Lockheed Martin
Nuclear Systems & Solutions
Outline/Agenda

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

Space Systems

- Carbon Monitoring Exploration
- Solar Power Exploration
- Wind Prediction

Aeronautics

- Aircraft Energy Technology
- Fuel Efficiency

Micro-Grids
Nano-Technology
Nuclear Controls

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

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

- Analog Systems
- Early digital safety, processor type
- Modern processor type, based on Industrial Control
- Modern processor type, based on Industrial Safety Systems
- FPGA type, based on industrial PLC architecture, Centralized logic
- FPGA type, Distributed Logic, designed for nuclear safety

LM FPGA-based Safety System Platform
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

Traditional Platforms (PLC)  DS3™/NuPAC Platform

• 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

**Traditional Platforms (PLCs)**

- **Centralized**

**DS3 Platform**

- **Decentralized**

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**Single GLM**

- **Cascaded GLMs**

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**IP** = Input Processing  
**LS** = Logic Solving  
**OP** = Output Processing

Partitioning of logic solving capability

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**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**

- Sensors
- Logic
- Actuators

**Physical Architecture**

- I&C Cabinets
- Reactor Trip Breaker
- Plant Components (Sensors & Actuators)
- to/from Main Control Room
- to/from Plant Control System

**Solution**

- **I&C Cabinets**
- **DS3™ Platform**
  - Cabinets
  - Power Supplies
  - Media Converters
  - Cables
  - Component Interface Circuits

- **FPGA, Application Specific Logic**
  - DS3 Platform
  - Chassis Assemblies
  - Modules
  - Programmable Logic
  - Cabling/Termination
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