Limerick Generating Station Digital Modernization Project LAR Pre-submittal Meeting

NRC Pre-submittal Meeting
June 29, 2021

Closed Portion

Architecture

Integrated Architecture

a,c

Integrated Architecture

The following changes to the Integrated Architecture presented during March's pre-submittal presentation.

PPS:

a,c

DCS:

a,c

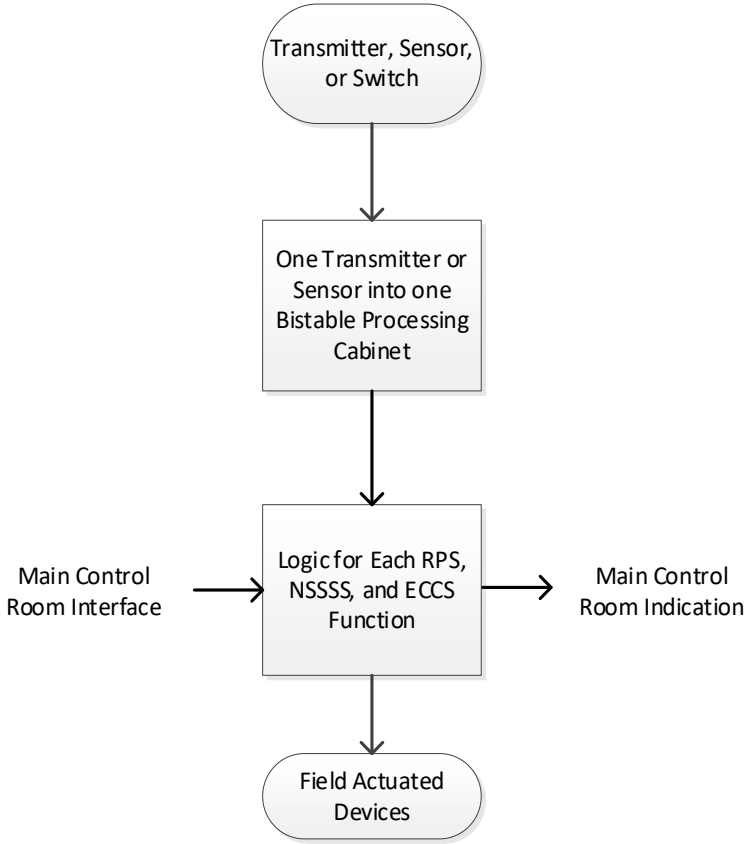
Sensor Reduction

Sensor Reductions

- Existing design implementation has multiple identical transmitters associated with input logic channels across the logic of all systems
- The PPS will evaluate Nuclear Boiler Instrumentation for the reduction of duplicated field transmitters
- The PPS will utilize an analyzed minimum set of transmitters to support diversity and redundancy
- The PPS will use four sensors to monitor each variable used for a reactor scram.
  - These sensors may also monitor the same variable for an engineered safety feature actuation
  - Analog measurements are converted to digital within each of four divisions
  - When a measurement exceeds the setpoint, the output of the comparison results in a channel partial trip condition
  - The partial trip condition is transmitted to the coincidence logic to form the signals that result in a safety feature actuation.

Sensor Reductions

RPS, NSSSS, & ECCS Typical Architecture



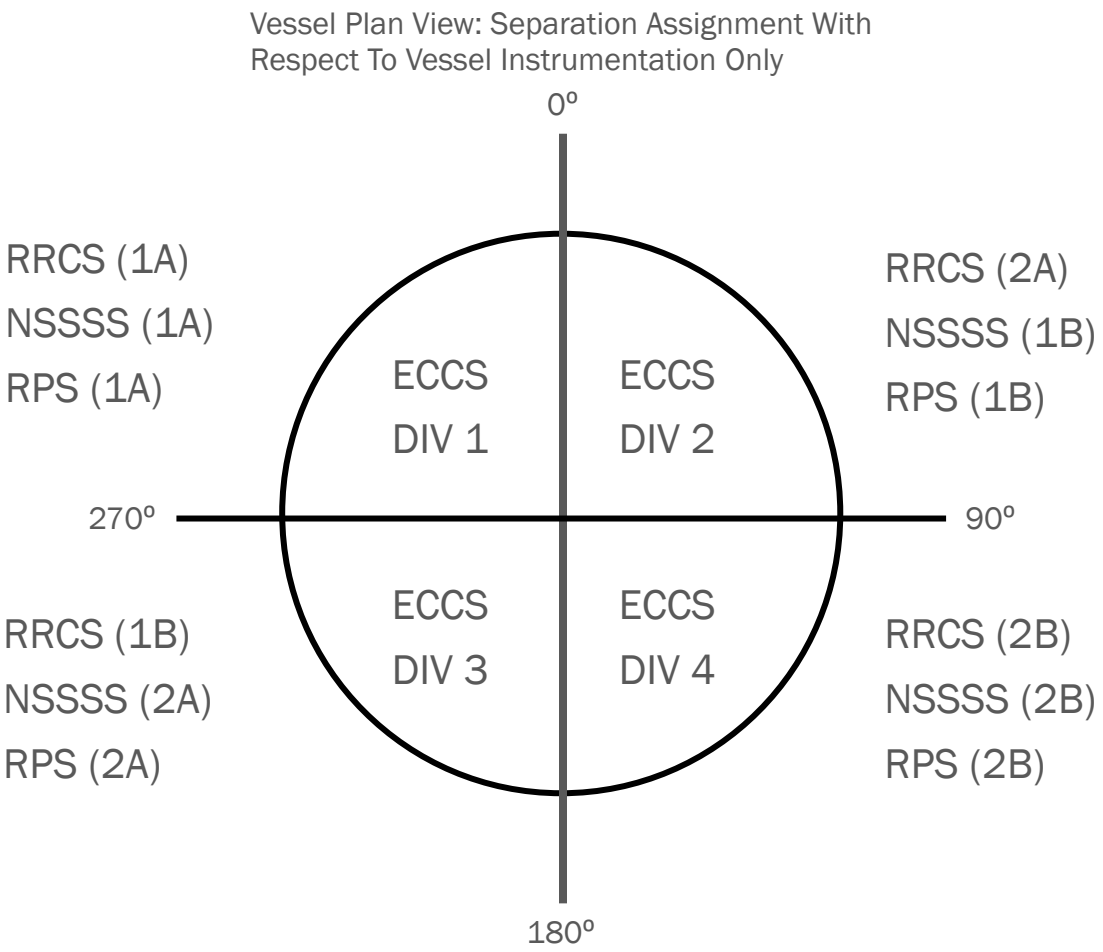
Sensor Reductions – Existing RWL 2

Existing Reactor Pressure Vessel Level Instrumetnation for Reactor Water Level 2						
Instrument	Function	Range	Variable Leg Nozzle	Nozzle Height	Reference Leg Nozzle	Nozzle Height
LT-1(2)N081A	NS4	WR	N16D	366”	N12D	599”
LT-1(2)N081B	NS4	WR	N16A	366”	N12A	599”
LT-1(2)N081C	NS4	WR	N16B	366”	N12B	599”
LT-1(2)N081D	NS4	WR	N16C	366”	N12C	599”
LT-1(2)N091A	CS(A)/RHR(A)/ADS(A), RCIC	WR	N16D	366”	N12D	599”
LT-1(2)N091B	CS(B)/RHR(B), HPCI	WR	N16A	366”	N12A	599”
LT-1(2)N091F	CS(B)/RHR(B), HPCI	WR	N16A	366”	N12A	599”
LT-1(2)N091C	CS(C)/RHR(C)/ADS(C)	WR	N16B	366”	N12B	599”
LT-1(2)N091G	CS(C)/RHR(C)/ADS(C)	WR	N16B	366”	N12B	599”
LT-1(2)N091D	CS(D)/RHR(D), HPCI	WR	N16C	366”	N12C	599”
LT-1(2)N091H	CS(D)/RHR(D), HPCI	WR	N16C	366”	N12C	599”
LT-1(2)N091E	CS(A)/RHR(A)/ADS(A), RCIC	WR	N16D	366”	N12D	599”
LT-1(2)N097A	RCIC	WR	N16D	366”	N12D	599”
LT-1(2)N097E	RCIC	WR	N16D	366”	N12D	599”
LT-1(2)N402A	RRCS	WR	N16D	366”	N12D	599”
LT-1(2)N402B	RRCS	WR	N16A	366”	N12A	599”
LT-1(2)N402E	RRCS	WR	N16B	366”	N12B	599”
LT-1(2)N402F	RRCS	WR	N16C	366”	N12C	599”
LT-1(2)15A	Wide Range Indication	WR	N16D	366”	N12D	599”
LT-1(2)15B	Wide Range Indication	WR	N16A	366”	N12A	599”

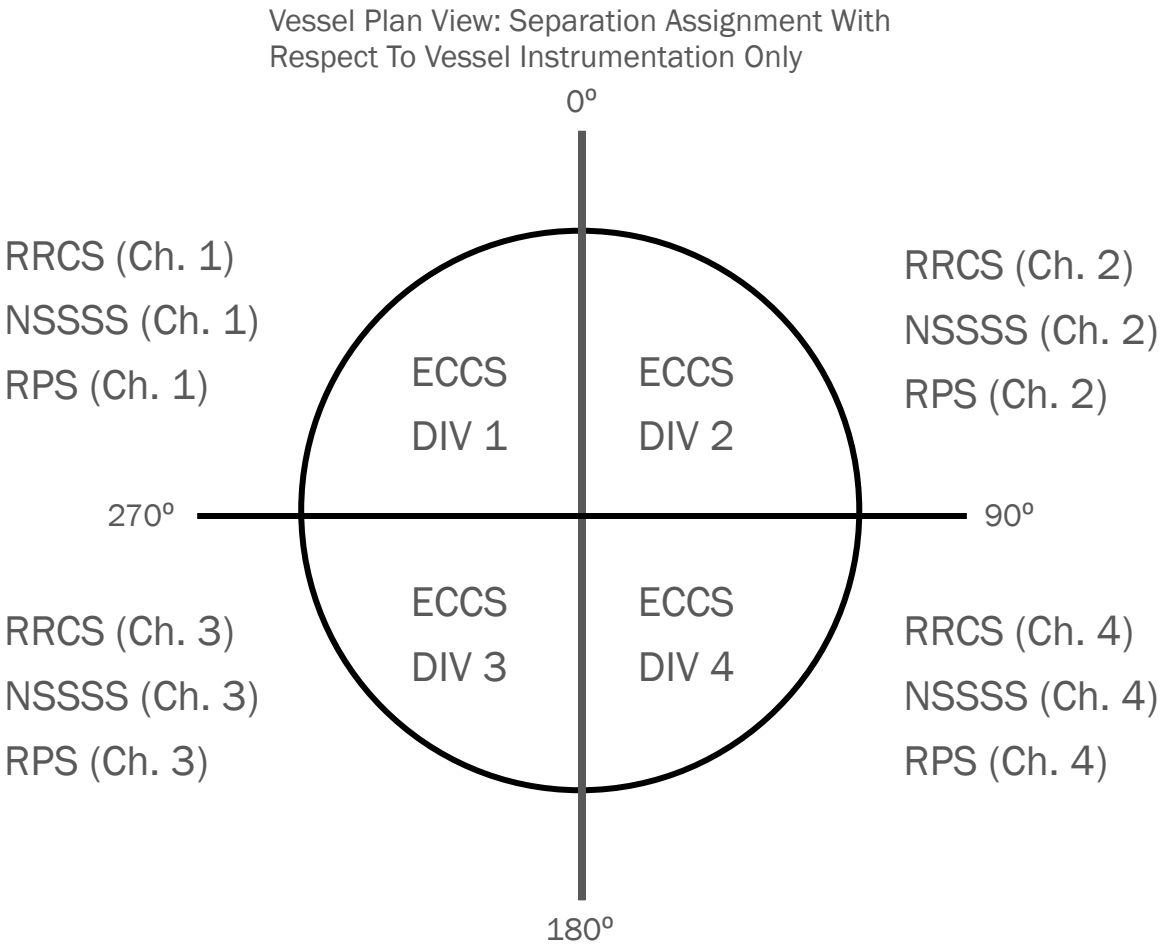
Sensor Reductions – Proposed RWL 2

Proposed Reactor Pressure Vessel Level Instrumetnation for Reactor Water Level 2						
Instrument	Function	Range	Variable Leg Nozzle	Nozzle Height	Reference Leg Nozzle	Nozzle Height
LT-1(2)N081A	NS4, CS(A)/RHR(A)/ADS(A), RCIC, RRCS, Wide Range Indication	WR	N16D	366”	N12D	599”
LT-1(2)N081B	NS4, CS(B)/RHR(B), HPCI, RRCS, Wide Range Indication	WR	N16A	366”	N12A	599”
LT-1(2)N081C	NS4, CS(C)/RHR(C)/ADS(C), RRCS	WR	N16B	366”	N12B	599”
LT-1(2)N081D	NS4, CS(D)/RHR(D), HPCI, RRCS	WR	N16C	366”	N12C	599”
LT-1(2)15A	Wide Range Indication	WR	N16D	366”	N12D	599”
LT-1(2)15B	Wide Range Indication	WR	N16A	366”	N12A	599”

Existing Sensor Assignment



PPS Sensor Assignment



PPS Sensor Failure Impact

Existing Systems	PPS
One out of Two Take Twice Logic Scheme	Two out of Four Logic Scheme
Two Channels could vote to scram while the other two changes do not vote resulting in half scram	All channels provide votes to scram or actuate from bi-stable channels to RPS NSSSS & ECCS - Ensures same scram initiator is required from more than one channel
Existing scram actuation occurs if any single scram initiator occurs in one division combined with any single scram initiator in the other division	Scram will no longer occur if the channels produce different scram initiators

Soft Controls

System Level Actuation Thread (Soft Controls)

a,c

Component Level Actuation Thread (Soft Controls)

a,c

Additional Component Level Actuations

a,c

System and Component Level Actuation (Soft Controls) Safety Display Software Implementation

- Robust software display design in accordance with the SPM for Important To Safety requirements (safety-related).

a,c

System, Component Level Actuation (Soft Controls) Redundancy and Diagnostics

- Fault tolerant design:
  - Redundant Safety Displays

a,c

[ ]

- Diagnostics (Active Monitoring)
  - Continuous monitoring of the Safety Display system software and hardware
  - Continuous monitoring of the AC160 software and hardware modules
  - Continuous monitoring of AF100 communications links
  - Continuous monitoring of HSL communication links

Diversity and Defense in Depth (D3) Approach

CIM Priority Module

Priority Module

a,c

CIM and CCF

a,c

Priority Module – Licensing Precedence

The LAR will also describe the CIM's internal diversity attributes and the licensing precedence of the Wolf Creek MSFIS application that was reviewed and approved by the NRC (ML# 0906103170)

a,c

- Rigorous Design Process
  - Includes Independent Verification and Validation
  - Reviewed by NRC as part of AP1000® PMS

Priority Module – Comparison of Design Features

a,c

- Rigorous Design Process
  - Includes Independent Verification and Validation
  - Reviewed as part of AP1000® PMS

D3 CCF Coping Analysis

Presentation of D3 CCF Coping Examples

- Four D3 CCF coping examples are presented to demonstrate the approach for a D3 CCF Analysis.

- These examples correspond to the following LGS UFSAR Chapter 15 events:

  - Chapter 15.1.4 Inadvertent Main Steam Relief Valve Opening
  - Chapter 15.2.3 Turbine Trip Without Bypass
  - Chapter 15.2.7 Loss of Feedwater
  - Chapter 15.6.5 LOCA Inside Containment

Presentation of D3 CCF Coping Examples (cont.)

a,c

Presentation of D3 CCF Coping Examples (cont.)

a,c

Four Examples of D3 CCF Coping Analysis Breakout

D3 CCF Coping Analysis Assumptions

a,c

Preliminary Summary of Required Diverse Actuations

a,c

Spurious Actuation

Spurious Actuation Due to a CCF

- BTP 7-19: Spurious Actuation is an initiating event

a,c

Spurious Actuation Due to a CCF

a,c

SECY 93-087 Position 4 Controls Discussion

Position 4 Diverse Manual Controls

- Position 4:

  *A set of displays and controls located in the main control room shall be provided for manual, system-level actuation of critical safety functions and monitoring of parameters that support the safety functions. The displays and controls shall be independent and diverse from the safety computer system identified in items 1 and 3 above (*those identified from D3 coping*).*

- SECY-93-0087 identified the following critical safety functions to be managed from the MCR in accordance with Position 4:
  - Reactivity control
  - Core heat removal
  - Reactor coolant inventory
  - Containment isolation
  - Containment integrity

Summary for Position 4 Controls

a,c

Summary of Diverse Containment Isolation (Position 4)

a,c

SECY 93-087 Position 4 Display Discussion

SECY 93-087 Position 4 Displays

Existing LGS Safety Parameter Display System (SPDS) can be credited for SECY-93-087 Position 4 displays:

- SPDS part of the Plant Process Computer (PPC)
- No changes anticipated to SPDS/PPC by the proposed modification
- SPDS meets the BTP 7-19 Position 4 Acceptance Criteria for Displays
- SPDS monitors and indicates the critical safety parameters of reactivity control, reactor core cooling and heat removal from the primary system, reactor coolant system integrity, radioactivity control, and containment conditions
- LAR and LTR will demonstrate SPDS is independent and diverse from the proposed PPS

SECY 93-087 Position 4 Displays (cont'd)

Existing LGS Safety Parameter Display System (SPDS) can be credited for SECY-93-087 Position 4 displays:

- SECY-93-087 Position 4 allows use of non-safety related equipment with adequate reliability and quality
- SPDS reliability established through:
  - Redundant and validated signals
  - On-line failure diagnostics
  - Processor backup
  - Use of quality components
- It will be demonstrated that the SPDS meets the BTP 7-19 Rev. 8 quality requirements
- SPDS designed using human factors engineering principles

Software Design Process for RRCS & DPS

a,c

Software Design Process for RRCS & DPS

Regulatory Guide 1.97 Discussion

Regulatory Guide 1.97 Impacts

- Implemented on safety and non-safety devices (depends on the variable category)
- Impacted variables to be brought into PPS (fully qualified system)
  - PPS is available post-design basis accident (LOCA, SSE, OBE, LOOP, etc.)
- Not all RG 1.97 variables will be brought into PPS – only those on the impacted MCR panels
- Limerick does not credit SPDS for Reg Guide 1.97 information
- Note that all current field sensors will be retained, i.e., no consolidation of RG 1.97 field sensors is planned
- Proposed change impacts display devices only

Next Pre-submittal Meeting

Topic Areas for next Pre-submittal Meeting

- MCR Human-System Interface and Human Factors Engineering
- VOP update
- Project status update
- Diversity and Defense in Depth (continued)
- Follow-up items identified from June 29 meeting

Closing Comments

Acronyms

Acronym	Definition
ADS	Automatic Depressurization System
AER	Auxiliary Equipment Room
AOI	Advant Ovation Interface
ARI	Alternate Rod Injection
ARP	Alternate Review Process
ASAI	Application Specific Action Item
ATWS	Anticipated Transient Without Scram
BPL	Bistable Protection Logic
BWR	Boiling Water Reactor
CAP	Corrective Action Program
CCF	Common Cause Failure
CDO	Central Design Organization
CRDR	Control Room Design Review
CIM	Component Interface Module
CRADA	Cooperative Research and Development Agreement
CPU	Central Processing Unit
CS	Core Spray
D3	Defense-in-Depth and Diversity
DCS	Distributed Control System
DDS	Data Display System
DEHC	Digital Electro-Hydraulic Control
DPS	Diverse Protection System
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EOP	Emergency Operating Procedures
EQSR	Equipment Qualification Summary Report
ESFAS	Emergency Safety Function Actuation System

Acronyms (cont'd)

Acronym	Definition
FMEA	Failure Modes and Effects Analysis
FMEDA	Failure Modes, Diagnostics, and Effects Analysis
FPGA	Field Programmable Gate Array
FSAR	Final Safety Analysis Report
HFE	Human Factors Engineering
HPCI	High Pressure Core Injection
HSL	High Speed Link
IBR	Incorporated by Reference
ILP	Integrated Logic Processor
INL	Idaho National Labs
I/O	Input/Output
ITAAC	Inspection, Test, Analysis, and Acceptance Criteria
LAR	License Amendment Request
LCL	Local Coincidence Logic
LGS	Limerick Generating Station
LOOP	Loss of Offsite Power
LPCI	Low Pressure Coolant Injection
LRA	Licensee Required Action
LTR	Licensing Technical Report
MCR	Main Control Room
MPB	Manual Partial Bypass
MPT	Manual Partial Trip
MSFIS	Main Steam and Feedwater Isolation System
MSIV	Main Steam Isolation Valve
NSR	Nonsafety-related
NSSSS	Nuclear Steam Supply Shutoff System
OBE	Operating basis earthquake
PC	Personal Computer
PMS	Protection and Monitoring System
PPC	Plant Process Computer

Acronyms (cont'd)

Acronym	Definition
PPS	Plant Protection System
PSAI	Plant Specific Action Items
QA	Quality Assurance
QMP	Quality Management Plan
RAI	Request for Additional Information
RCIC	Reactor Core Isolation Cooling
RHR	Residual Heat Removal
RPS	Reactor Protection System
RPV	Reactor Pressure Vessel
RRCS	Redundant Reactivity Control System
RWCU	Reactor Water Cleanup
SER	Safety Evaluation Report
SFMS	Supplier Fundamental Management System
SDC	Shutdown Cooling
SDV	Scram discharge volume
SLCS	Standby Liquid Control System
SPDS	Safety Parameter Display System
SPM	Software Program Manual
SR	Safety-related
SRNC	Safety Remote Node Controller
SRV	Safety Relief Valve
SSE	Safe Shutdown Earthquake
SyDS	System Design Specification
SyRS	System Requirements Specification
TS	Technical Specifications
TU	Trip Unit
UFSAR	Updated Final Safety Analysis Report
VOP	Vendor Oversight Plan
WEC	Westinghouse