Lockheed Martin Nuclear Systems & Solutions

LOCKHEED MARTIN

Nuclear Systems & Solutions

Outline/Agenda

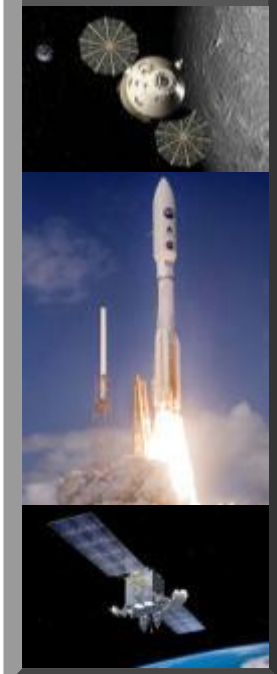
- **Introduction to Lockheed Martin**
- **FPGA-based Safety System Platform**

Introduction - Lockheed Martin

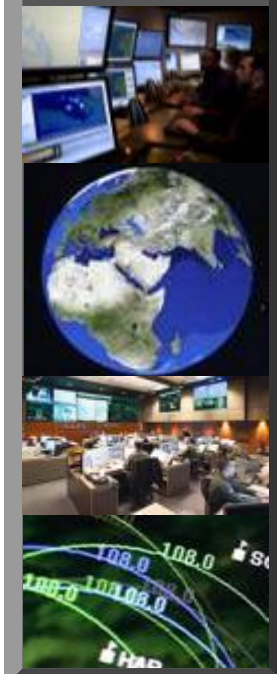
LOCKHEED MARTIN

Aeronautics

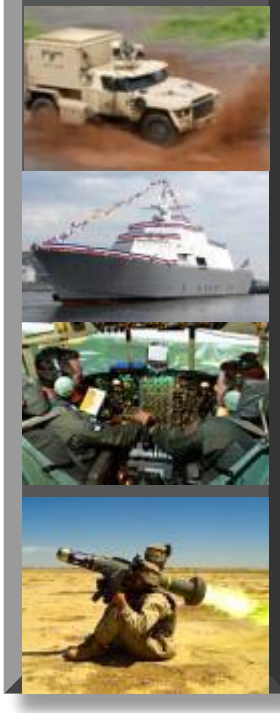
Space Systems



Information Systems & Global Services



Electronic Systems



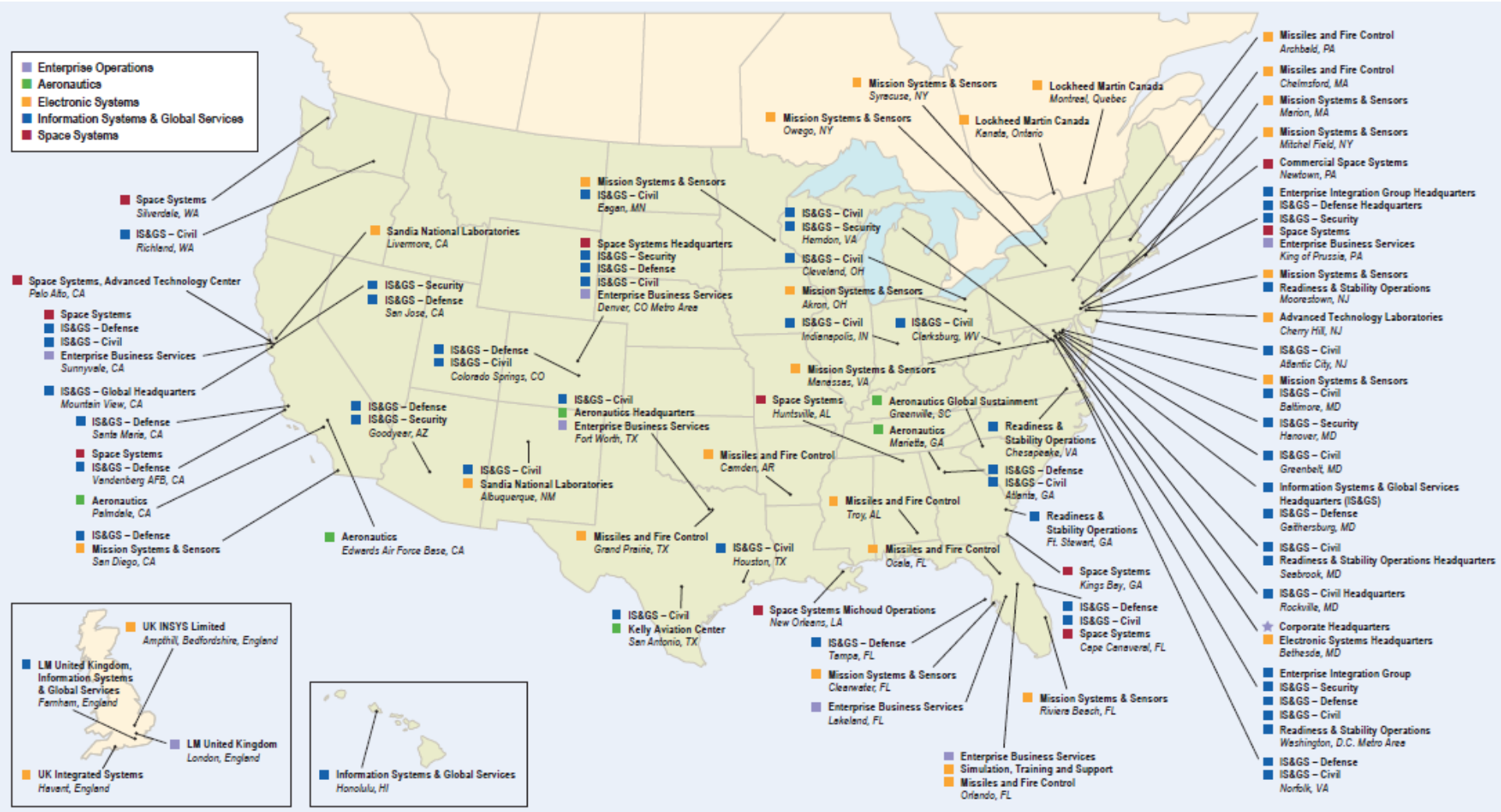
A Leader in Global Security

The Men and Women of Lockheed Martin

- **123,000 Employees**
- **66,000 Scientists, Engineers and IT Professionals**
- **Operations in 573 Facilities, 500 Cities, 46 States and 75 Countries**

Partners to Help Customers Meet Their Defining Moments

Lockheed Martin Locations



Our Customers

- Departments of
  - Defense
  - Homeland Security
  - Commerce
  - Energy
  - Health & Human Services
  - Housing & Urban Development
  - Justice
  - State
  - Transportation
- NASA
- Social Security Administration
- Environmental Protection Agency
- U.S. Postal Service
- Intelligence Communities
- Foreign Governments

We Never Forget Who We're Working For ™

Lockheed Martin Energy Portfolio

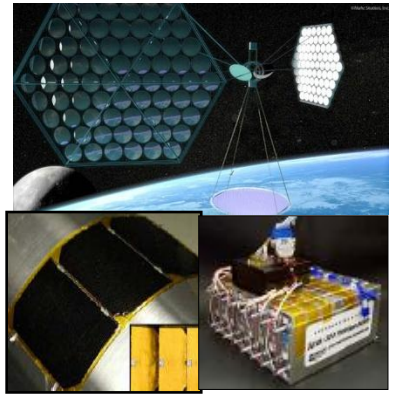
Information Systems & Global Services

- Energy Efficiency
- Technical & Engineering Services
- Smart Grid
- Site & Lab Management

Electronic Systems

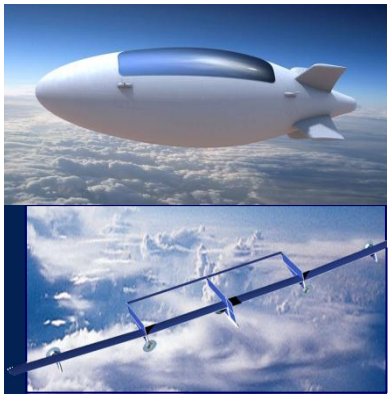
- Energy Generation
  - Solar
  - Ocean Thermal
  - Wave
  - Biomass
  - Fuel Cells
  - Storage
- Micro-Grids
- Nano-Technology
- Nuclear Controls

Space Systems



- Carbon Monitoring Exploration
- Solar Power Exploration
- Wind Prediction

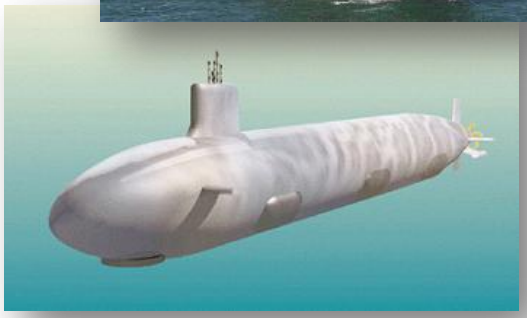
Aeronautics



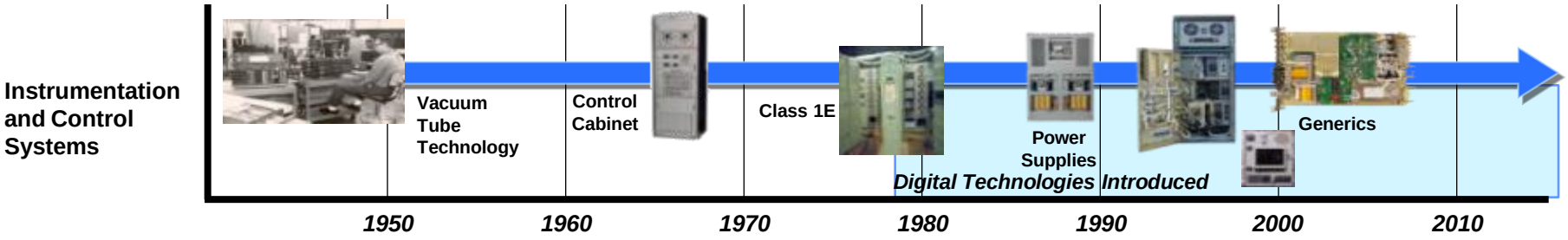
- Aircraft Energy Technology
- Fuel Efficiency

A Global Security Company Addressing Energy and Climate Challenges

Nuclear I&C and Complementary Products



- **Largest I&C supplier to the U.S. Navy – systems on ALL nuclear vessels**
- **Design and manufacturing for GEN3+ reactor systems**
  - Contracted and teamed with providers of safety-related equipment and designs
  - Commercial I&C
  - Safety (Class 1E) and non-safety equipment applications
- **Integrated analog and digital designs**
- **Harsh environment/high reliability**
  - Devices qualified to strict military standards (environmental)



Proven Track Record on Domain-relevant Products

About Lockheed Martin

- **Development and support of products with life-spans measured in decades**
- **Significant relevant competencies**
- **Extensive resources in people, labs, manufacturing, tools, and training provides vast amount of "reach back"**

People and Places

- 123,000 employees
- 66,000 scientists and engineers
- 25,000 IT professionals
- Operations in 573 facilities, 500 cities, 46 states and 75 countries

Major Competencies

- Nuclear I&C
- Systems Engineering
- System Integration and Test
- Digital System Design
- Safety Critical System Design
- Product Sustainment
- Program Management
- Production Manufacturing
- Logistics
- Virtual Prototyping
- System Simulation/Modeling
- Electronics Packaging
- Reliability/Maintainability
- Advanced Algorithms
- Quality Assurance

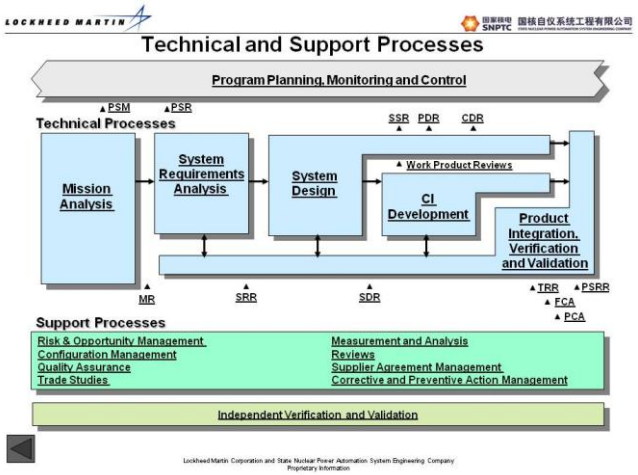
Beginning-to-End Product Development and Support

Established, Rigorous Process

- **Mature Quality and Safety processes have proven history of building and certifying safety critical systems to our customers**

Industry Standards

Regulations & Guidance



Mature Process Maps to NRC Requirements Provides Roadmap to Qualification

SNPAS Partnership

- **Lockheed Martin and State Nuclear Power Automation Engineering Systems (SNPAS) executed a Cooperative Development Agreement during Q4 2010**
  - **Received DoE Determination in September 2010**
  - **Established Dedicated Facility Outside of Scranton, PA in Q1 2011**
  - **SNPAS Technical Development Team On-Site in Dedicated Facility since Q2 2011**
- **Cooperative Development Program Activities**
  - **Mature the NuPAC Conceptual Design to a Documented, Validated and Qualified Platform**
  - **Perform CAP1400 Reactor Protection System (RPS) Requirements Analysis**
  - **Conceptualize CAP1400 RPS Architecture From NuPAC Platform Elements**
  - **Establish SNPAS Systems Engineering Policy, Procedure & Instruction Infrastructure Based on NQA-1**
  - **Provision of Initial Target Plant CAP1400 RPS Hardware**

FPGA-based
Safety System Platform

Motivation

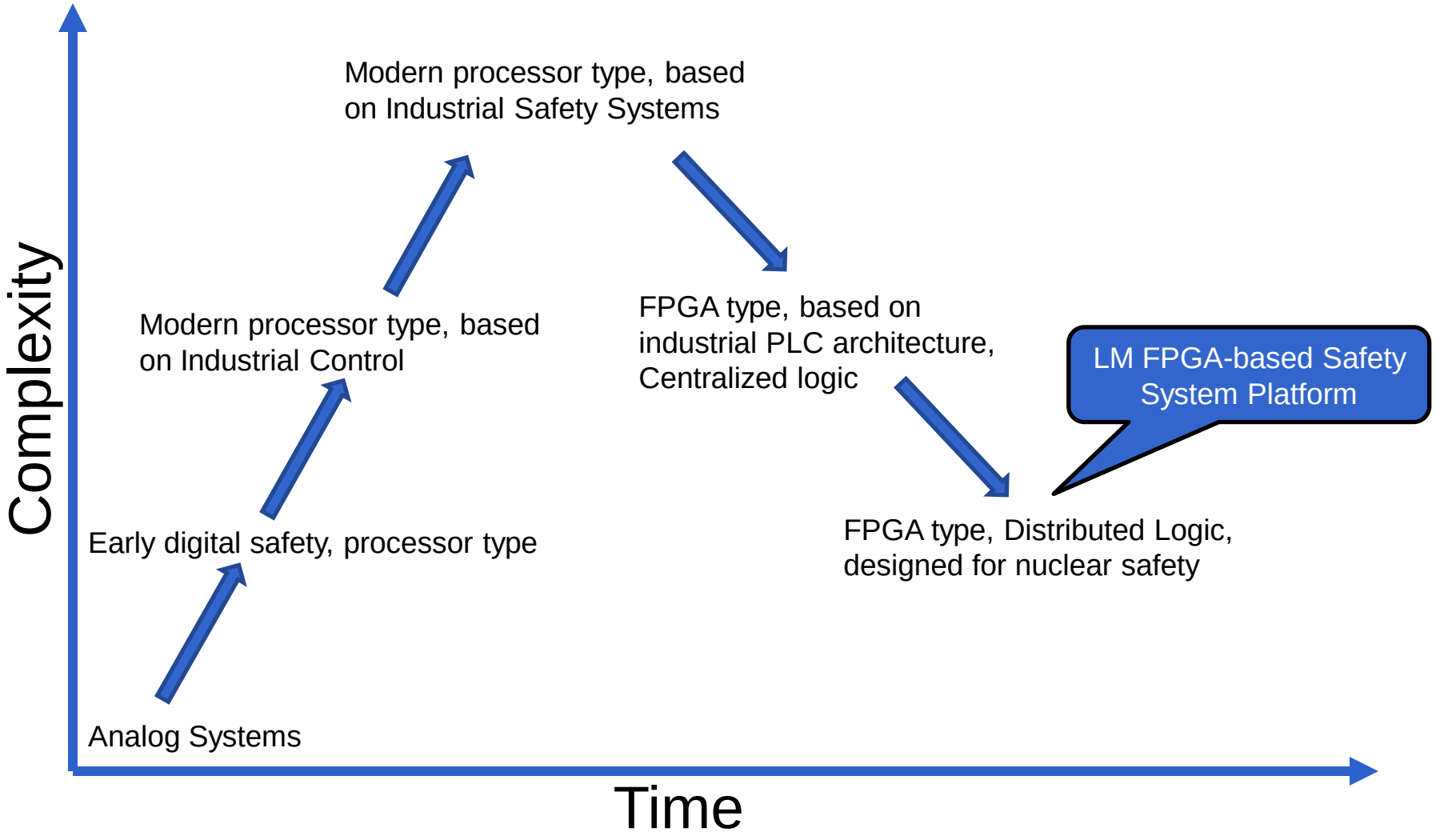
- **The application of digital technology challenges the licensing of I&C safety systems**
- **Key Issues**
  - **Potential software common-cause failures**
  - **Inter-channel communication**
  - **Cyber security**
  - **Communication between non-safety and safety systems**
  - **Dedication of commercial off-the-shelf equipment**

Objective

- **Provide a control system platform for digital I&C safety systems to support the effective design, construction and operation of both existing and new reactors**

- **Key Points:**
  - **Digital technologies enhancing safety, reliability and efficiency**
  - **Technical approach eliminating common-cause failure vulnerabilities**
  - **Design, qualification and production under an Appendix B quality assurance program**

Complexity Over Time



Safety System Platform

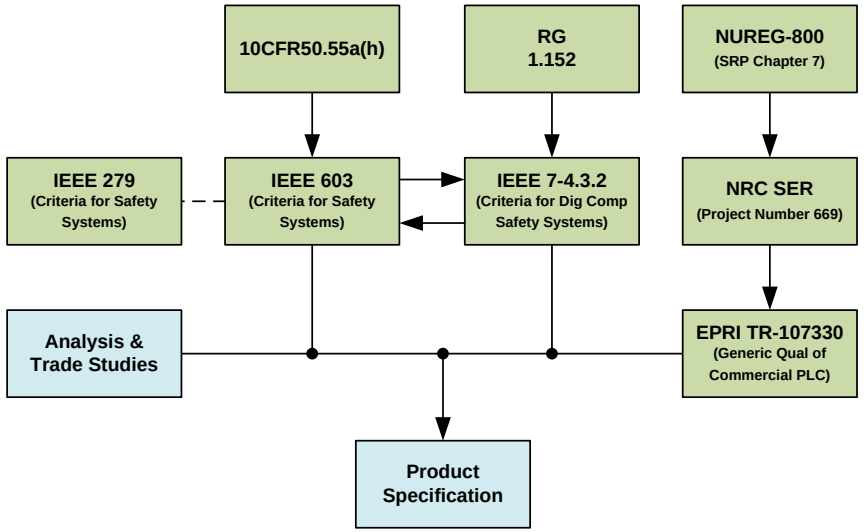
- **The *DS3*™ a.k.a. the *NuPAC***
  - **Based on functional and physical requirements in EPRI TR-107330**
  - **Design to eliminate common-cause failure vulnerabilities**
    - **No microprocessors, operating systems, or executable software**
    - **FPGA-based state machine**
  - **Design for safety**
    - **Simple and deterministic**
    - **Functionally and physically segmented**
  - **Security of an embedded system**
  - **Certified Building Blocks**
    - **Generically-qualified (with U.S. NRC approval) modules ready to be configured for customers' application-specific requirements**

NRC Approved – Generic Building Block
(Safety Evaluation Report)

A Premier FPGA-based Platform Designed Specifically for Use in NPP I&C Safety Systems

Product Specification

- **Lockheed Martin Product Specification**
  - **Derived requirements from NRC incorporated, endorsed, or accepted industry standards**
    - **Functional, Performance, and Physical Requirements**
      - **Based on EPRI TR-107330**
    - **Development Process Requirements**
      - **Lockheed Martin Process**
      - **Project-specific processes for programmable logic**
        - **IEEE Std. 7-4.3.2-2003**
    - **Quality Assurance Requirements**
      - **QMS meets ASME NQA-1**



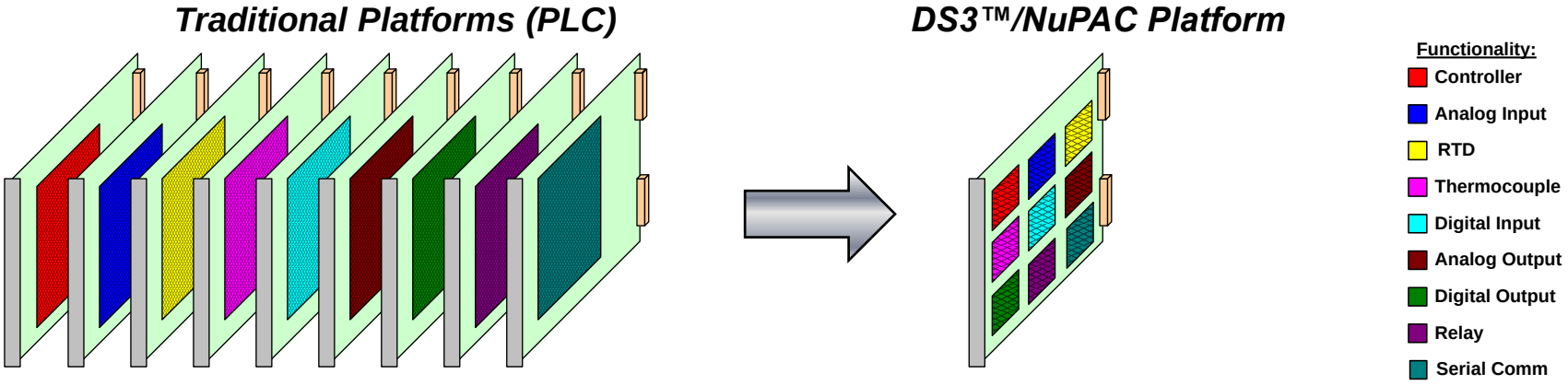
Starting Point for the Product Design Activities

Physical Architecture

- Generic, modular, scalable and distributed
- Generic Logic Module (GLM)
  - Input Processing, Logic Solving, Output Processing
- Chassis mounted / cabinet installed
- Industry-standard card form factors and chassis
- Suitably rugged for design basis events and long service life
  - Withstand requirements per EPRI TR-107330
    - Environmental, EMI/RFI, ESD, Seismic

Form Factor and Function Similarity to Commercially-available PLCs

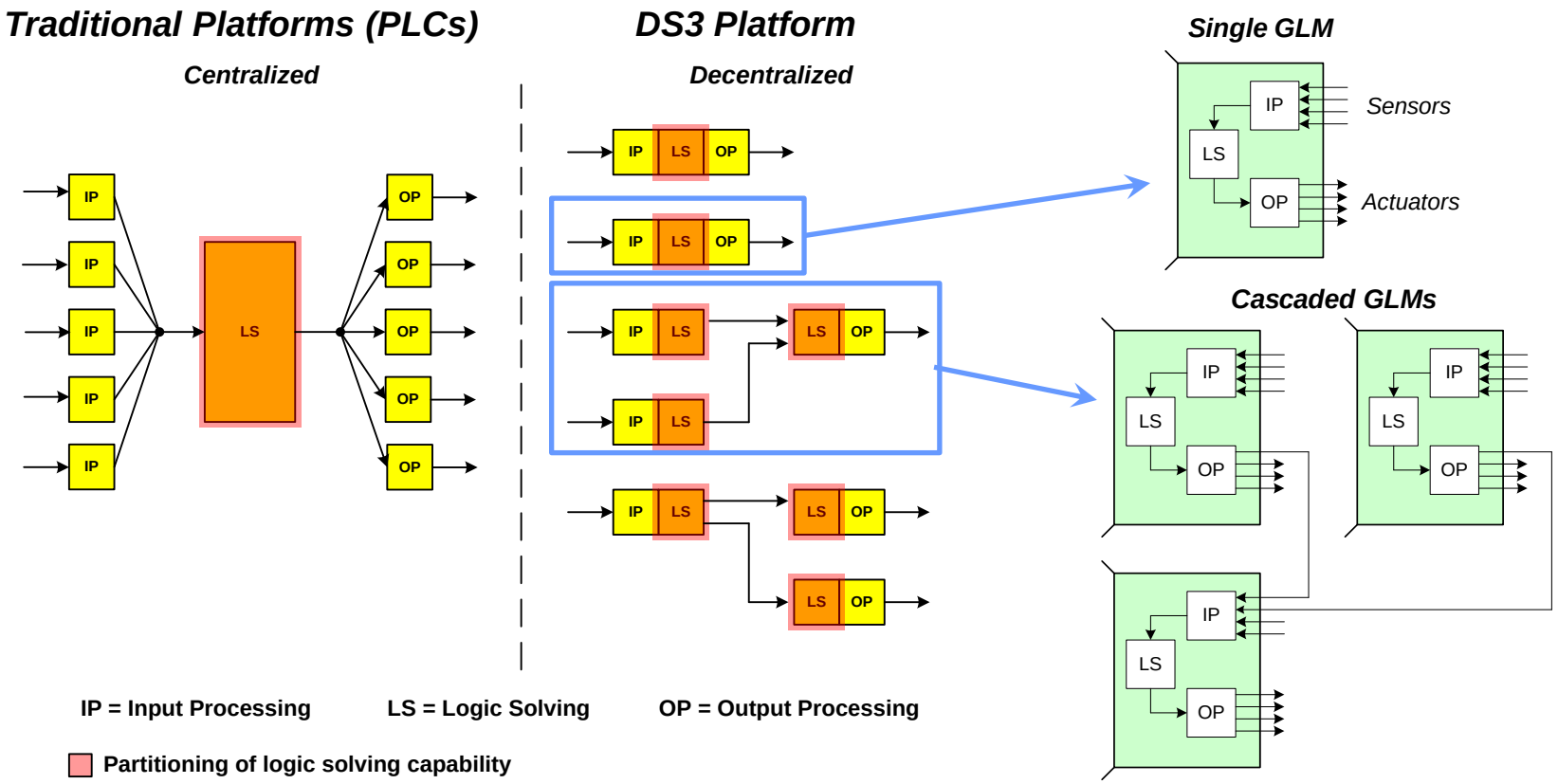
Paradigm



- **Integrates all functionality of a PLC on a single *GENERIC LOGIC MODULE*, the GLM**
  - User-configurable I/O supports all standard types
  - Provides an onboard FPGA-based logic solving capability
  - Scalability provided by paralleling and cascading GLMs
    - Efficiently supports partial system upgrades/retrofits up to complete safety system replacements or new plant safety system architectures
- **Promotes *SYSTEM SAFETY***
  - Avoids the highly-integrated and highly-complex (Decentralized vs. Centralized Architecture)
  - Keeps the design as simple as possible - architecture reduces system infrastructure and associated complexity
  - Supports functional and physical partitioning
  - Simple hardware-based state machine versus a complex microprocessor with an operating system and software
  - Facilitates diversity, verifiability, and thus licensability
- ***SIMPLIFIES* system-level *FMEA* for retrofits**

Akin to Legacy Hardware-based Systems (e.g. Trip Modules)

Functional Partitioning

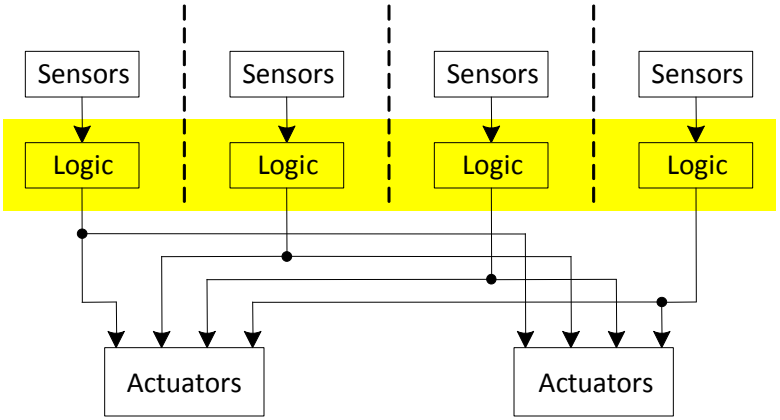


Keep the design as SIMPLE as possible

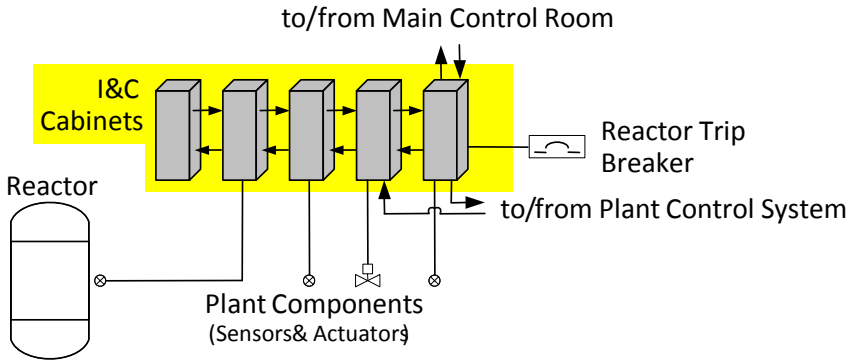
- Avoids the highly-integrated and highly-complex
- Many small modest logic elements instead of one large complex logic element
- No system size limitations, and no performance degradation with increase in system size
- Enhances ability to verify and validate
- Provides the easiest path to licensing success

Notional Implementation

Functional Architecture



Physical Architecture



Solution

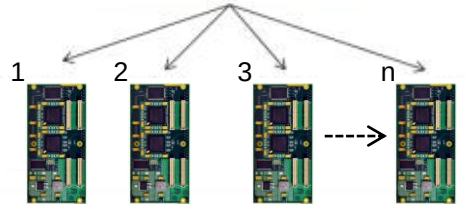
I&C Cabinets

Cabinets
Power Supplies
Media Converters
Cables
Component Interface Circuits

DS3™ Platform

DS3 Platform
Chassis Assemblies
Modules
Programmable Logic
Cabling/Termination

FPGA, Application Specific Logic



Summary

- **Platform provides a flexible FPGA-based architecture**
- **Applicable to both safety & non-safety applications**
- **Seeking generic approval via NRC Safety Evaluation Report (SER)**
- **Submitted topical report accepted for review in May 2012**

Questions