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Sonali Sinha Roy, Maria Eduarda Montezzo Coelho

Changing the World's Energy Future

Idaho National Laboratory

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

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The Digital Engineering Vision for DOME: Facilitating Design, Deployment, and Operations

Intern: **Sonali Sinha Roy** || Mentor: **Maria Eduarda Montezzo Coelho** || Manager: **Peter A. Suyderhoud**

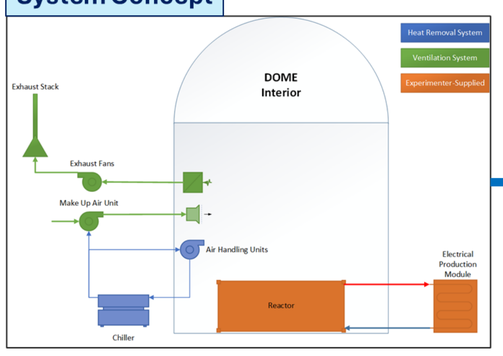
Intern's Affiliation: **Purdue University** || INL Organization: **Digital Engineering – Model Based Design Group (B711)**

DOME: Demonstration of Microreactor Experiments

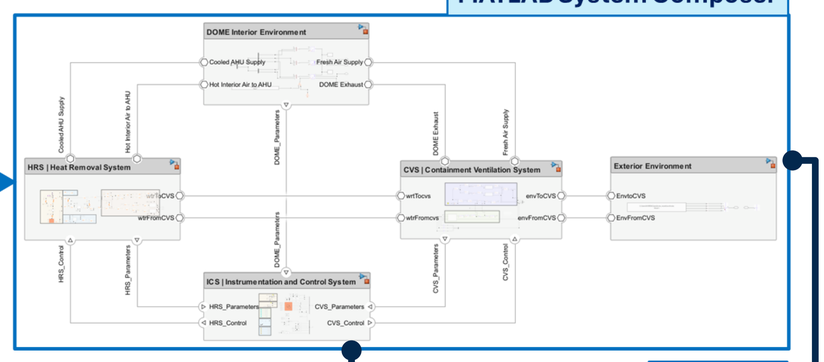
- Microreactor testing initiative sponsored by the DOE's National Reactor Innovation Center (NRIC).
- Repurposes the decommissioned Experimental Breeder Reactor (EBR)-II facility at INL's Materials and Fuels Complex (MFC) as a Hazard Category 2 test bed for a series of commercial microreactor experiments.
- Complex system with several interacting elements, including microreactor (up to 20 MWth), radioactive confinement, temperature and pressure regulation, and ventilation system.

Systems Modeling Approach

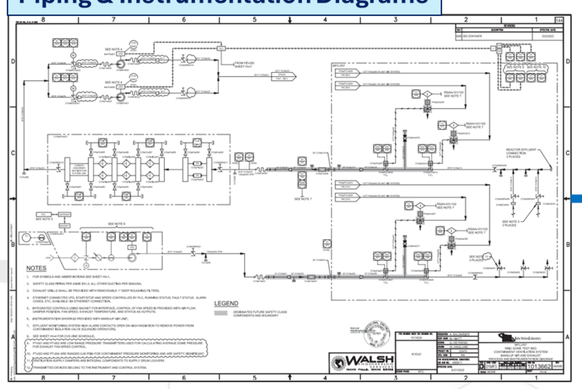
System Concept



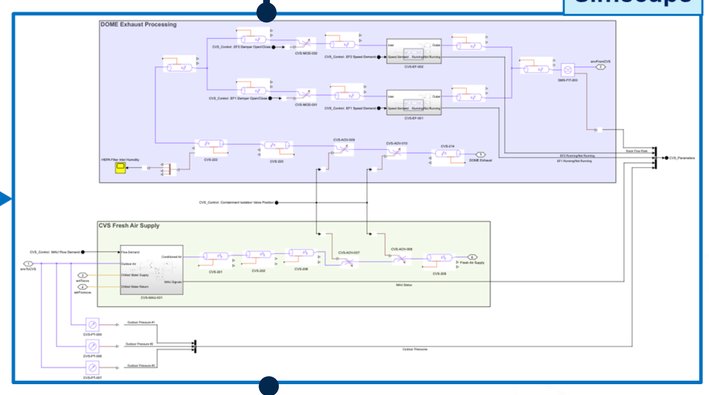
MATLAB System Composer



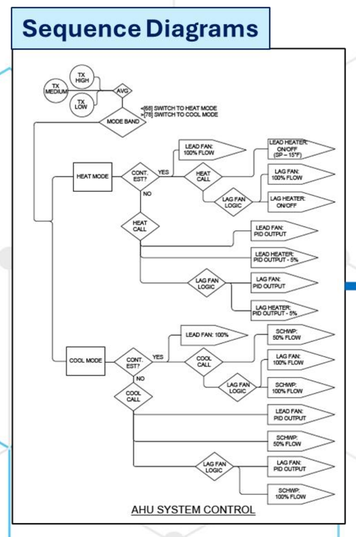
Piping & Instrumentation Diagrams



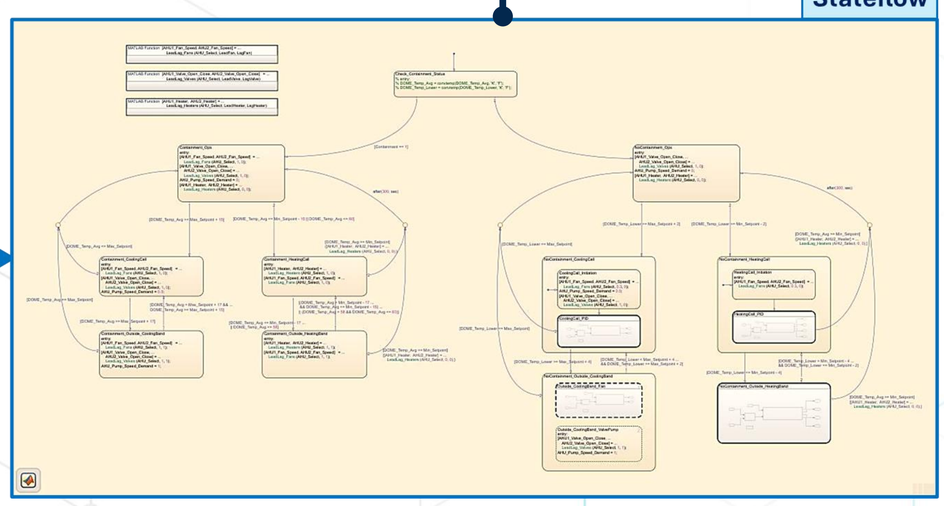
Simscape



Sequence Diagrams



Stateflow



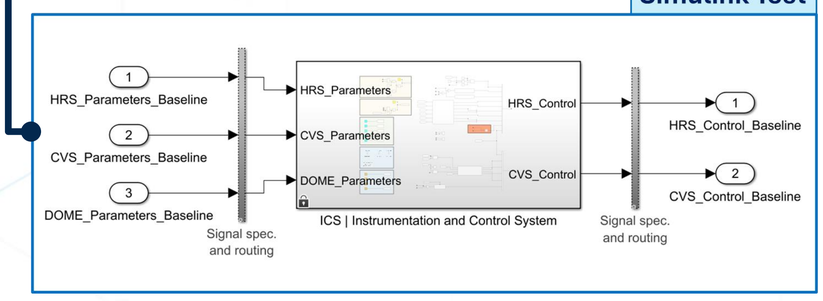
Goal: To assemble all the information on DOME systems into a single integrated, hierarchical, executable, and testable digital model.

Technical Approach: Model-based Systems Engineering (MBSE)

Tool: MathWorks MATLAB & Simulink

- **System Composer**: Specification of the system architecture; captures high-level interactions among systems.
- **Simscape**: Definition of each system's physical components, such as pipes, sensors, and heat exchangers.
- **Stateflow**: Design of combinatorial and sequential decision logic with event-based and time-based triggers.
- **Simulink Test**: Design and management of systematic, simulation-based tests of the systems and components.

Simulink Test



Applications

Optimization of the engineering design process through a shift from traditional paper-based methods to a **data-driven approach** using industry-leading **modeling and simulation** techniques.

Design Optimization:

The model can be run with different sets of parameters to optimize the facility's design. Examples include:

- Tuning PID controller parameters.
- Maximizing energy efficiency.
- Identifying equipment configurations (e.g., pipe dimensions) to minimize thermal losses.

Facility Simulator / Emulator:

The model can be used to test various operating conditions, including different test reactors, to evaluate the facility's overall performance based on metrics like temperature, pressure, and radiation levels. The model can be connected to high-fidelity multi-physics simulation tools (e.g., MOOSE) for deeper analysis.

Digital Twin:

The model is designed to eventually evolve into a digital twin that can accept real sensor data from the facility. It can be used to monitor operations and conduct predictive analysis in response to changes in operating conditions. The DOME twin could interface with a digital twin of the microreactor to create a "twin of twins."

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