

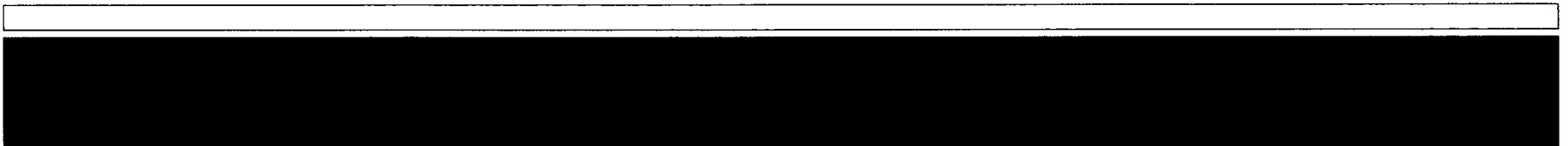


**Rolls-Royce**

***SPINLINE 3***

Equipment Qualification Testing  
Status and Results

August 25, 2011



# Agenda

- Introduction
- Qualification Testing Program Overview
- Qualification Testing Status and Results
- Path Forward
- Open Discussion
- Summary and Conclusions



# Qualification Testing Program Overview

- References for Generic Qualification
- Qualification Test Specimen
- Scope of Qualification Testing
- Safety Functions Tested During Qualification
- Qualification Testing Sequence
- QTS – Hardware Modules
- QTS Architecture



# References for Generic Qualification

- Qualification testing performed in accordance with the following primary references:
  - RG 1.89, “Environmental Qualification of Certain Electrical Equipment Important to Safety for Nuclear Power Plants”
  - RG 1.100, “Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants”
  - RG 1.180, “Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems”
  - Regulatory Guide 1.209, “Guidelines for Environmental Qualification of Safety Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants”
  - IEEE Std 323-2003, “IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Stations”
  - IEEE Std 344-1987, “IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations”
- Complies with seismic and EMC guidance in EPRI TR-107330, “Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants”

# Qualification Test Specimen

- Representative Hardware Configuration
  - Reactor Trip System
  - Engineered Safety Features Actuation System
- Typical technical functions for target systems:
  - Signal conditioning (temperature)
  - Input Acquisition (discrete, analog and pulse signals (neutron detector))
  - Digital Processing (threshold comparison, vote, command ...)
  - Output Generation (actuator drive, vote and analog signals)
  - Network Communication & surveillance
  - Support Functions
    - Power Supply
    - User Interface
    - Equipment Integrity

# Scope of Qualification Testing (1/2)

- Pre-Qualification Acceptance Testing
  - Pre-Qualification Testing System Setup and Checkout Testing
  - Pre-Qualification Testing Operability Testing
  - Pre-Qualification Testing Prudency Testing
- Qualification Testing
  - Radiation Exposure Withstand Testing
  - Environmental Testing System Setup and Checkout Testing
  - Post Radiation Exposure Operability Testing
  - Post Radiation Exposure Prudency Testing
  - Environmental Testing including:
    - High Temperature and High Humidity Operability Testing
    - High Temperature and High Humidity Prudency Testing
    - Low Temperature and Low Humidity Operability Testing
    - Ambient Temperature and Ambient Humidity Operability Testing

# Scope of Qualification Testing (2/2)

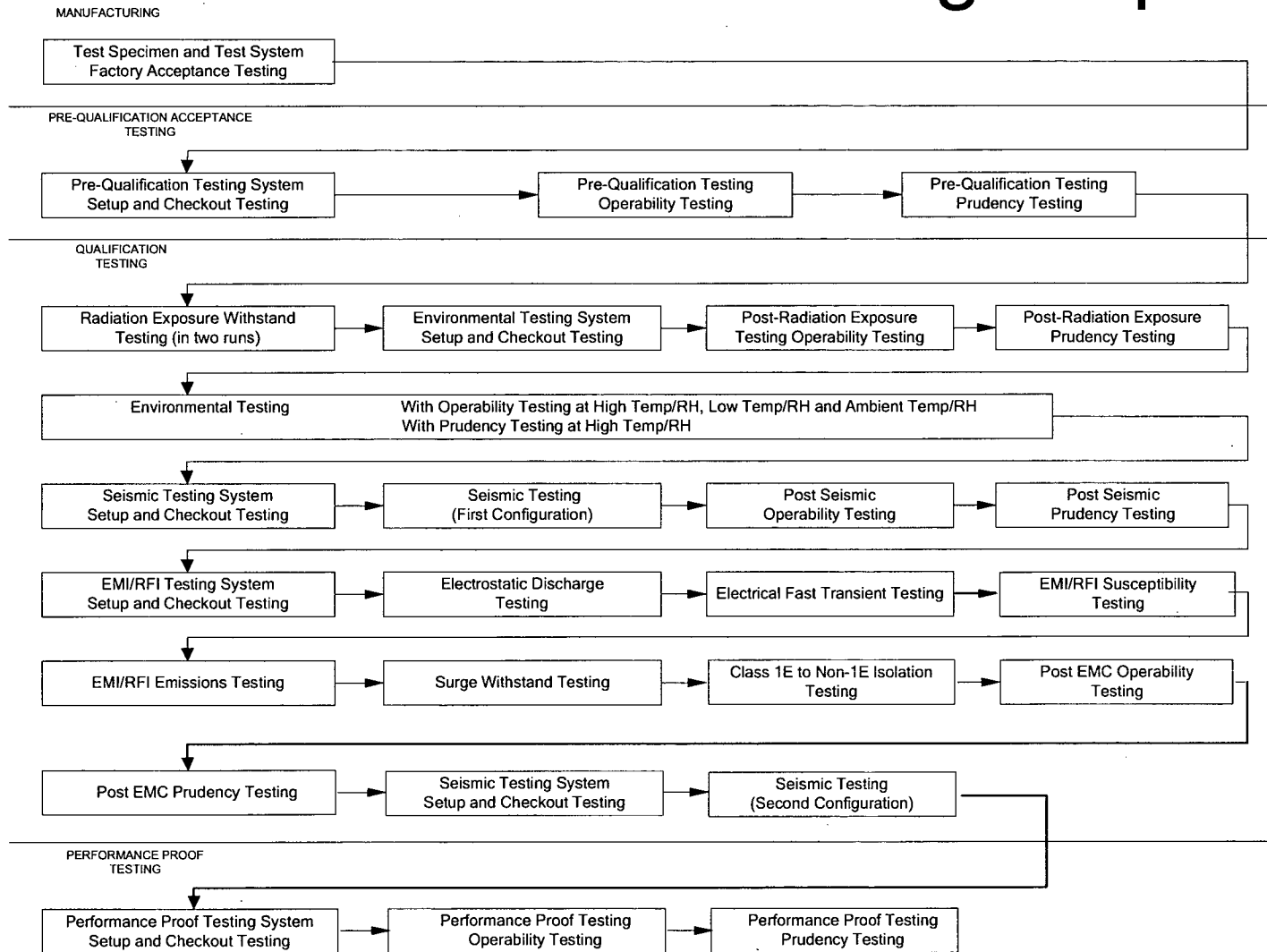
- Qualification Testing (cont.)
  - Seismic Testing System Setup and Checkout Testing
  - Seismic Testing
  - Post Seismic Operability Testing
  - Post Seismic Prudency Testing EMI/RFI System Setup and Checkout Testing
  - EMI/RFI Emissions Testing
  - EMI/RFI Susceptibility Testing
  - Electrical Fast Transient Testing
  - Surge Withstand Testing
  - Electrostatic Discharge Testing
  - Class 1E to Non-1E Isolation Testing
- Performance Proof Testing
  - Performance Proof Testing System Setup and Checkout Testing
  - Performance Proof Testing Operability Testing
  - Performance Proof Testing Prudency Testing

# Safety Functions Tested During Qualification

- Qualification testing demonstrates the following system behavior:
  - Correct functioning during normal and abnormal plant operating conditions.
  - Proper response of inputs to applied input signals,
  - Proper response of outputs to application program control,
  - Proper control of connected output devices,
  - Proper operation of communication interfaces,
  - Acceptable input/output accuracy,
  - Acceptable response time,
  - Proper response to momentary interruption of input power,
  - Proper response to loss of input power,
  - Proper response to input power quality (voltage and frequency) variations,
  - Proper failover to redundant components.



# Qualification Testing Sequence



# QTS – Hardware Modules (1/3)

- The *SPINLINE* 3 QTS included the following types of hardware modules and components:
  - Chassis
  - Signal Conditioning Modules
  - Signal Input Modules
  - Digital Processing Modules
  - Signal Output Modules
  - Communication Modules
  - Power Supply Module
  - Power Distribution Hardware
  - Terminal Blocks
  - Cable and Wire Sets
  - Fan Cooling Hardware
- The QTS includes a Test Specimen Application Program (TSAP) that was driven by a simulator during testing.

# QTS - Hardware Modules (2/3)

- Signal conditioning:
  - RTD conditioning : 8PT100 board, I.8PT100 interface board, and 8PT100 terminal block
- Signal Acquisition:
  - Discrete: 32ETOR TI SR board, I.32ETOR/T interface board, and 32ETOR terminal block
  - Analog: 16EANA ISO board and I.16EANA interface board
  - Pulse: ICTO board and I.ICTO interface board
- Digital Processing:
  - UC25 N+ board
- Signal Generation:
  - Discrete: 32ACT board and I.32ACT interface board, MV16 voting module and 8SRELAY relay terminal blocks
  - Analog: 6SANA ISO board and I.6SANA interface board

# QTS - Hardware Modules (3/3)

- Network Communication:
  - Nervia daughter board and I.Nervia interface board
  - 3TP/2FL and 4TP hubs and TP/FL converter
- Power Supply and Distribution Hardware:
  - ALIM 48V/5V-24V board and I.ALIM 48 interface board
  - First stage to convert 120 VAC field power supply to DC power supply
  - Second stage providing 24 VDC and 48 VDC required by *SPINLINE 3*

# QTS – Test Specimen Application Program

- Objectives:

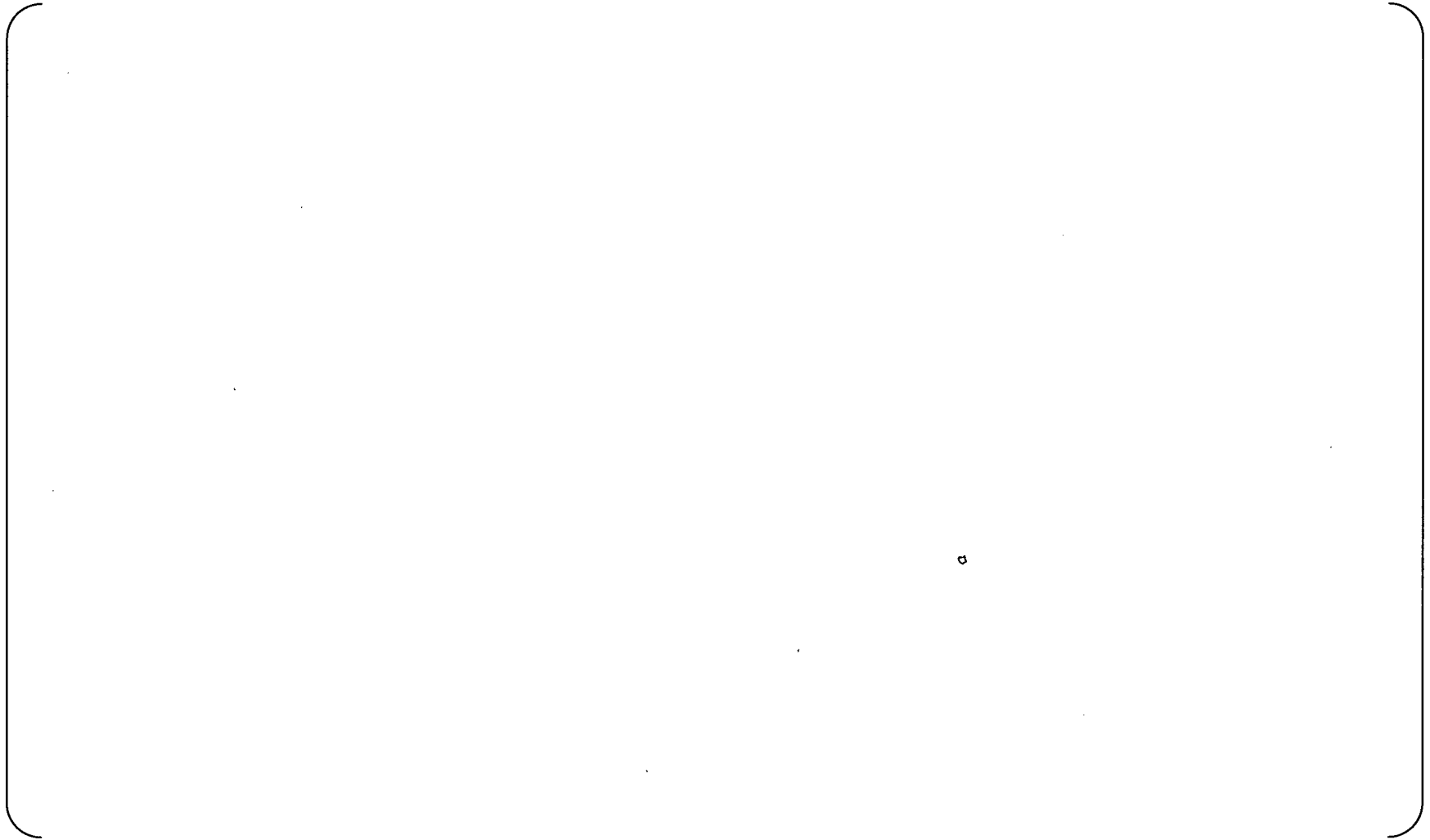
- TSAP description:



# QTS Architecture (1/2)



# QTS Architecture (2/2)



# Qualification Testing Status and Results

- Qualification Testing Status
- Test Exceptions
- Test Results





# Qualification Testing Status

- Tests were performed in NTS testing laboratories located in Boston during March - June 2011

<b>Qualification Test Series</b>	<b>Progress</b>	<b>Test Exceptions</b>
Radiation	100% Complete	None
Environmental	100% Complete	None
Seismic	100% Complete	None
EMC	100% Complete	See note 1
Isolation 1E-Non 1E	100% Complete	None
Performance Proof Testing	100% Complete	None

# Test Exceptions

- Note 1 (EMC Test Series)
- Justification will be provided in the Test Summary Report for not performing these tests.

# Test Results (1/4)

- Overall, the QTS went through the entire test program with limited problems
  - Some seismic weaknesses were identified in some equipment
  - Voltage tolerances slightly exceeded for one power supply
  - One replacement board used for some tests without prior environmental testing
- Operability and Prudency tests were generally satisfactory at all stages
  - Some limited data comparison errors need to be resolved
- Performance proof testing revealed nothing significant
- Analysis of test events and suspect equipment recorded logs is ongoing, in order to:
  - Explain some comparison errors (distinguish real errors from test equipment incompatibilities)
  - Make sure we fully understand all events/failures, in order to build the right path forward (supplemental tests)



# Test Results (2/4)

Qualification Tests	Test Deficiencies
Radiation	None
Environmental	None
Seismic	



# Test Results (3/4)

Qualification Tests	Test Deficiencies
EMC	
Isolation 1E-Non 1E	None
Performance Proof	None



# Test Results (4/4)

Other Events	Test Deficiencies
16EANA	
48VDC/24VDC Power converters	
DAS	



# Path Forward

- Roadmap to Resume Qualification Tests
- Schedule for Qualification Testing Submittals
- Modified Review Schedule



# Roadmap to Resume Qualification Tests

- Perform Preliminary Assessment of Test Findings - Ongoing
- Perform Forensic Evaluation of QTS Components - Started
- Complete Investigations and Prototype Testing - Target Completion
- Finalize Design Changes and Mechanical Adjustments on **SPINLINE 3** Platform - Target Completion
- Update Qualification Test Plan and Procedures - Target Completion
- Finalize Arrangements with Test Laboratory - Target Completion
- Fabricate New Qualification Test Specimen - Target Completion

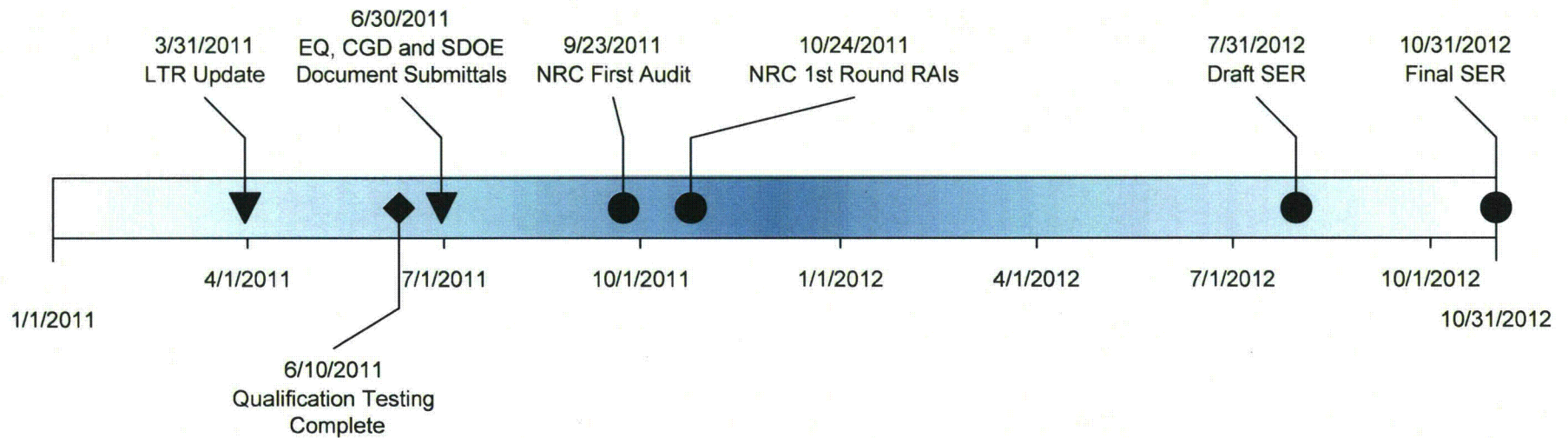


# Supplemental Tests

- Initial assessment is to rerun necessary test with to essentially the same Qualification Test Specimen and test procedures to accomplish the following:



# Current Review Schedule



**Current Understood Review Plan**

# Proposed Review Schedule



# Open Discussion

- Questions
- NRC Perspectives



# Summary and Conclusions

