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Advanced Reactor Cyber Analysis and Development Environment (ARCADE) for University Research

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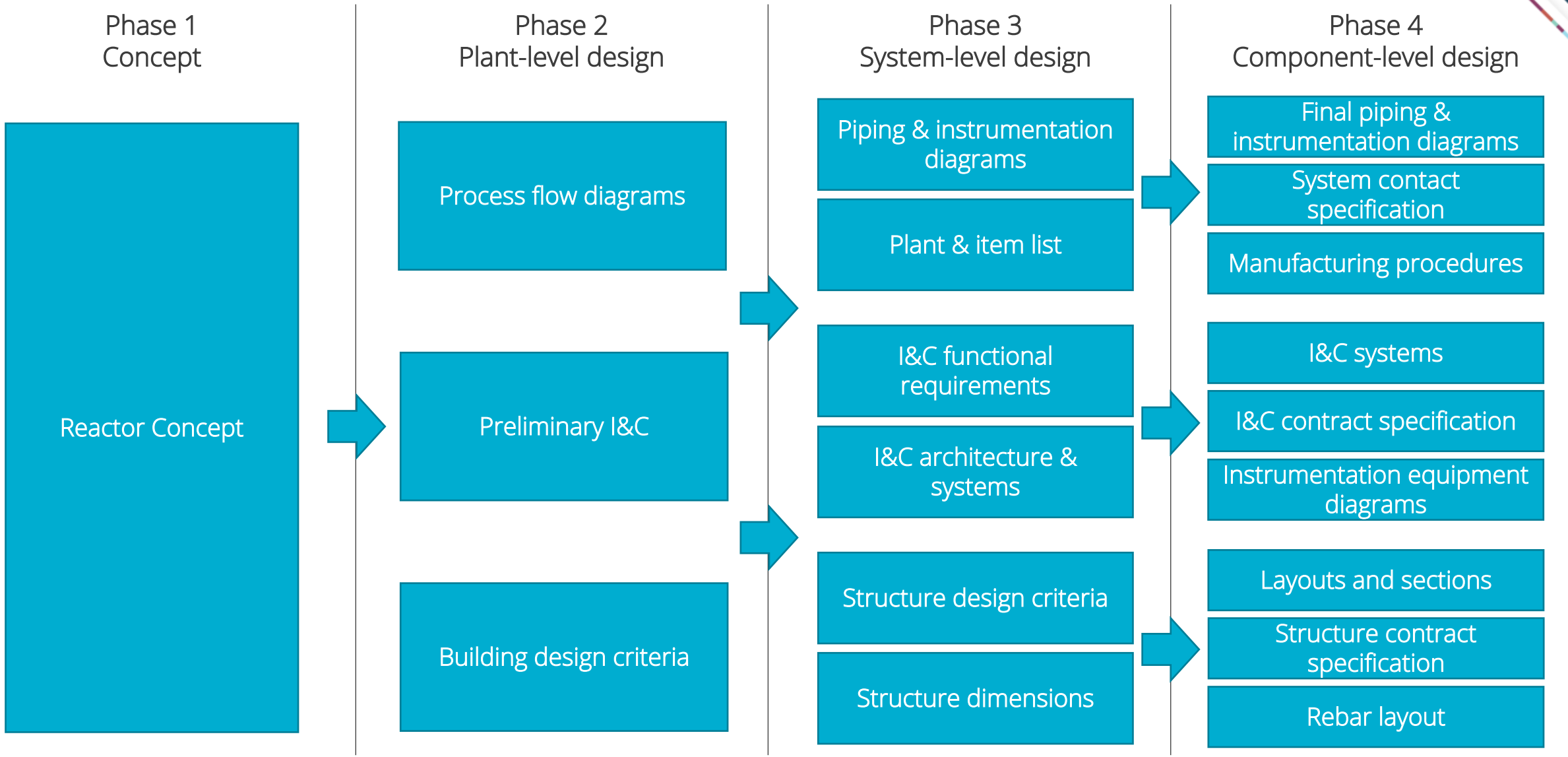
Why use physics models for cybersecurity?

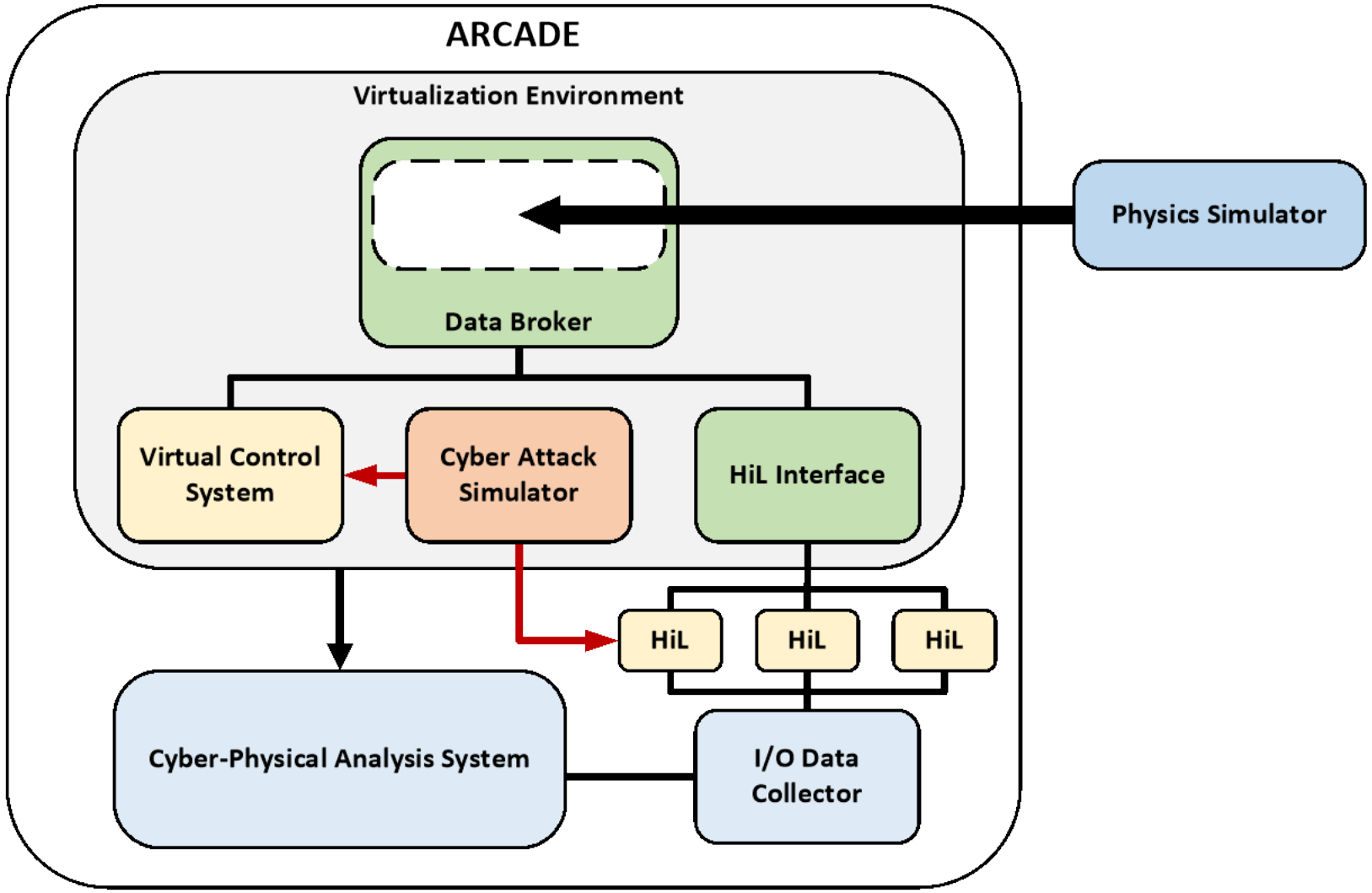
- Models and experimentation allow the evaluation of cyber consequences to systems
- Demonstration of plant robustness factors to mitigate cyber-attacks
- Integrate systems hazards analysis techniques (e.g., STPA) with cybersecurity
- Rapidly test diverse cyber mitigation strategies
- Parallel and automated system testing for experimental efficiency
- Training, exercises, and education of operators

ARCADE can support cybersecurity analysis throughout the design process



Citation: World Nuclear Association, "Design Maturity and Regulatory Expectations for Small Modular Reactors", 2021

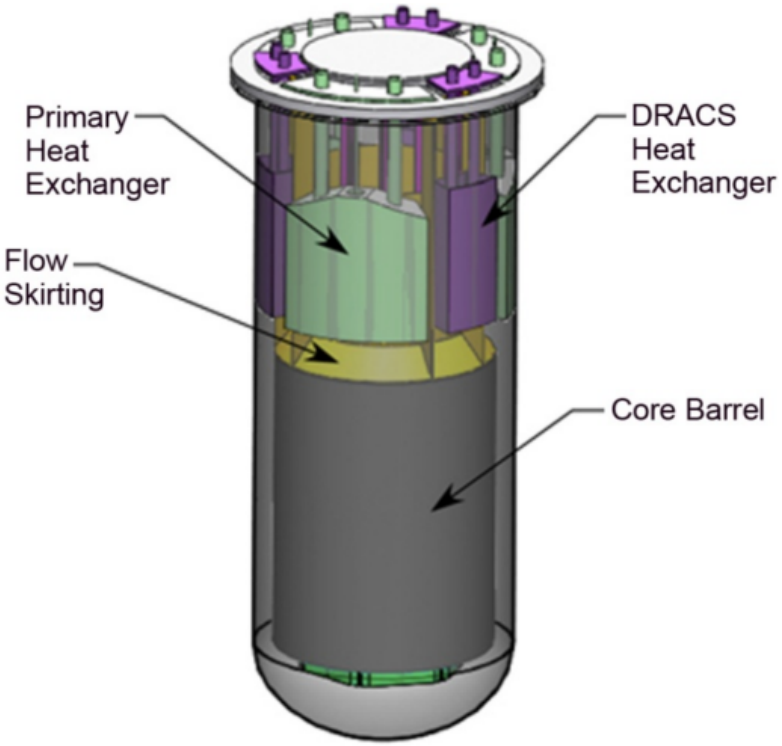
Advanced Reactor Cyber Analysis and Development Environment (ARCADE)

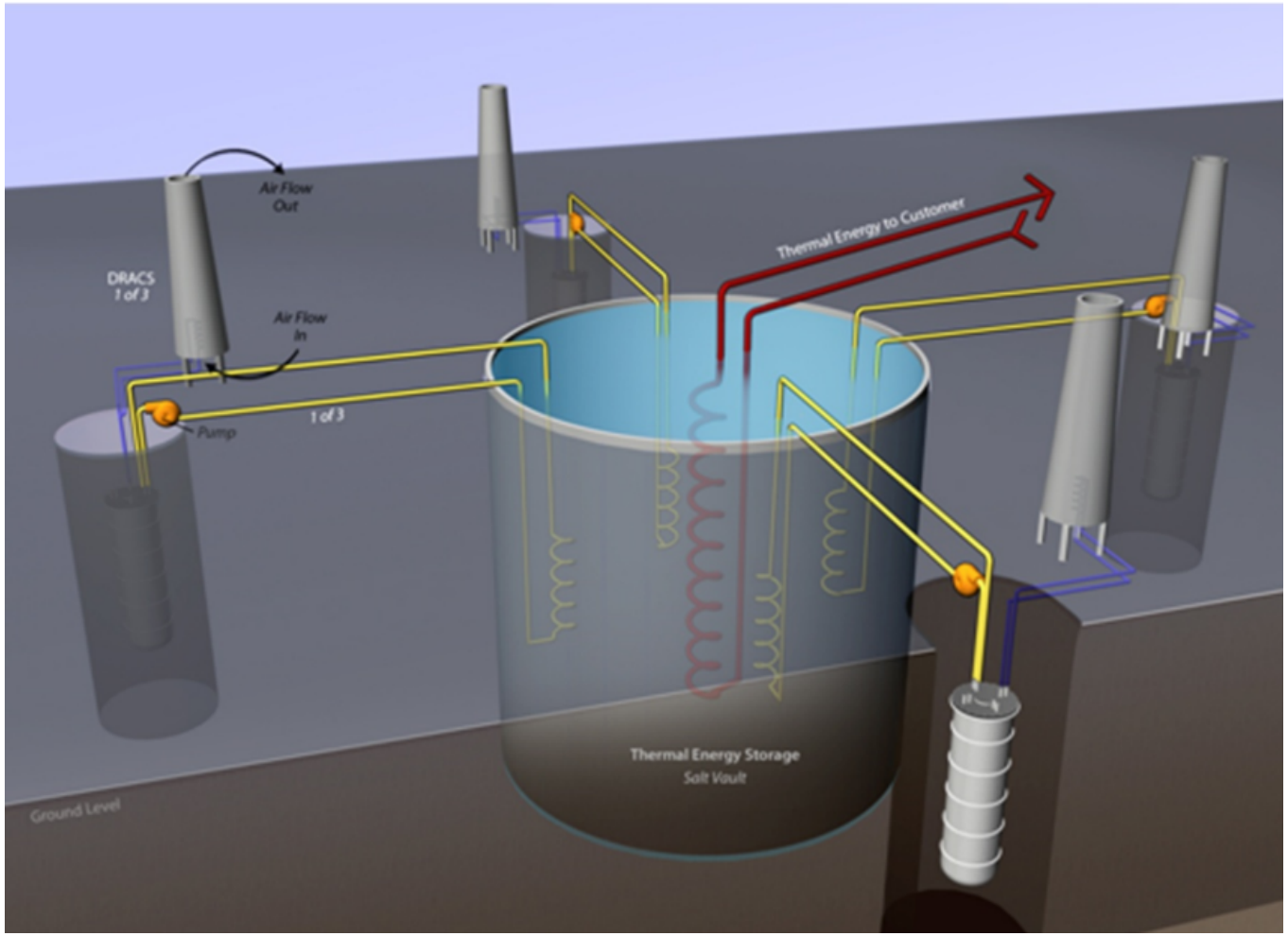


ARCADE Open-Source Software Stack

Components	Technology
Virtualization Environment	minimega
Physics Integrator	Sandia DataBroker
Cyber Attack Simulator	ManiPIO & Kali Linux
PLC Runtime Environment	OpenPLC
SCADA Interface	scada-LTS
Physics Simulation	Not Included

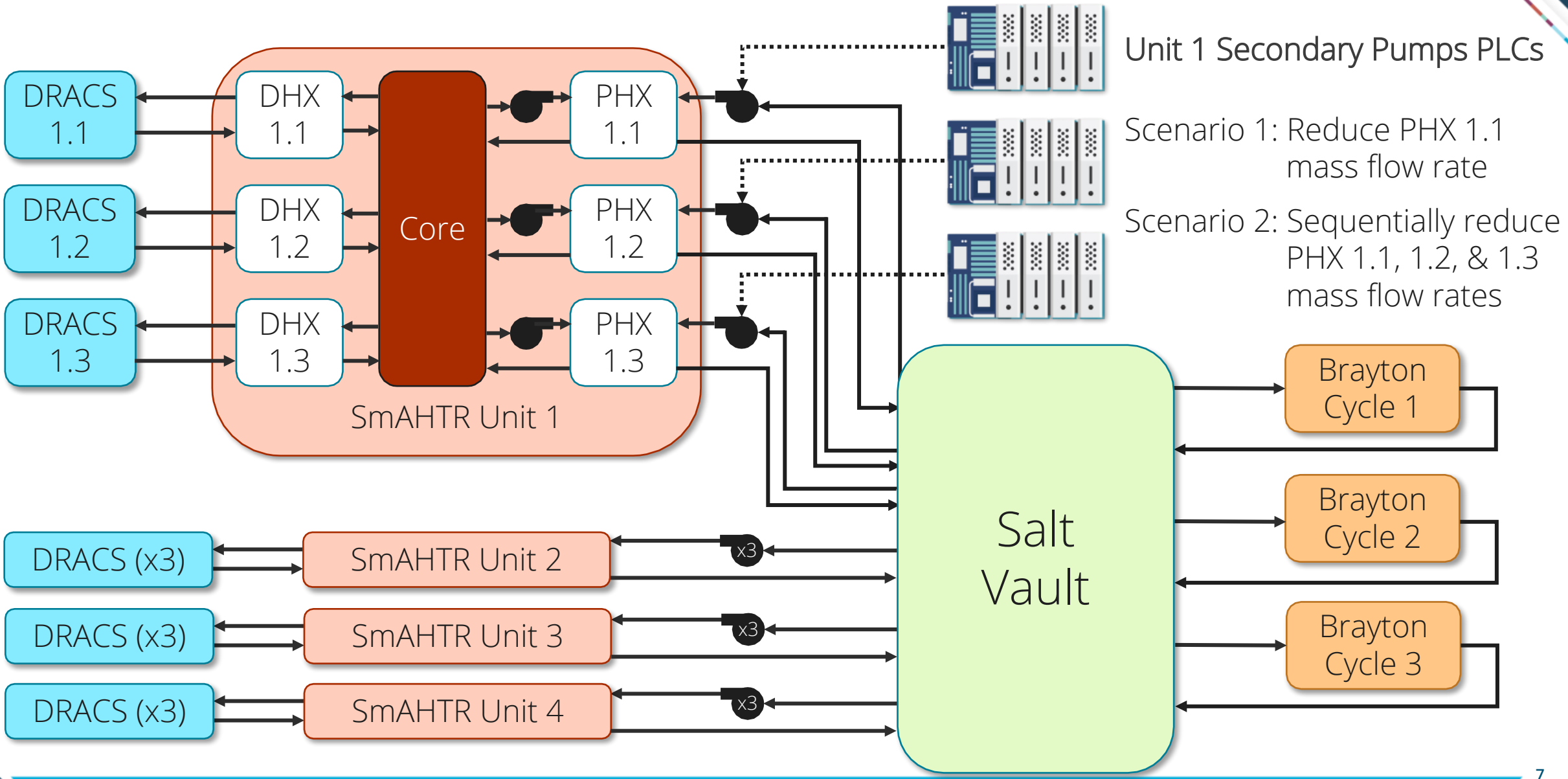
Small Modular Advanced High-Temperature Reactor (SmAHTR)





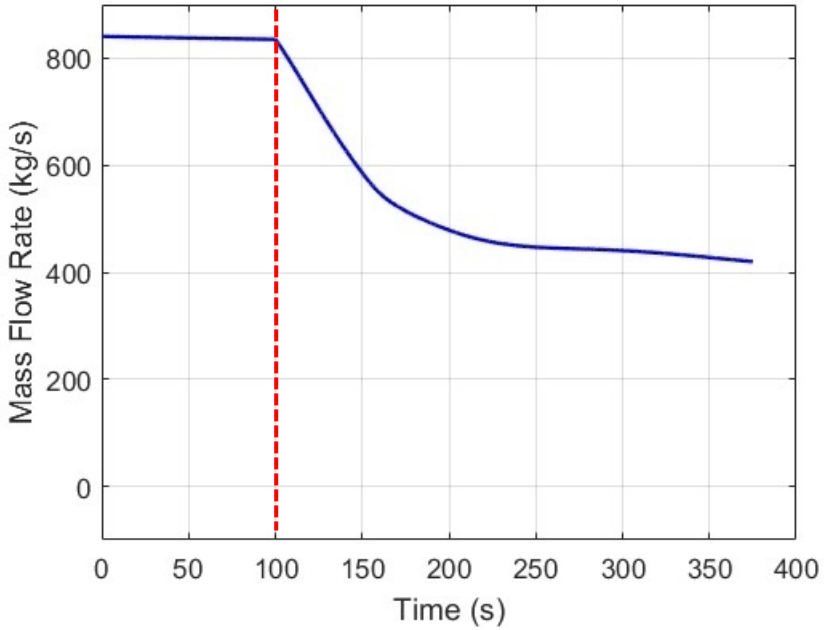
Citation: Oak Ridge National Laboratory, "Pre-Conceptual Design of a Fluoride-Salt-Cooled Small Modular Advanced High-Temperature Reactor (SmAHTR)", 2010

The University of Pittsburgh's SmAHTR model was integrated with ARCADE for cybersecurity R&D



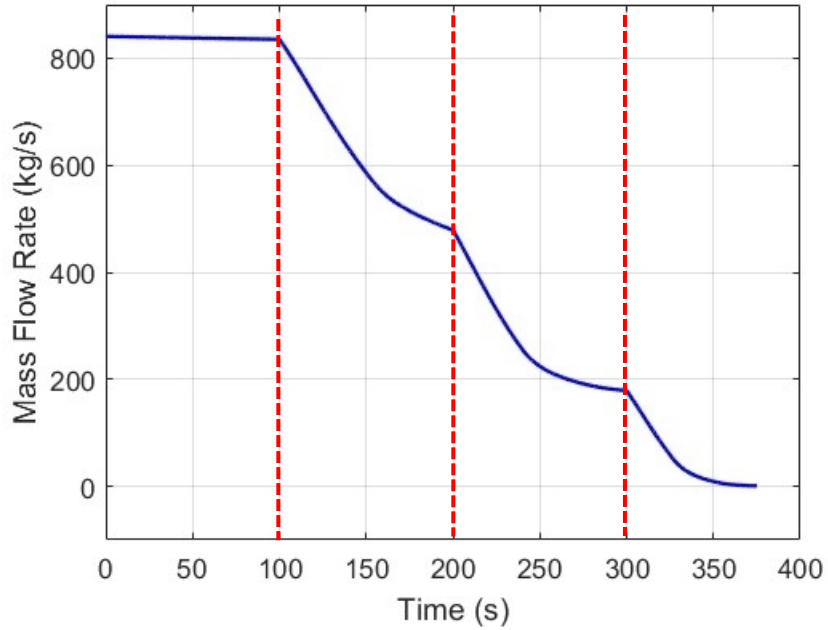
Unit 1 PHX secondary coolant mass flow rate was reduced to examine the effects on plant conditions

Scenario 1:
Reduce mass flow rate for PHX 1.1



Unit 1

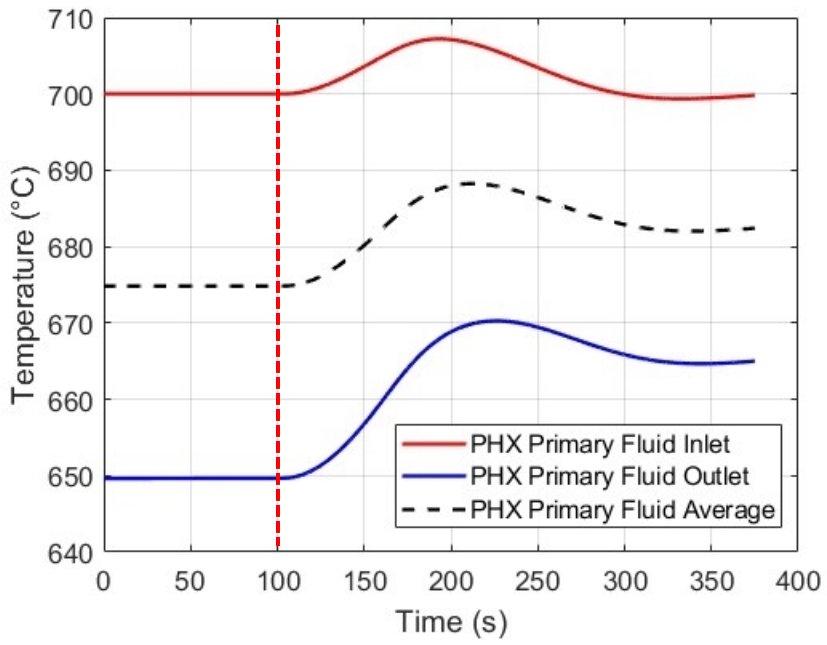
Scenario 2:
Sequentially reduce mass flow rates for PHX 1.1, 1.2, & 1.3



Unit 1

Primary fluid temperature stabilized for Scenario 1, but grew without bound for Scenario 2

Scenario 1:
Reduce mass flow rate for PHX 1.1



Unit 1

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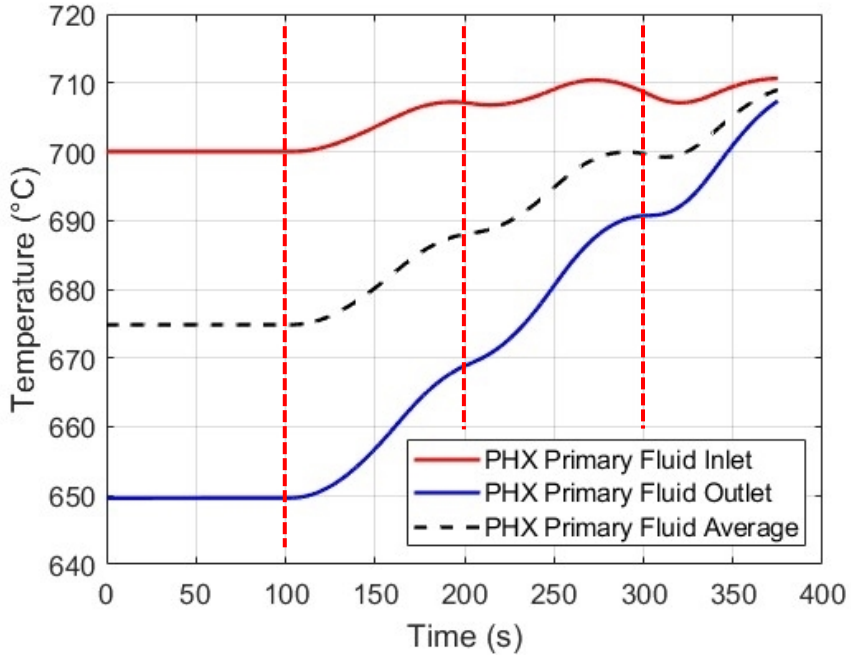
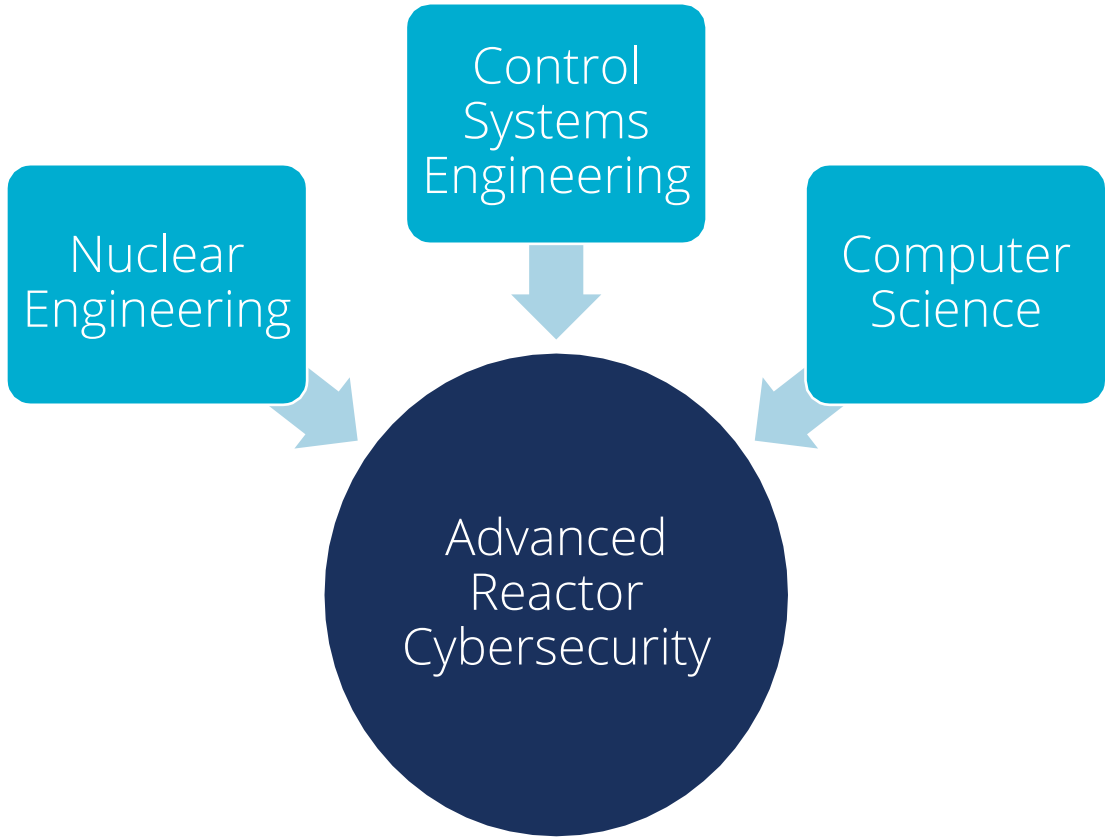


Unit 1

ARCADE can be used by universities for workforce development for the security of advanced reactors

- Nuclear power plant cybersecurity R&D
- Development of interdisciplinary coursework in cyber-physical systems
  - ARCADE can also be used with non-nuclear physics models
- Raise research reactor operators' awareness of cybersecurity and its effects
- Fundamental cyber-physical systems R&D



Thank you for your time and attention

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