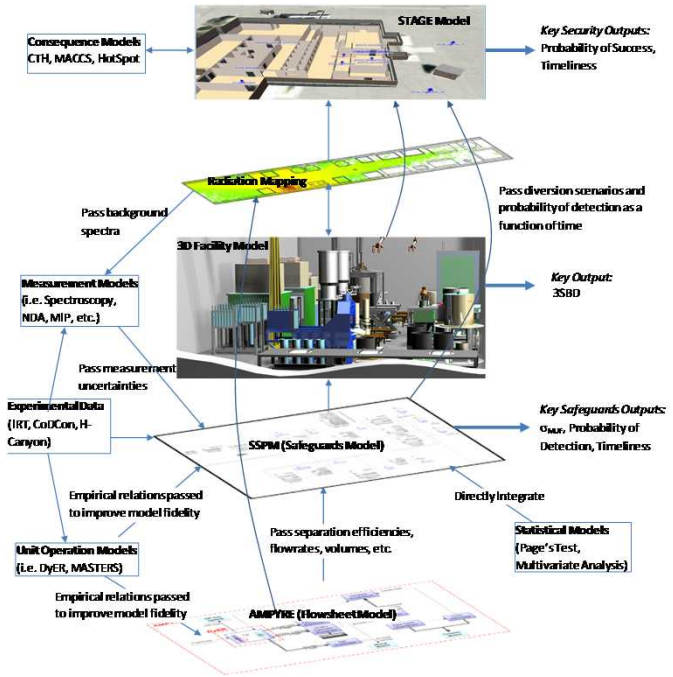

Advanced Integration Roadmap

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U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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Overview

- Advanced measurement instrumentation, modeling capabilities, and laboratory test beds all play a role in developing efficient and effective safeguards and security systems. The purpose of the Advanced Integration Roadmap is to describe how all the capabilities will be integrated and identify any gaps that may exist.
- The rest of the slides outline the key sections of the report.

Introduction

- **Safeguards and Security Metrics:**
  - MUF, sMUF, and detection probability for safeguards
  - Probability of success and timeliness for defeating both outsider and insider attacks
  - Cost, including both capital and operating
- **Nuclear Material Accounting:**
  - Traditional balances.
- **Process Monitoring:**
  - Direct use
  - Indirect use
- **Containment, Surveillance, Physical Security, and Other Data Types:**
  - C/S typically dominate for areas with discrete items
  - PPS
  - Ambient intelligence

Virtual Facility, Distributed Test Bed

- **Provide Overview of the 2020 Milestone**

Quantifying and Propagating Uncertainties

- **Instrument Level**
  - Various projects have looked or are looking at quantifying measurement uncertainties either through modeling, testing, or a combination.
- **Facility Level**
  - Existing modeling capabilities propagate the uncertainties from the individual measurements to determine the overall safeguards and security metrics. NMA and direct use PM data is done well.
  - More work is needed on applying uncertainties to quantities that are estimated use indirect PM data (including both using unit operation models and triggering points for further analysis.
  - More work could be considered for sabotage analysis and ambient intelligence.
- **Fuel Cycle Level**
  - Generally beyond the scope of the MPACT effort, but the capabilities and results can feed into the modeling done for the Fuel Cycle Options Study.

Technologies, Models, and Test Beds

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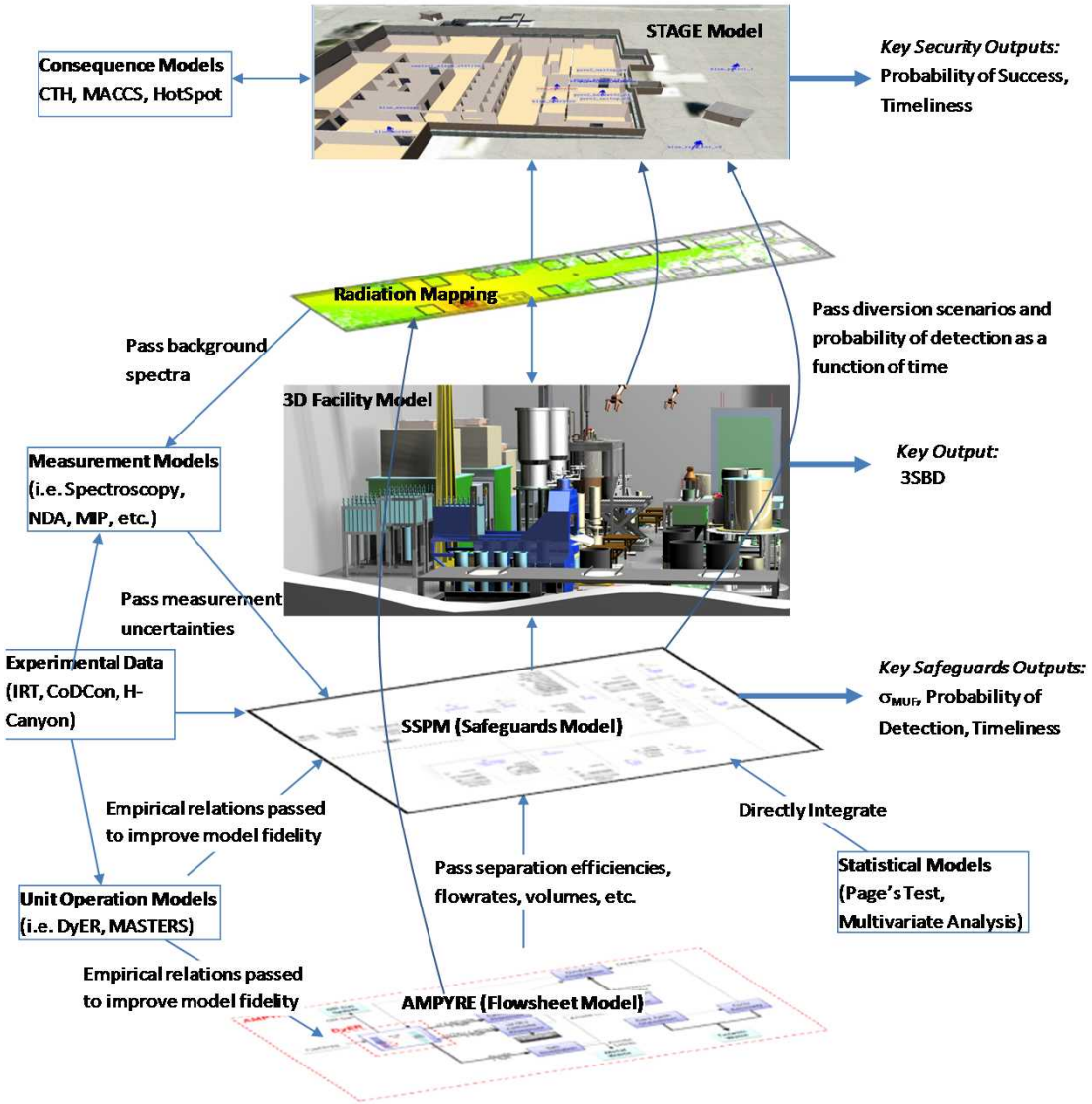
Detector/Instrument Models	Application/Comments
Neutron signatures of storage casks	Neutron fingerprinting
Multi-Isotope Process (MIP) monitor	Gamma analysis of reprocessing streams
Delayed gamma	NDA measurements of spent fuel
Neutron detector design	Various uses
Muon imaging of dry casks	Measuring gross defects
Electrochemical radiation signatures	Mapping and design of systems
Process/Facility Level Models	
AMUSE	Aqueous flowsheet development
AMPYRE	Electrochemical flowsheet development
DyER	Dynamic electrorefiner model
PyFOM	3D operations model
SSPM	Safeguards model
STAGE	Physical security model
Consequence Models	
CTH	Shock physics
MACCS, HotSpot	Dispersion codes
Instrumentation	
Triple Bubbler	Mass, volume, density of molten salts
Voltammetry	Actinide content in molten salts
MIP Monitor	Gamma analysis of various streams
UV-Vis-NIR Spectroscopy	Various species in streams
Microfluidic Sampler	Reducing sample volume
Electrochemical Sensor	In situ measurement of actinides in salt
High Dose Neutron Detector	For measurements in hot cell
Microcalorimeter	Significantly improved gamma spec.
Test Beds	
H-Canyon	Provides aqueous streams for testing
Co-Decontamination Demo	Process monitoring test bed
Integrated Recycled Test	NNSA-funded but will provide safeguards data

Advanced Data Integration Path Forward



- **Purpose of this figure is to show how the capabilities link together.**
- **This figure is based on Echem, so we could design similar figures for other types of facilities.**
- **Future work will develop the linkages between capabilities more.**