U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Clean. Reliable. Nuclear.

DOE-NE Cybersecurity R&D

November 2023

INL/MIS-23-75925

Shannon Eggers, PI

Supply Chain & Cyber-Informed Engineering (CIE)

Model-Based Systems Engineering (MBSE)

FY23: Supply Chain Project—Software Bill of Materials (SBOM) R&D

OBJECTIVE: Extend FY22 SBOM work to advance capabilities in implementing an SBOM program at nuclear facilities

- **ISU, Dr. Lesie Kerby, "Cyber Data Science with Software Bill of Materials"**
  - Prototyped a scalable tool, "Vulnerability Overview, Research, and Threat Exploration" (VORTEX), that (1) uploads a CycloneDX SBOM in .json format, (2) analyzes it against vulnerability data (NVD), and (3) creates graph visualizations of the components, relationships, and vulnerability details.
- **Ga Tech, Dr. Fan Zhang, "Final Project Report on SBOM Project"**
  - Compared capabilities of open-source SBOM generation tools on software development kit, a PLC DLL and device firmware.
- **Purdue, Dr. Hany Abdel-Khalik, "Monitoring Behavioral Changes in ICS using SBOM"**
  - Evaluated the use of an SBOM generation tool to identify if modifying parameters or adding components to simulator software can be detected automatically.

FY23: Cyber-Informed Engineering Project

OBJECTIVE: Develop a decision analysis framework to address digital risk and engineering design decisions in early lifecycle phases of an integrated energy system project.

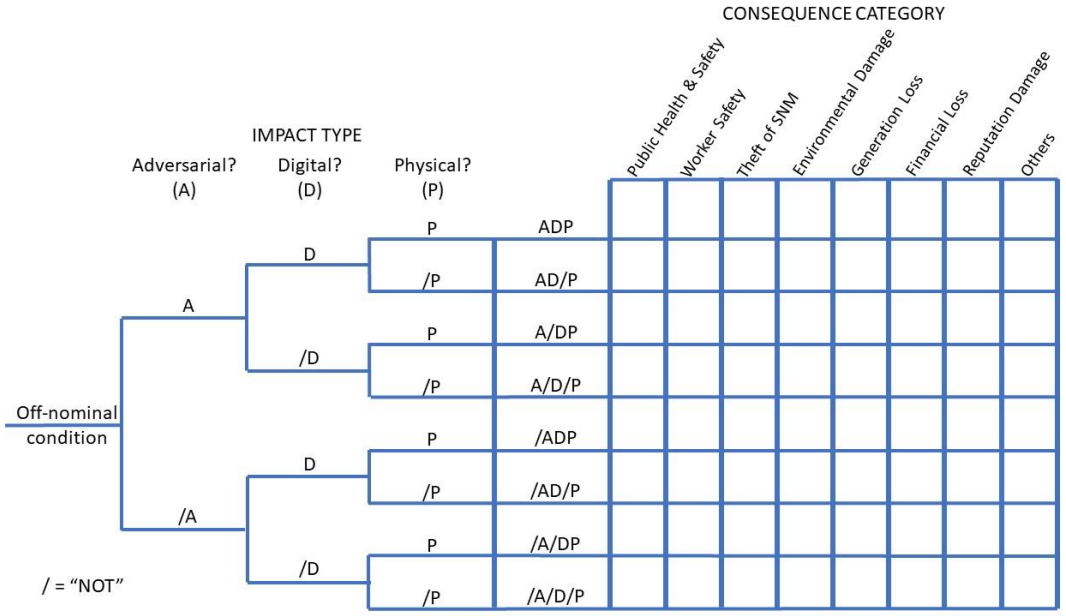
DIGITAL RISK

"Likelihood that a threat successfully misuses a vulnerability leading to an adverse impact"

Threats: Adversarial and non-adversarial

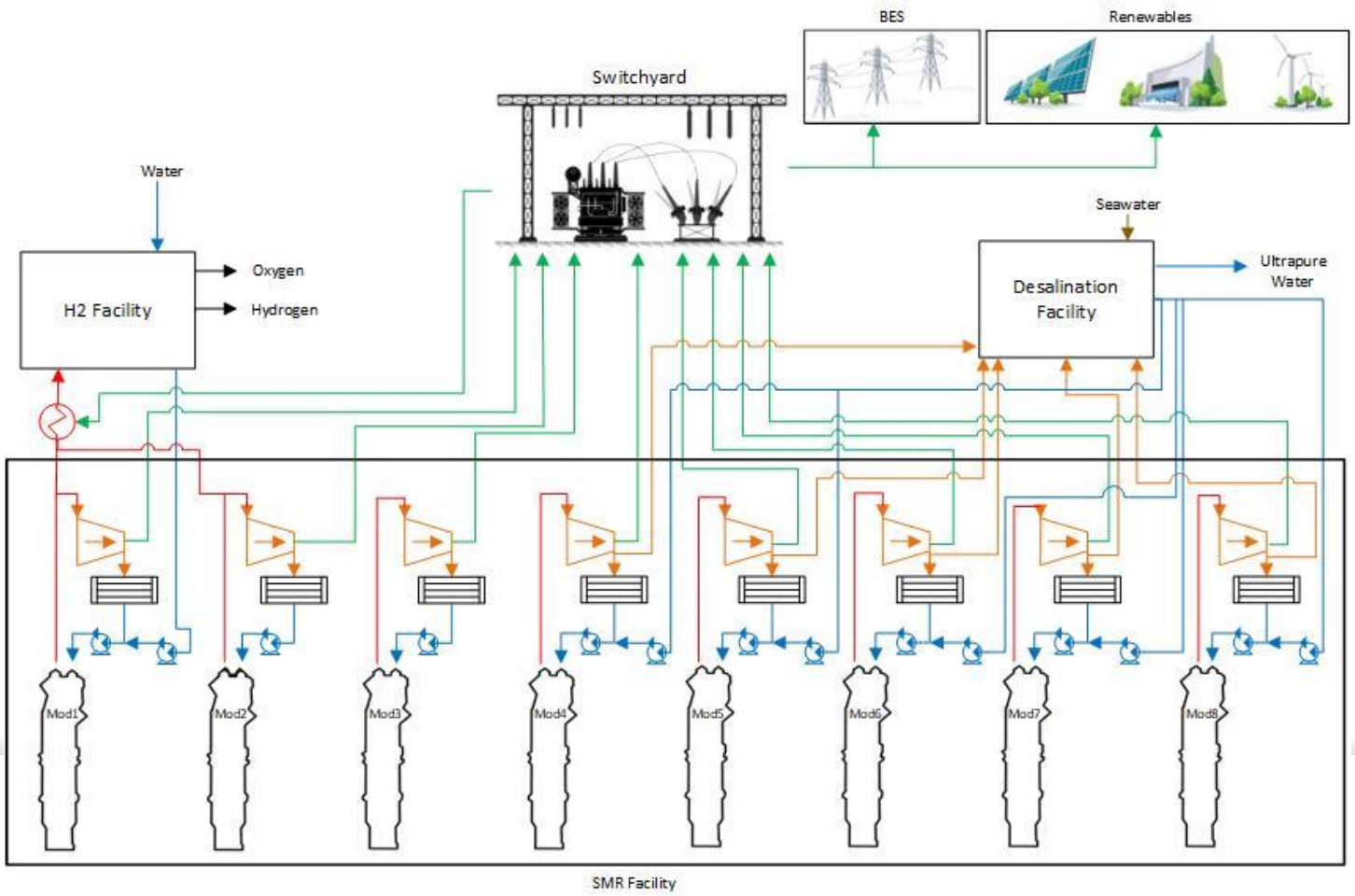
Vulnerabilities: Weakness, flaw

Impacts: Health & safety, financial, theft, etc.

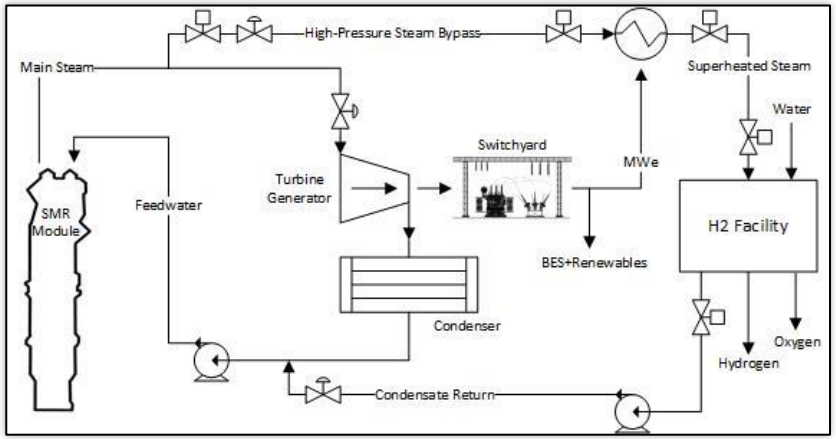


FY23: Cyber-Informed Engineering Project

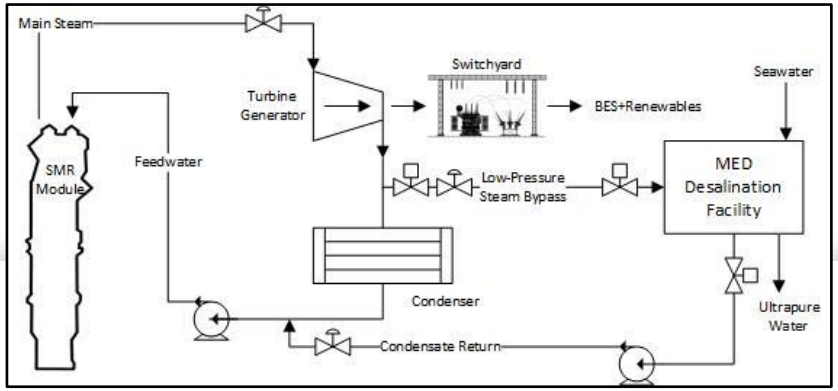
Concept of Operations for a Small Modular Reactor (SMR)-driven Integrated Energy System (IES)



HTSE-based Hydrogen Facility

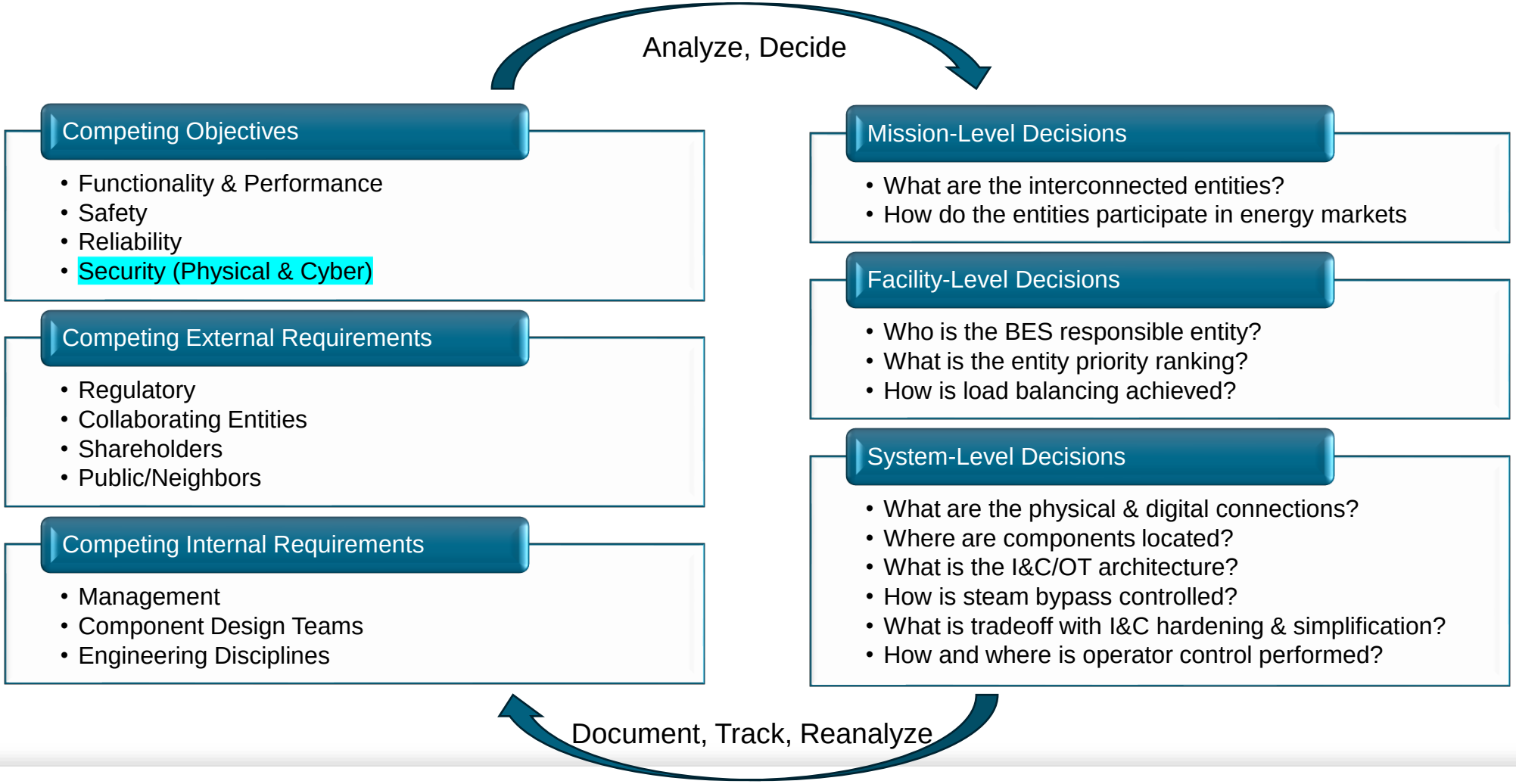


MED-based Desalination Facility



FY23: Cyber-Informed Engineering Project

Digital Risk Integrated Engineering Decision Analysis Framework



FY23: Cyber-Informed Engineering Project

- **Outputs**
  - INL/RPT-23-74867, “Digital Engineering and Cybersecurity Decision Analysis in Early Phases of SMR-Driven IES Projects”
  - Paper to be submitted to the Journal of Critical Infrastructure Protection
  - Abstract submitted to ANS Advanced Reactor Safety (ARS) Conference

FY24: Inclusion of CIE principles in Model-Based System Engineering Tools

- **This project will:**
  - Identify digital risk and cybersecurity gaps in existing MBSE tools.
  - Propose and develop solution(s) for incorporating digital risk management and security-by-design into MBSE.
  - Perform case study(ies) to improve/validate solution(s).
  - Socialize the results to promote adoption within the marketplace.

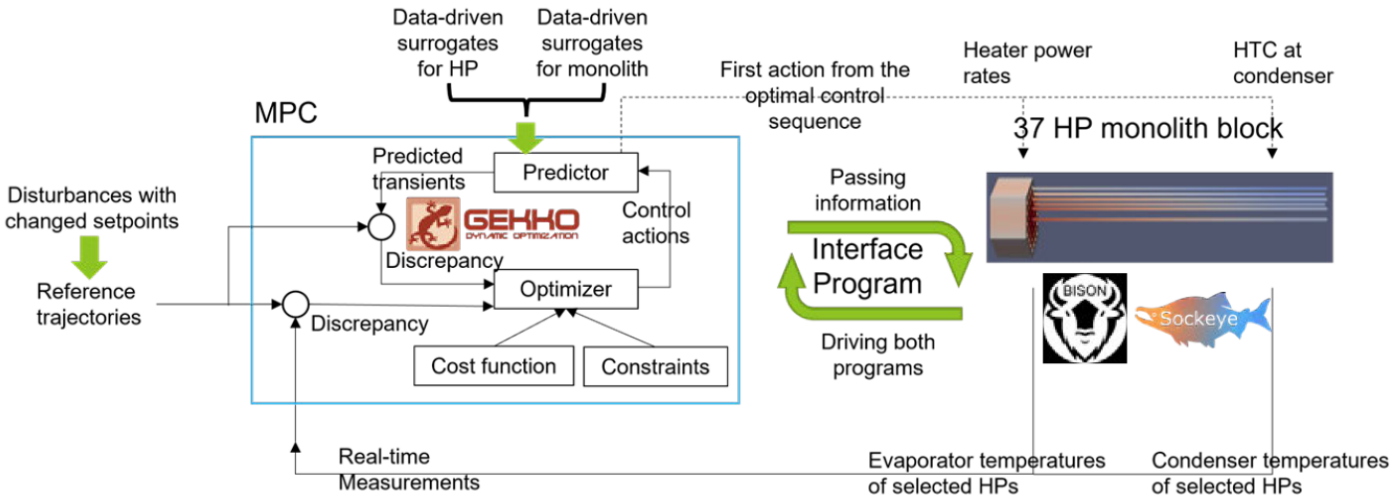


Figure 4. Information flow between the A-MPC controller and the MOOSE-based simulator.

Oncken, J., L. Lin, and V. Agarwal. "Adaptive Model Predictive Control forHeat-Pipe-cooled Microreactors under Normal and HeatPipe FailureConditions." 2023 ANS NPIC-HMIT, Knoxville, TN.