

ADVANCED REACTOR SAFEGUARDS & SECURITY

Diverse Redundant Communications

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PRESENTED BY

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Problem Statement



- IEEE standards "prohibit" the use of cryptographic mechanisms within nuclear safety systems
- Cryptographic mechanisms are the most mature and evaluated cybersecurity controls
- Lack of these mechanisms reduce both robustness and reliability of I&C systems (i.e., resilience) against cyber-attacks
- There is a need for turn-key solutions to implement cryptographic mechanisms in a deterministic manner while minimizing impacts on safety/licensing criteria



Research Effort



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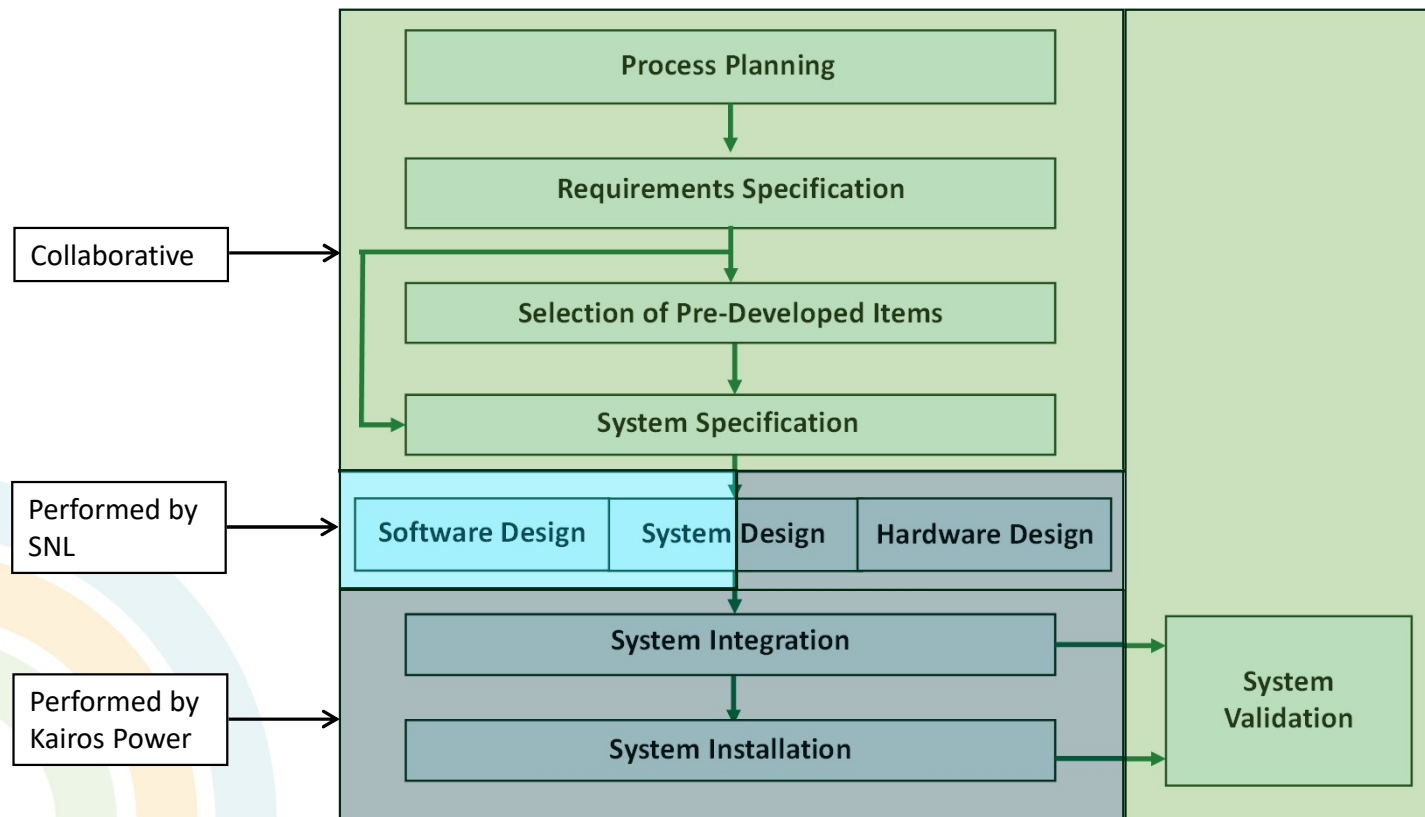
Research Objectives

- Demonstrate the process of a Tier 3 Analysis from the TCA
- Produce a safety-focused cryptographic device prototype for nuclear power applications
- Collaborate with industry partner(s) to aid in the use of cryptographic protections within a nuclear power plant
- Enable secure, limited data exchange across security zones and untrusted network paths
 - Path to wireless and remote monitoring/operations
- Demonstrate integration in a vendor test environment
- Enable wireless technologies, remote monitoring, and remote operations (FY27++)

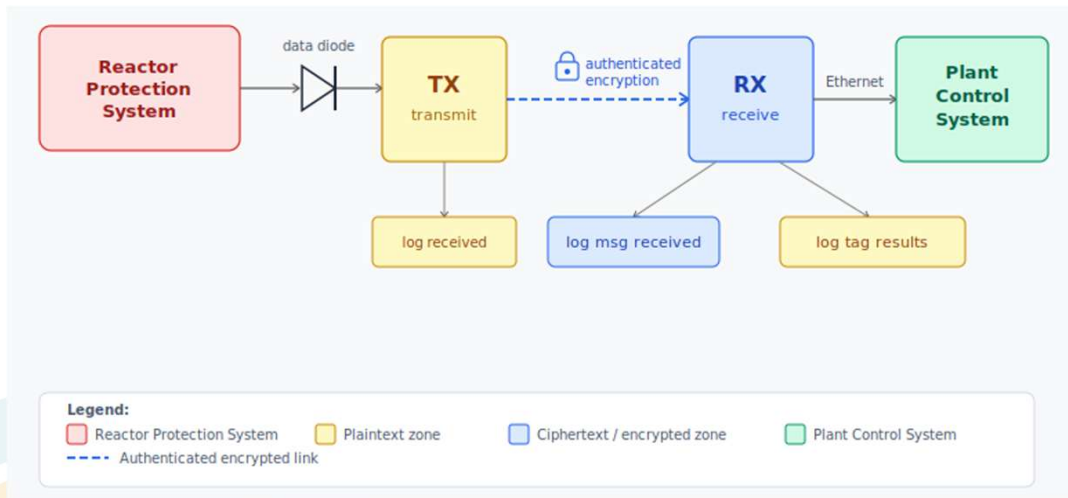
Process Planning – Collaboration with Kairos



Leverages System Lifecycle Process



System Concept & Key Documents



- System Specification
- Software Specification
- Hardware Specification
- Software Development Process
- Pre-Developed Items
- Fabrication
- Realization
- Testing

Requirements Specification(s)



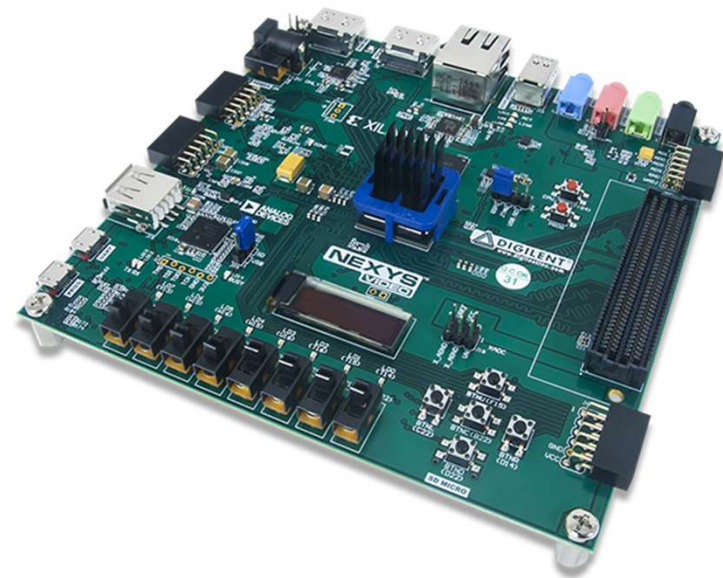
Type of Requirement	Requirement	Rationale
Functional	The design shall implement an Authenticated Encryption with Associated Data (AEAD) cipher suite.	Fortification in Single System at LBL III to mitigate Distort and Deceive
Performance	The design shall support a minimum throughput to accommodate data transmission at the required sample rate.	Chokepoint in Architecture to mitigate Deny

Selection of Pre-Developed Items



- Cost-Benefit of using Commercial Cryptography Cores
 - Estimated \$80k for an AES256GCM core
 - Controlled Software
 - Can't share with research partners
- FPGA Criteria
 - At least two Ethernet ports, preferably more
 - Support at least one AES256GCM core and 2+ ethernet MACs

Selected FPGA Development Board – Nexys Video



Current Status/Timeline



Completed

- AES-256-GCM Encrypt
- AES-256-GCM Decrypt
- Ethernet Pipeline
 - 5 Ports functioning on development board simultaneously
 - Currently uses raw Ethernet, not UDP/TCP
- Functional Testing
 - Single FPGA and two laptops for testing the encryption and decryption
 - FPGAs standalone

To Do

- Open Source Current Codebase
- Documentation
- Logging
- Test Cases
- Test Execution



Future Work



FY26 Challenges

- Specification revisions
 - Limitations resulting from Kairos fabrication processes (e.g., translating FPGA dev board)
- Remote Test Environment - SNL
 - Race-conditions
 - Resource/performance limits (e.g., multiple systems)
- Schedule conflicts/demands of a Potential Hermes Test
 - Onsite at ORNL

FY27+

- Diverse Wireless technologies between two FPGAs
 - Diverse Timing, handshaking protocols, protocols
- Integrate Hermes System(s) or Proprietary Digital Twin (AR Vendor).



Questions?

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