Research Spotlight Forum

8.6.19 Cybersecurity

NICSim: Nuclear Instrumentation and Control Simulation for Evaluating Response to Cyber-attack

PRESENTED BY:

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Distinguished and Regents' Professor, Nuclear, Mechanical, and Chemical & Biological Engineering, UNM

Founding director, Institute for Space and Nuclear Power Studies, UNM. http://isnps.unm.edu/

Fellow, ANS, ASME), AIChE), and IAASS, and Associate Fellow AIAA

Author and inventor, 380 journal articles, 262 conference proceeding papers, 57 transactions, 89 technical report, a book and 6 book chapters, 50 book volumes, and 7 patents.

Honors, DOE Certificate *for Outstanding Contributions to Space Nuclear Power and Propulsion*; ANS Distinguished Faculty Member Honor, AIChE Heat Transfer and Energy Conversion Division Award, ANS Thermal Hydraulics Memorial Award; ASME Heat Transfer Memorial Award, AIChE Donald Q. Kern Award

Supervised 32 PhD Dissertations and 30 MS Thesis at UNM

Research Interest: space nuclear power and propulsion; natural and combined convection; boiling and two-phase flow; nuclear fuels and materials; nuclear reactors' design, thermal-hydraulics, and safety; dynamic simulation of reactor systems; walk-away safe small modular reactors (SMRs); electronics cooling; heat pipes and thermosyphons; Computational Fluid Dynamic (CFD); Molecular Dynamics(MD) simulations; water and alkali-metals convection heat transfer in rod bundles; energy conversion; and nuclear plant cybersecurity.

Research group interests: SMRs, nuclear plant cybersecurity, dynamic modeling of reactor systems; electronics cooling; molten-lead reactors; neutronic & thermal hydraulic analyses. (2 Professors and 2 GS)

Keywords: space nuclear power; dynamic modeling; and cybersecurity of nuclear systems.

CURRENT WORK IN CYBERSECURITY

Objectives:

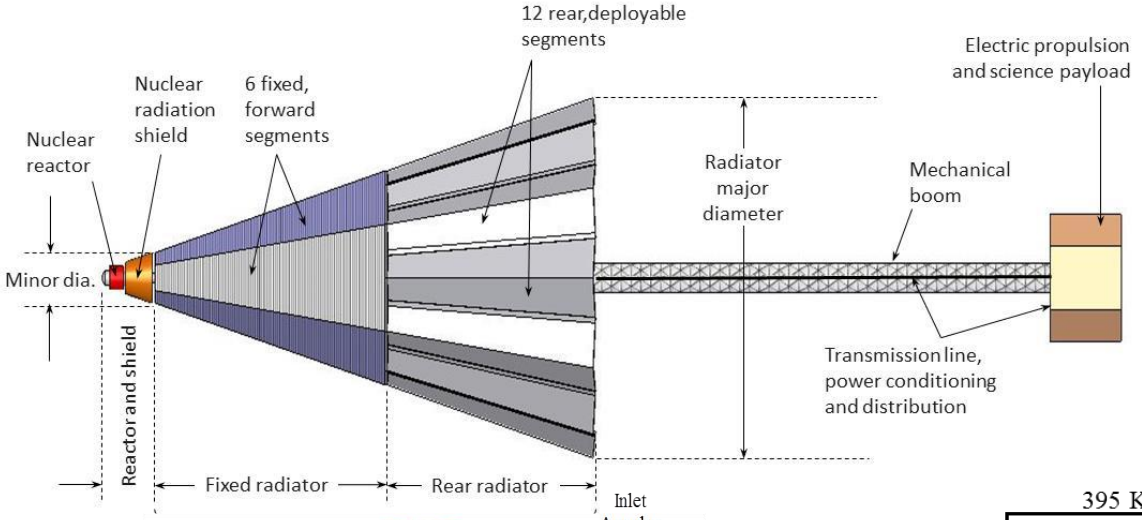
Develop a *Nuclear Instrumentation and Control Simulation (NICSim) platform* with emulytics and modeling capabilities of a physics-based, dynamic model of PWR nuclear power plant, and use DOE SCEPTRE framework at SNL to emulate the plant's digital instrumentation & control (I&C) systems, both nominally and while under cyber-attack

Project major elements:

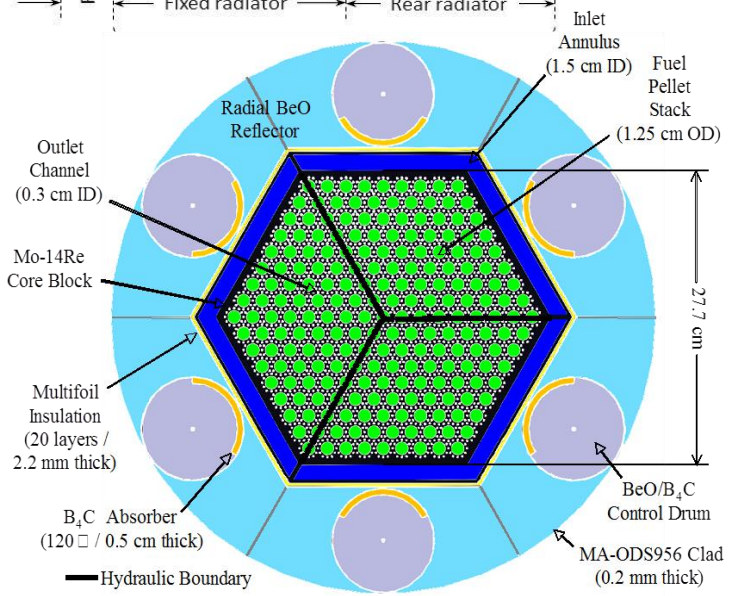
(1) Implement and validate programmable logic controller (PLC) emulation in SCEPTRE
(2) Identify and characterize a reactor safety monitoring and control system
(3) Implement a fully-emulated safety system
(4) Develop reactor system dynamic model
(5) Integrate NICSim platform elements
(6) Establish testing and evaluation framework
(7) Test reactor safety monitoring system model under cyber-attack.

CURRENT WORK IN CYBERSECURITY (Cont.)

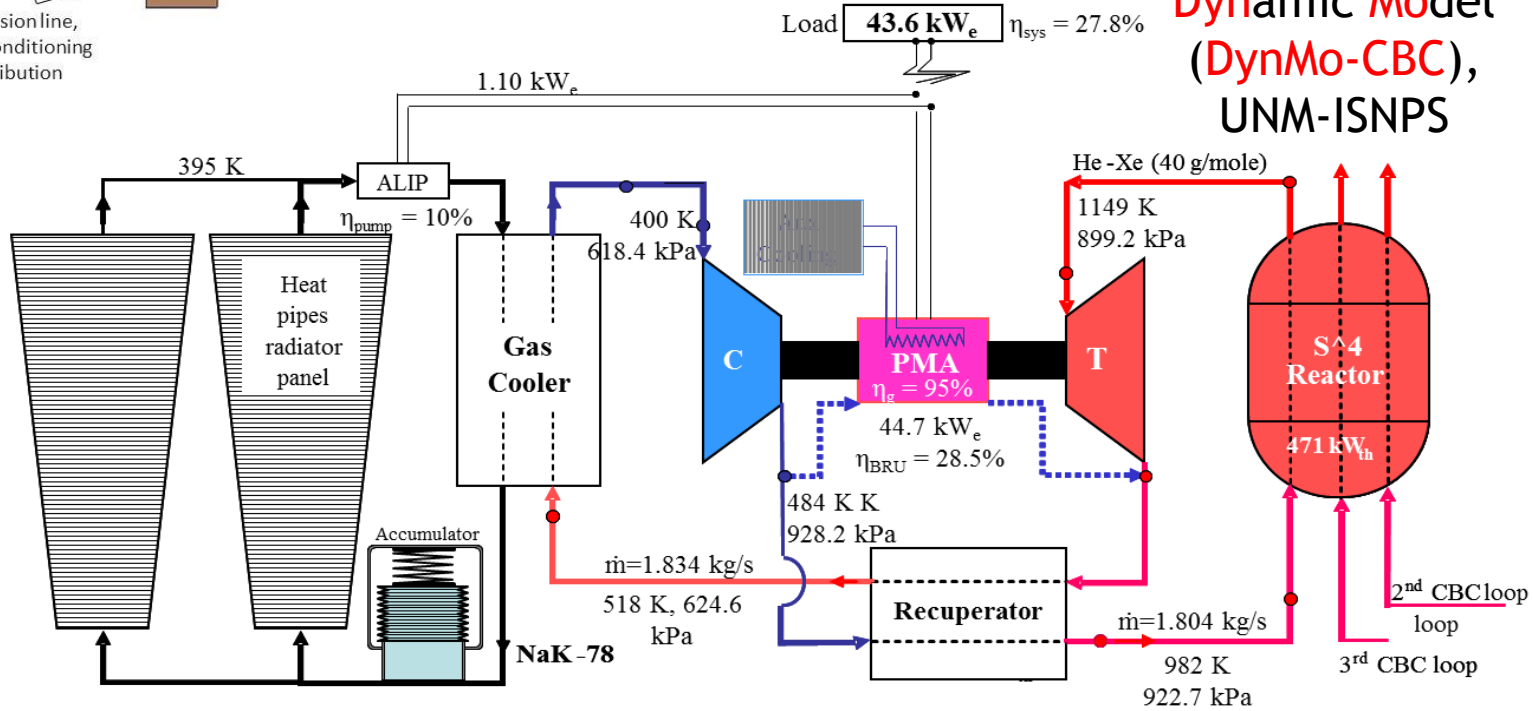
Application to space nuclear reactor power systems



S^4 nuclear reactor space power system with CBC loops *for avoidance of single-point failures* (UNM-ISNPS)



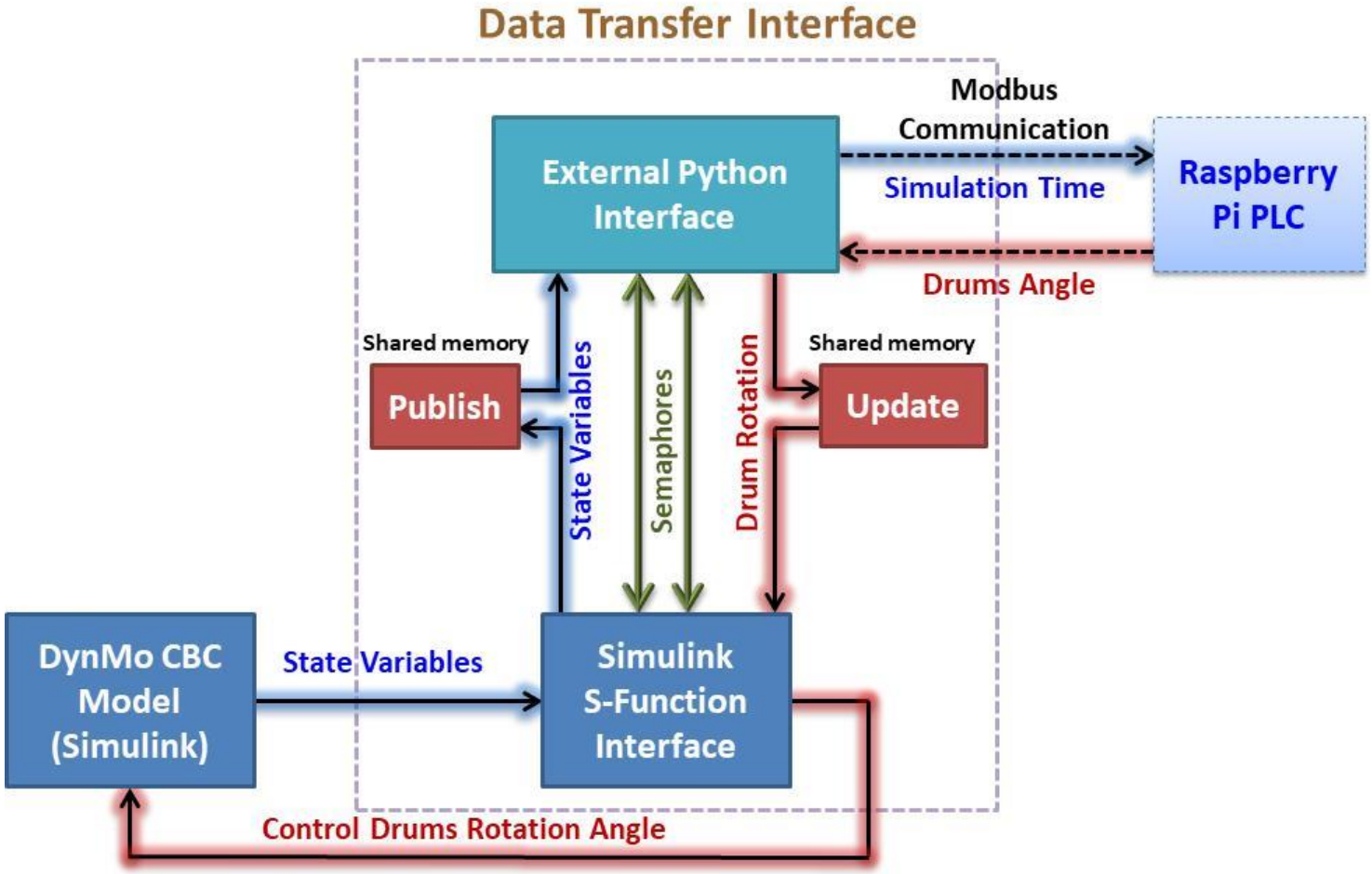
Dynamic Model (DynMo-CBC), UNM-ISNPS

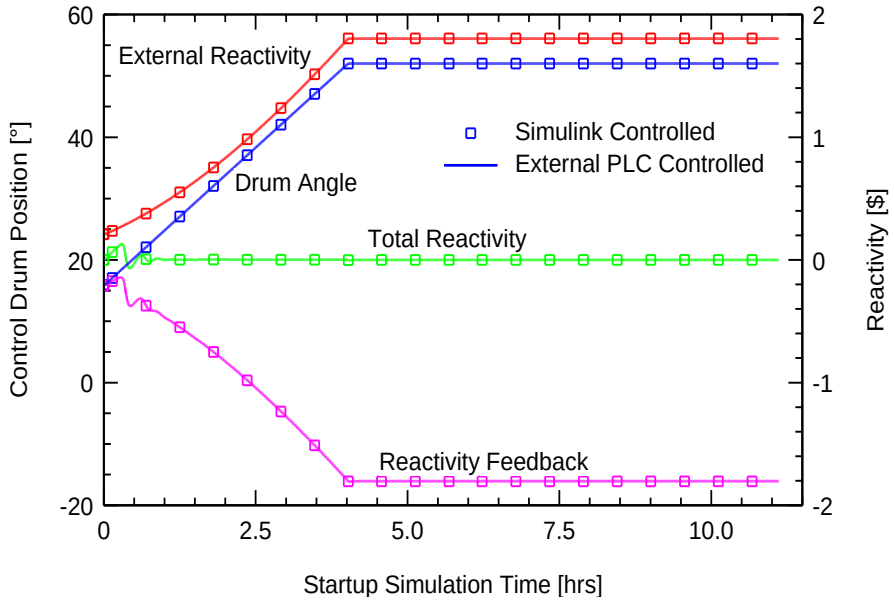


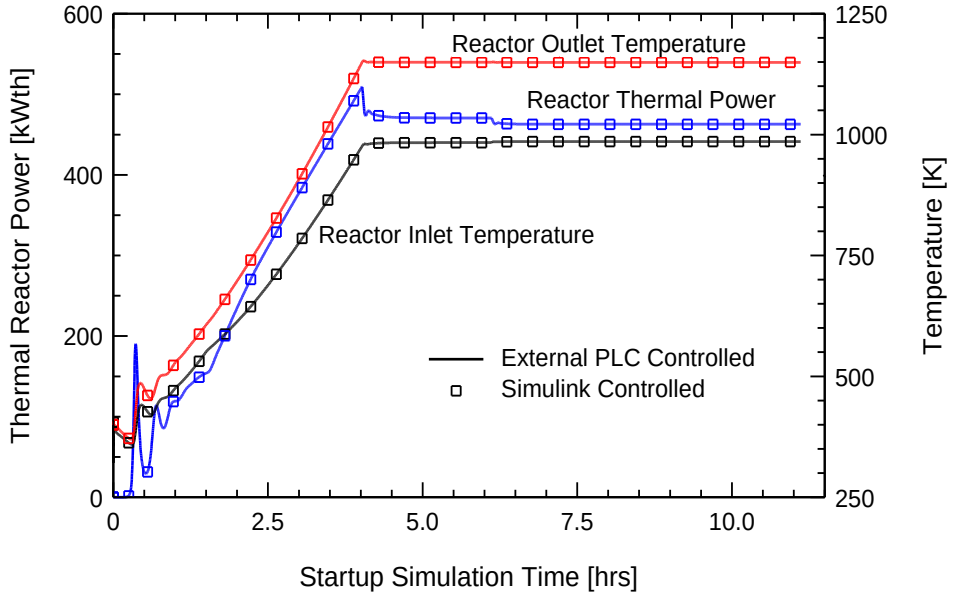
-El-Genk, M. S., Tournier, J.-M., P., and Gallo, B. M., "Dynamic Simulation of a Space Reactor System with Closed Brayton Cycle Loops," *J. Propulsion and Power* 26(3), 2010, 394 - 406.
- El-Genk, M. S. and J.-M., P. Tournier, "**DynMo-CBC**: Dynamic Simulation Model for a Space Reactor Power System with Multiple CBC Loops," *Proc. 7th International Energy Conversion Engineering Conference*, Paper No. AIAA-2009-4577, Denver, Co, 3- 5 August 2009.

CURRENT WORK IN CYBERSECURITY (Cont.)

Fast & synchronous interface for space reactor power system's Dynamic Model (DynMo-CBC)

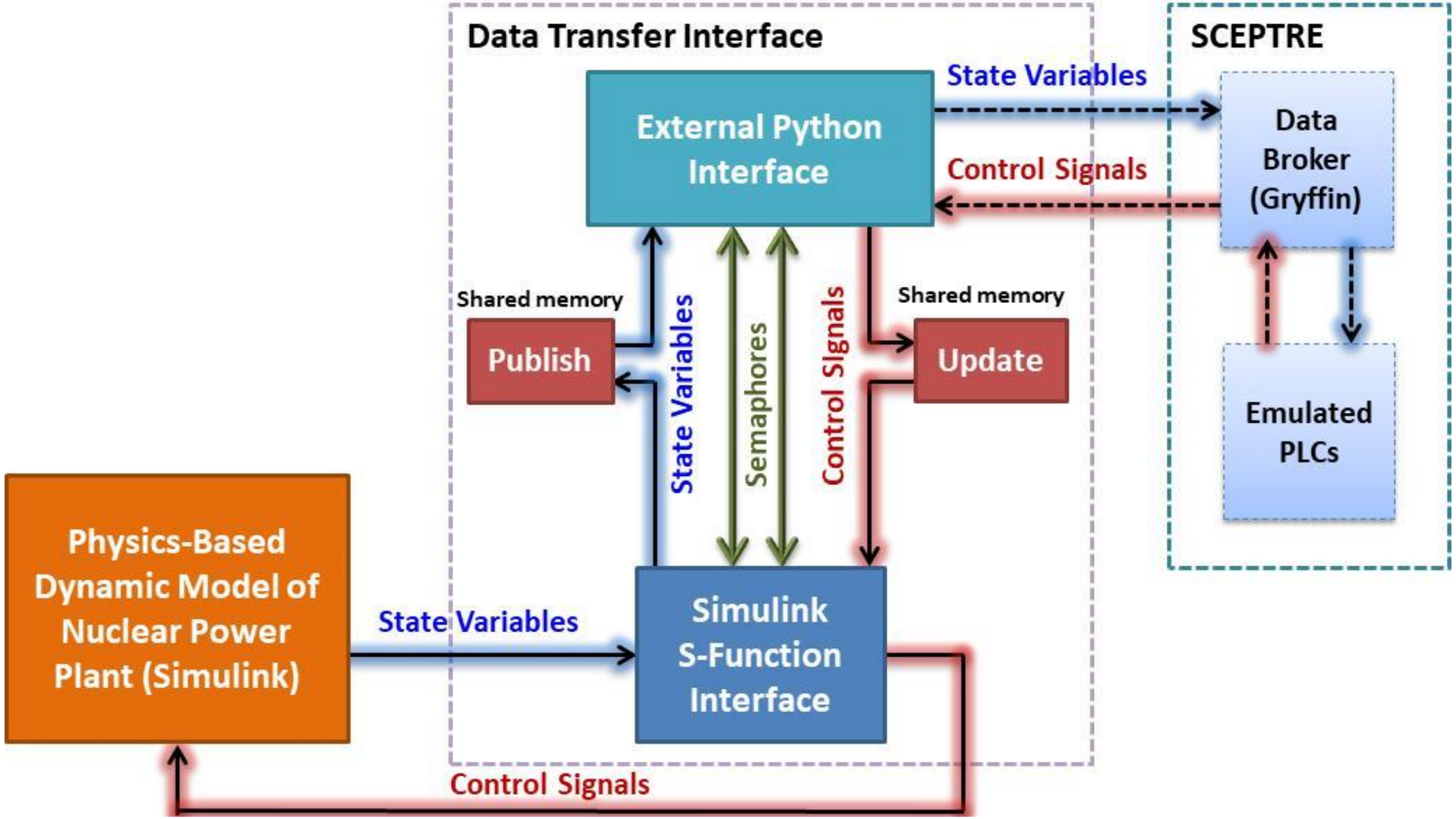






El-Genk, M., Schriener, T., Lamb, C., Fasano, R., and Hahn, A. ***Implementation and Validation of PLC Emulation and Data Transfer***. Technical Report No. ISNPS-UNM-02-2019, Institute for Space and Nuclear Power Studies (ISNPS), University of New Mexico, July 2019.

CURRENT WORK IN CYBERSECURITY – **NICSim Implementation**



FUNDING SOURCES and NICSim project Team

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Sandia National Laboratories (SNL)

NICSim Project Team

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RESEARCH NEEDS AND AREAS OF POTENTIAL COLLABORATION

- Establishing capabilities for developing high fidelity emulation models of Programmable Logic Controllers (PLCs) → would expand NICSim capabilities to other potential applications
- Expand uses of developed data transfer interface under this project to Simulink-Matlab based models in other applications. *Examples include industrial processes, unmanned vehicles, remote operation and control of space nuclear reactor and propulsion systems, chemical processing, renewable energy, accident avoidance, .. etc.*