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July 2024

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Changing the World's Energy Future

Idaho National Laboratory

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Organization: B711 (Model Based Design)

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

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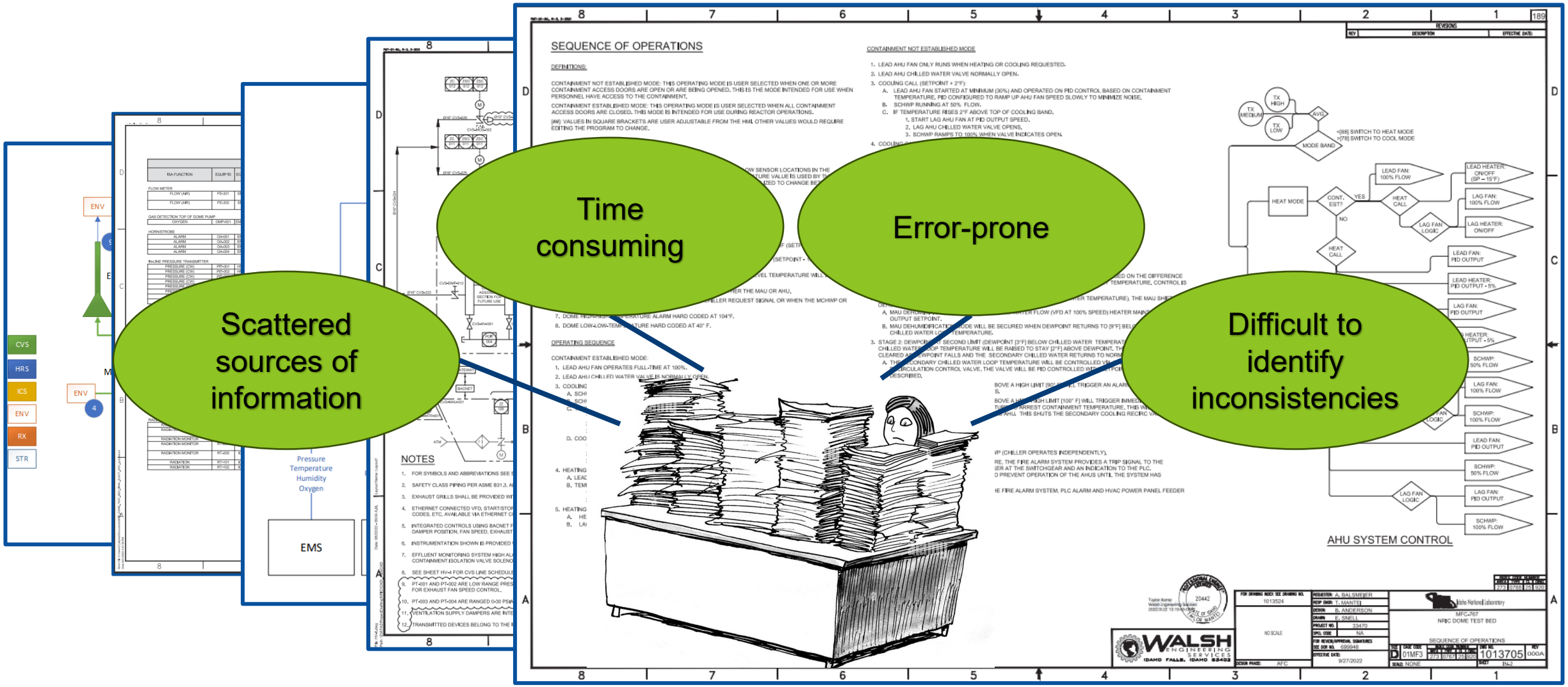
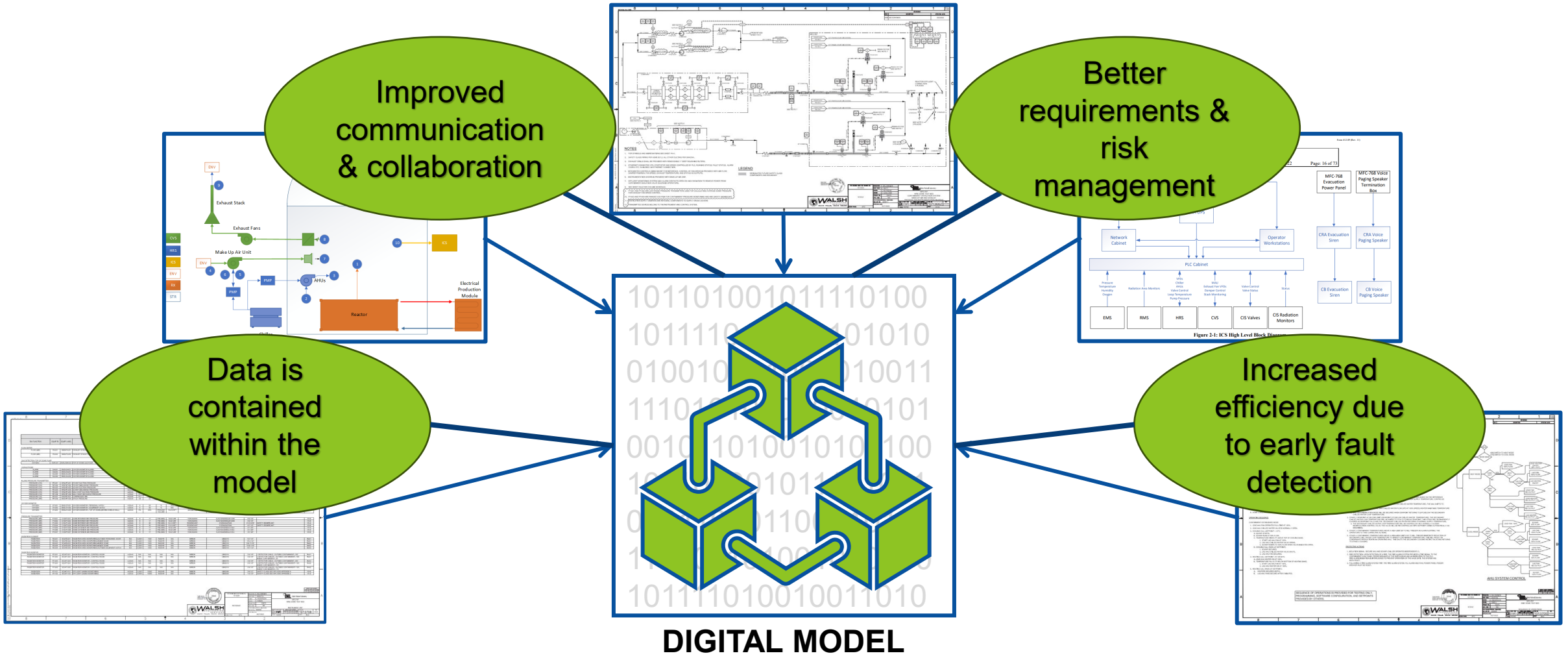
DOME: Demonstration of Microreactor Experiments

- Microreactor testing initiative sponsored by the DOE's National Reactor Innovation Center (NRIC).
- Repurposes the decommissioned Experimental Breeder Reactor (EBR)-II 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.

Traditional Systems Engineering Approach



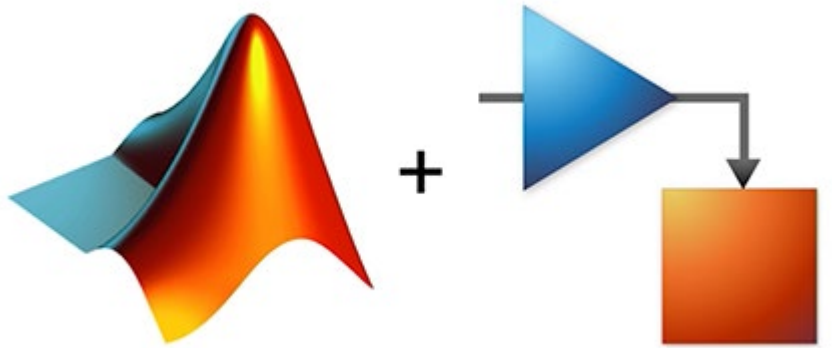
Model-based Systems Engineering



MBSE Tools

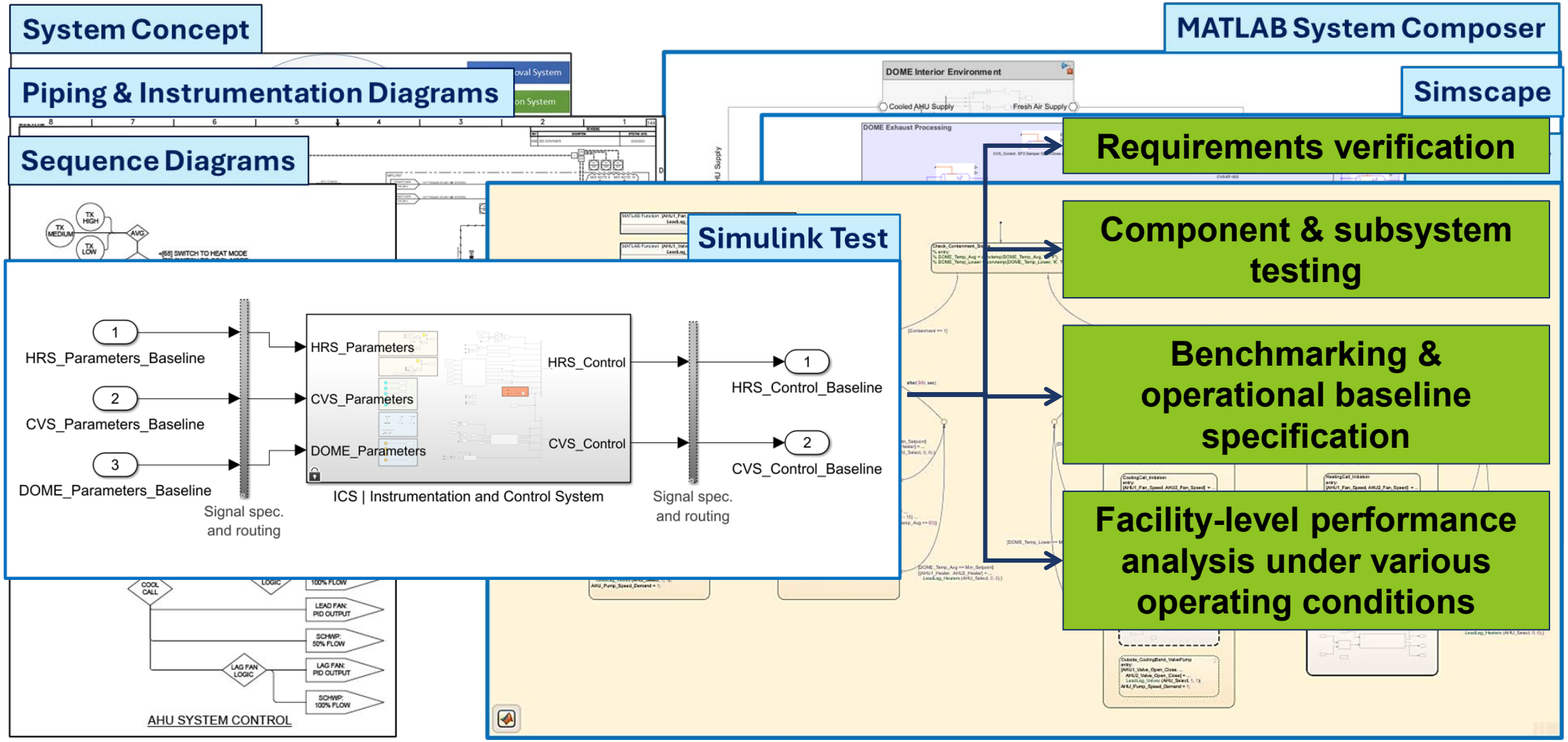
- Lots of options!
  - **Languages:** Unified Modeling Language (UML), Systems Modeling Language (SysML), Lifecycle Modeling Language (LML), Arcadia, etc.
  - **Tools:** MagicDraw (Dassault Systèmes), Innoslate (SPEC Innovations), Capella, Rhapsody (IBM), GENESYS (Vitech), etc.
- We selected the MathWorks suite, i.e., **MATLAB & Simulink**.
  - Multi-faceted capability.
  - Easily programmable.
  - Automatic code generation for graphical elements.
  - Convenient to interface with external tools.

MathWorks®

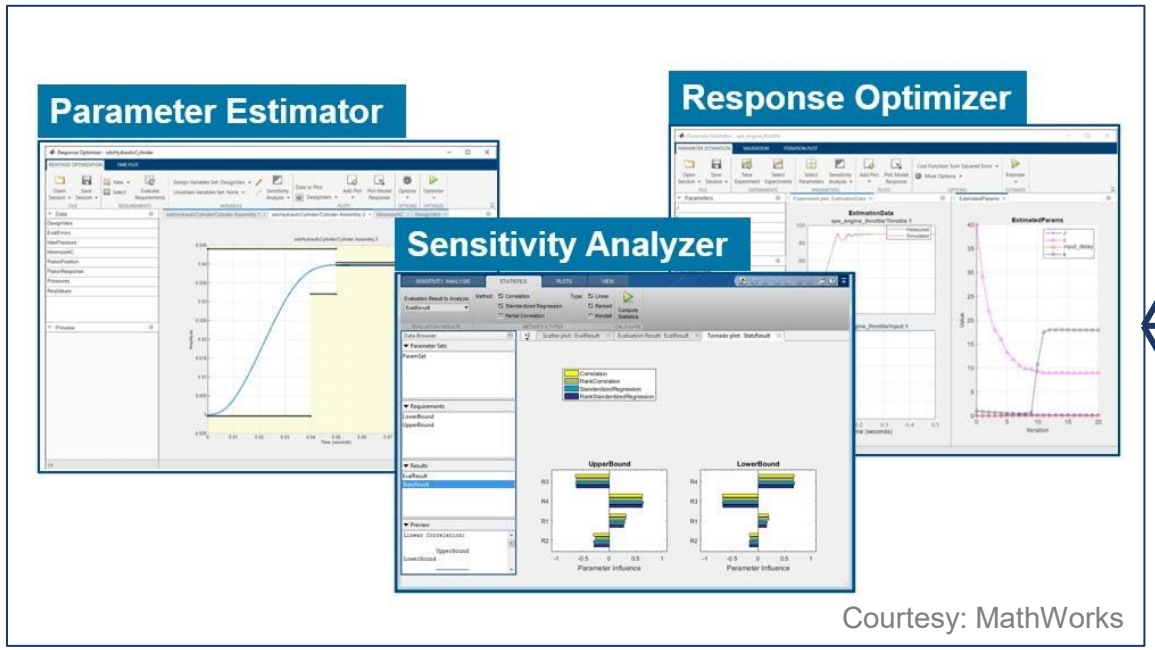


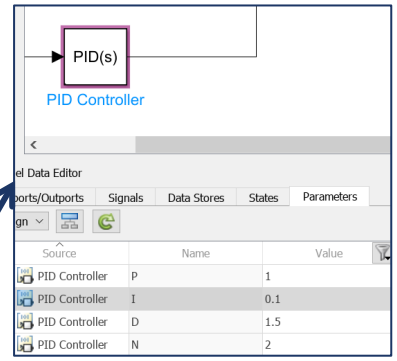
MATLAB & Simulink

The DOME Digital Model



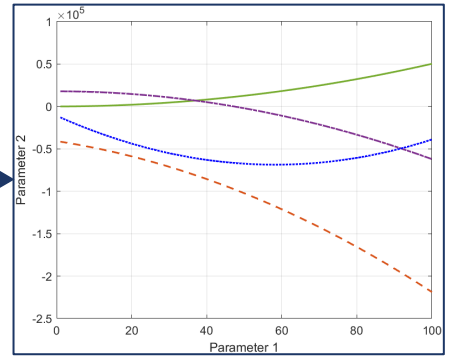
Application: Design Optimization



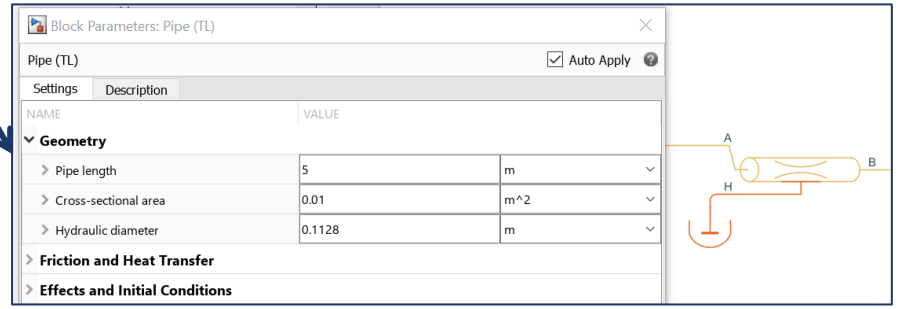


Parameter tuning

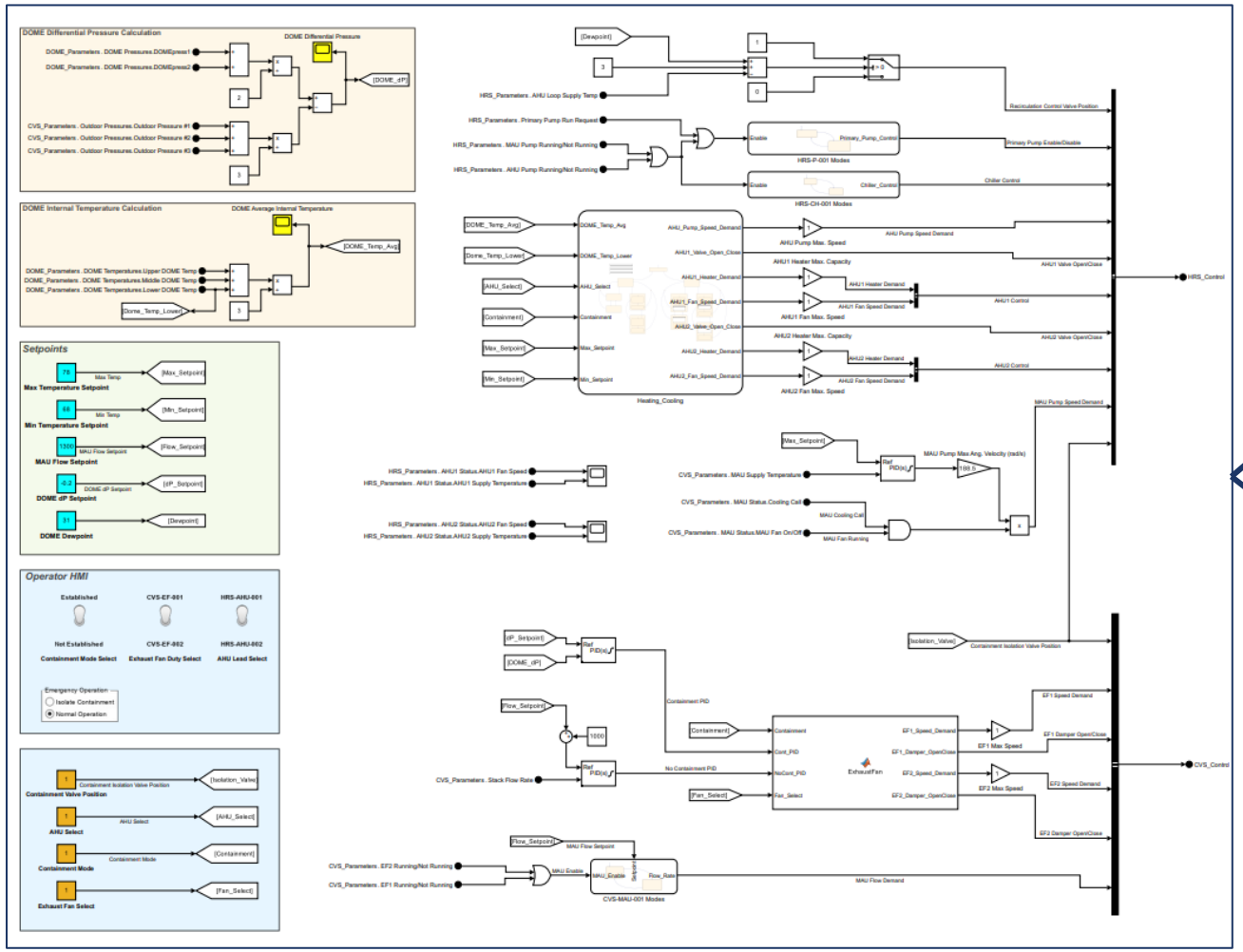
Performance optimization



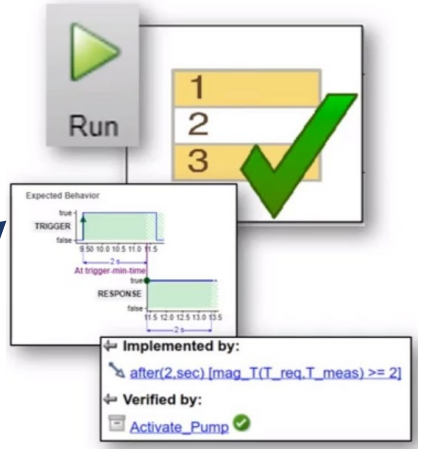
Equipment configuration



Application: Facility Simulator / Emulator

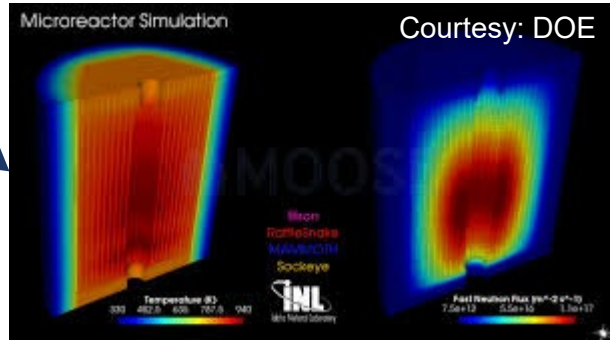


Testing and evaluation



Courtesy: MathWorks

Interfacing with high-fidelity multi-physics models



Application: Digital Twin

Real-time sensor data

Facility monitoring &
operator training

Predictive analysis
& virtual testing

Conclusion

- Digital engineering (DE) can lead to the **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**.
- The goal is to successfully implement DE for the **end-to-end engineering lifecycle management** for DOME.
  - Proof of concept.
  - Learning opportunity.
  - Opens up possibilities for future nuclear reactor projects, including nuclear power plants.
  - Could be applied to other types of energy systems.

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