

# APR1400 I&C Systems

---

**Safety I&C Licensing Plan**

**Safety I&C Design Features I, II, III**

# Safety I&C Licensing Plan

## Overview

### Safety I&C Licensing Plan

- Digital safety platform
- Platform independent approach

## Technical Issues

## Licensing Submittals

## Summary

# 1 Overview

7<sup>th</sup> Pre-application Review Meeting

# Overview

## I&C Design Features

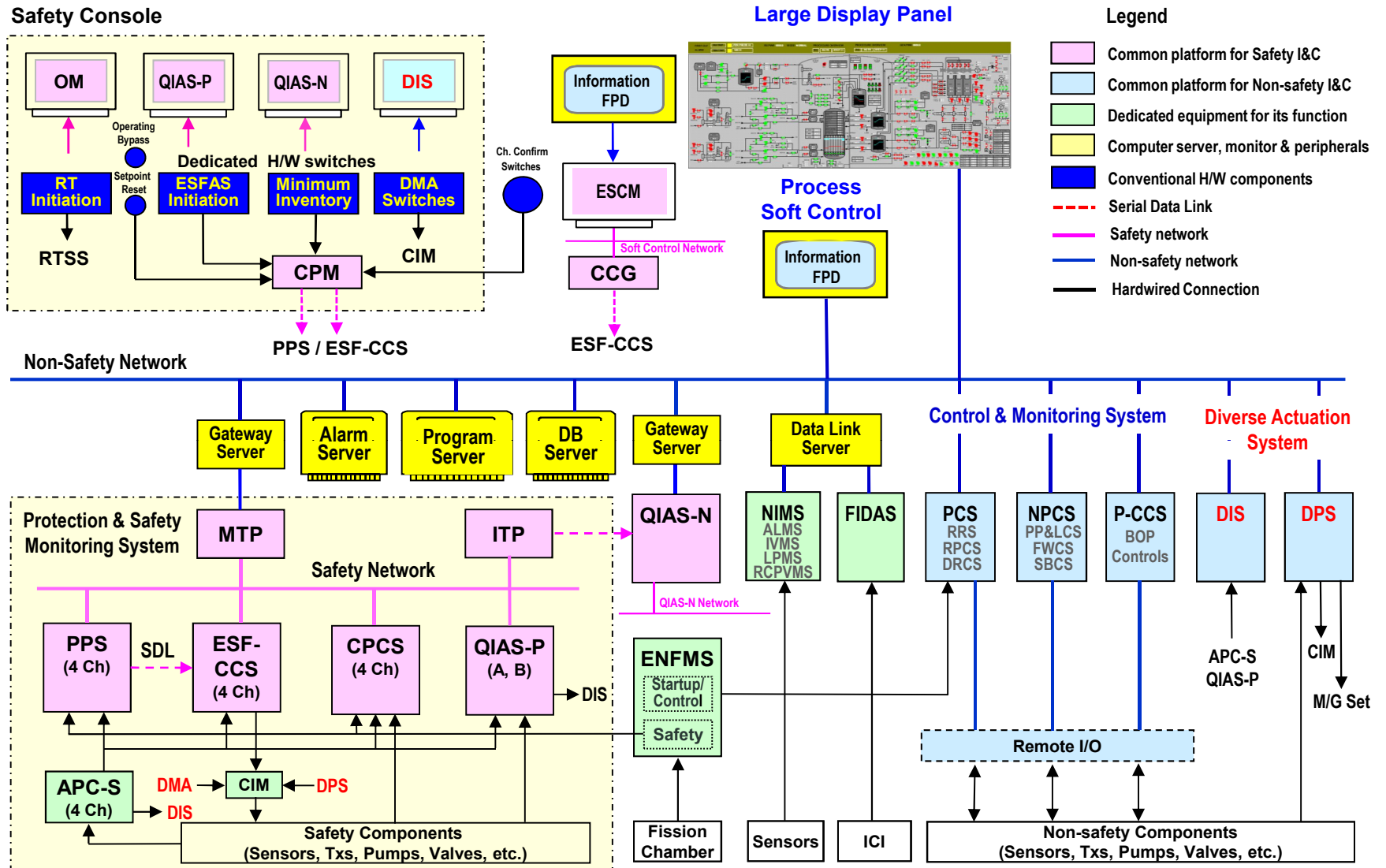
- Safety I&C system uses qualified PLC platform
- Non-safety I&C system uses DCS platform
- Four channel redundancy for safety I&C system except QIAS-P(A/B)
  - Installed in physically separated I&C equipment rooms
- Electrical isolation, physical separation and communication independence
  - Between redundant safety channels
  - Between safety system and non-safety system
- Diversity to cope with the CCF of digital safety I&C system
  - Diverse Protection System
  - Diverse Indication System
  - Diverse Manual ESF Actuation (DMA) Switches

# Overview

## I&C Systems

- Protection & Safety Monitoring System
  - PPS, ESF-CCS, CPCS, QIAS-P
- Control & Monitoring System
  - QIAS-N
  - PCS, NPCS, P-CCS
- Diverse Actuation System
  - DPS, DIS, DMA SW
- Dedicated System
  - ENFMS, APC, NIMS, CIM
- Human-System Interface System
  - MCR, RSR
- Data Communication Network
  - Safety network and serial data link
  - Non-safety network

# Overall I&C Architecture



APC-S : Auxiliary Process Cabinet – Safety, CIM : Component Interface Module, CPCS : Core Protection Calculator System, DIS : Diverse Indication System, DMA : Diverse Manual ESF Actuation, DPS : Diverse Protection System, ENFMS : Ex-core Neutron Flux Monitoring System, ESCM : ESF-CCS Soft Control Module, FIDAS : Fixed In-core Detector Amplifier System, ICI : In-Core Instrumentation, NIMS : NSSS Integrity Monitoring System, NPCS : NSSS Process Control System, OM : Operator Module, P-CCS : Process Component Control System, PCS : Power Control System, QIAS-P/N : Qualified Indication & Alarm System - PAMI / Non-safety

## 2 Safety I&C Licensing Plan

7<sup>th</sup> Pre-application Review Meeting

# Safety I&C Licensing Plan

## I&C Platform History

Systems Plants	Reactor Trip System	ESFAS Systems	Protection Process	NSSS Control	PCS	TBN Control	Main Control
Kori 1	Relay Logic (WEC)	Relay Logic (WEC)	Foxboro H-line	Foxboro H-line	Foxboro H-line	DCS	Conventional
Kori 1 (Upgrade)	Relay Logic (WEC)	Relay Logic (WEC)	Spec200 Spec200m (Foxboro)	Spec200 Spec200m (Foxboro)	Spec200 Spec200m (Foxboro)	DCS	Conventional
Kori 2,3,4 YGN 1,2	SSPS Relay Logic (WEC)	SSPS Relay Logic (WEC)	7300 Analog	7300 Analog	7300 Analog	Mark V (GE)	Conventional
YGN 3,4	Relay Logic (ABB-CE)	Relay Logic (ABB-CE)	Spec200 (Foxboro)	Spec200 Spec200m (Foxboro)	ILS (Forney)	Mark V (GE)	Conventional
Ulchin 3,4 YGN 5,6	Relay Logic (ABB-CE)	Relay Logic (ABB-CE)	Spec200 (Foxboro)	Spec200m/PLC (Foxboro)(Omron)	PCS (Eaton)	Mark V (GE)	Hybrid
Wolsong 1,2,3,4	Relay Logic (AECL)	Relay Logic (AECL)	Analog/PDC (AECL)	DCC X/Y (Computers Control)	Analog/Relay (AECL)	Mark V (GE)	Hybrid
Ulchin 5,6	PLC (WEC)	PLC (WEC)	Spec200 (Foxboro)	PLC (Omron)	AFS100/ECS1200 (HFC)	Mark V (GE)	Hybrid
Shin Kori 1,2 Shin Wolsong 1,2	PLC (WEC)	PLC (WEC)	Spec200 (Foxboro)	PLC (Omron)	HFC6000 (HFC)	Mark VI (GE)	Hybrid
Shin Kori 3,4 (APR1400)	PLC (WEC)	PLC (WEC)	PLC (WEC)	DCS (WEC)	DCS (WEC)	Mark VI (GE)	Compact Workstation
Shin Ulchin 1,2 (APR1400)	PLC (DOOSAN)	PLC (DOOSAN)	PLC (DOOSAN)	DCS (DOOSAN)	DCS (DOOSAN)	Mark VI (GE)	Compact Workstation

# Safety I&C Licensing Plan

## Digital Safety Platform (1/5)

- Ten APR1400 NPPs are under construction
  - Six units in KOREA
  - Four units in UAE
- Two digital safety platforms
  - Common Q<sup>TM</sup> (WEC) for SKN 3&4 and BNPP 1,2,3&4
  - POSAFE-Q<sup>TM</sup> (DOOSAN) for SUN 1&2 and SKN 5&6
- APR1400 I&C licensing plan
  - DC stage : Platform independent approach
  - COL stage : Selection of specific platform

# Safety I&C Licensing Plan

## Digital Safety Platform (2/5)

Plant	Platform	Remarks
SKN 3&4	Common Q (WEC)	Cold Hydro Test: '12. 5 Fuel Loading: '13. 1
BNPP 1,2,3&4	Common Q (WEC)	Completion: 2017/20
SUN 1&2 SKN 5&6	POSAFE-Q (DOOSAN)	Localized and qualified safety digital platform
APR1400 DC	Platform Independent	Specific platform at COL stage

# Safety I&C Licensing Plan

## Digital Safety Platform (3/5)

- Two Compatible Safety Platforms (PLC)



Common Q  
(WEC)

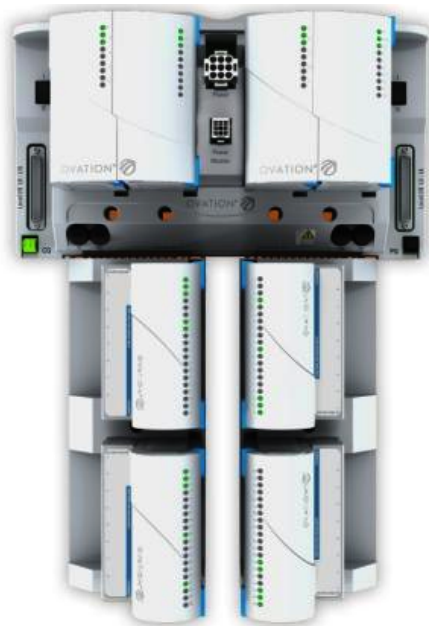


POSAFE-Q  
(DOOSAN)

# Safety I&C Licensing Plan

## Digital Safety Platform (4/5)

- Two Compatible Non-Safety Platforms (DCS)



**OVATION™**  
(Emerson)



**OPERA™**  
(DOOSAN)

# Safety I&C Licensing Plan

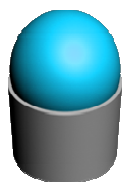
## Digital Safety Platform (5/5)

- MMIS Integrated Performance Test Facility



# Safety I&C Licensing Plan

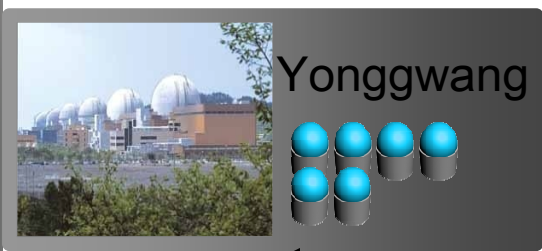
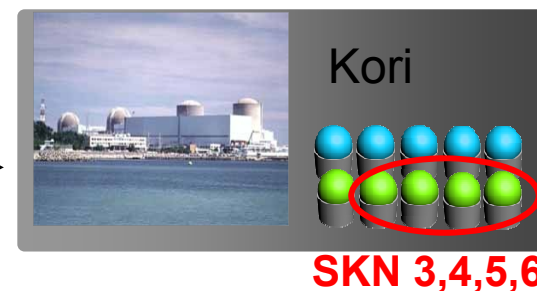
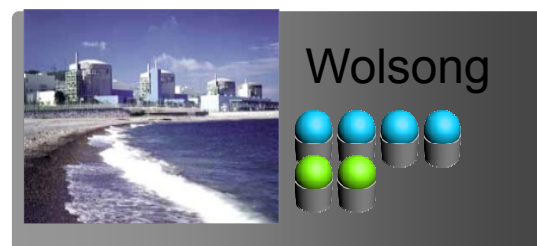
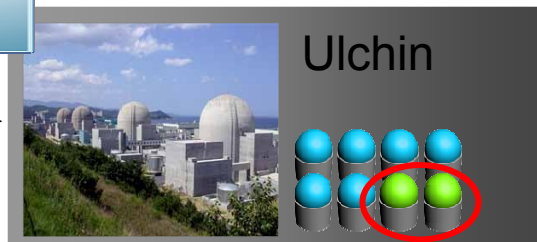
## Status of NPPs in Korea



In operation  
21 units  
(18,716 MW)



Under construction  
3 OPR1000  
**6 APR1400**  
(11,400 MW)



# Safety I&C Licensing Plan

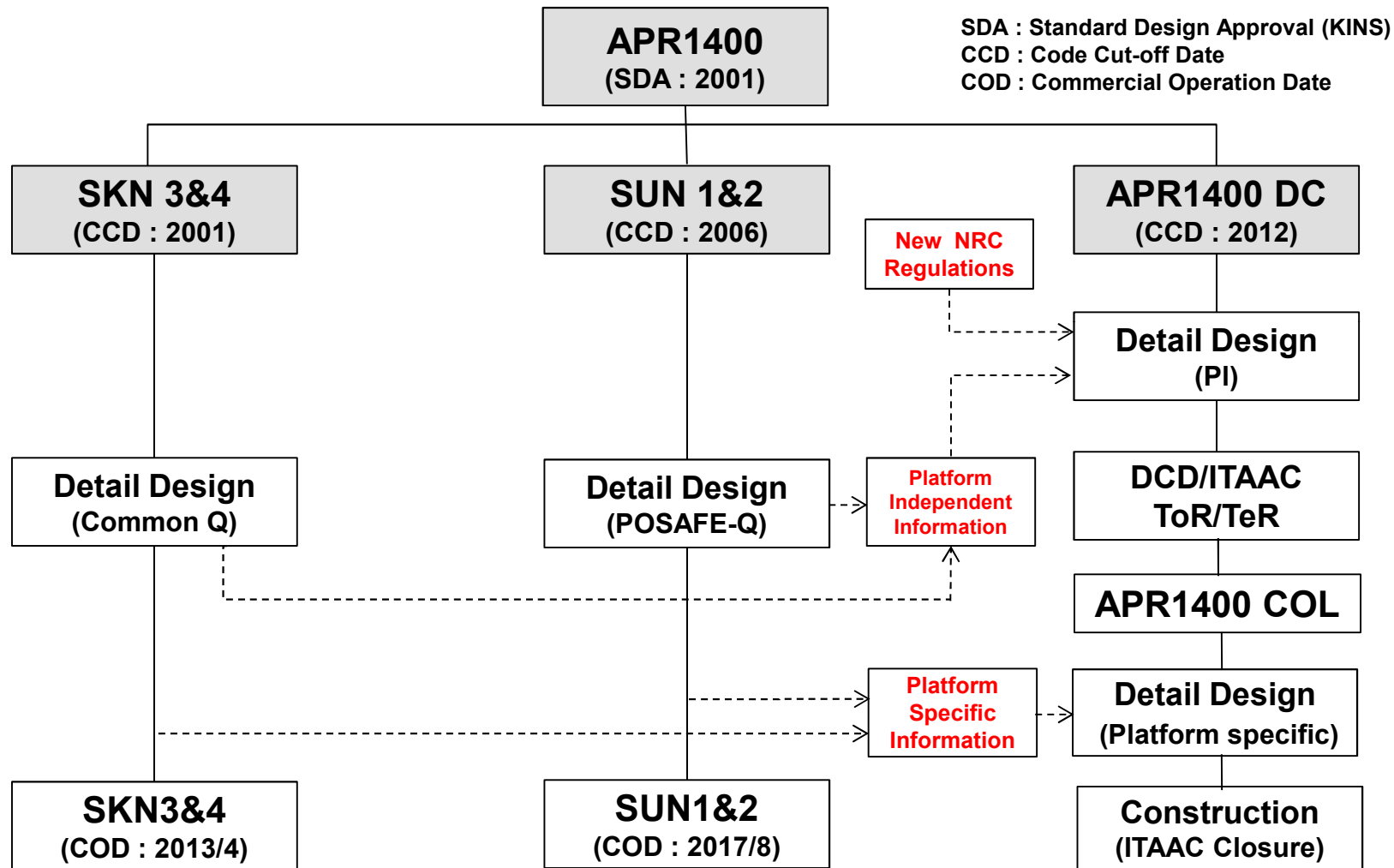
## Platform Independent approach

- APR1400 DC Approach

- Two compatible platforms (Common Q / POSAFE-Q)
- MMIS detail design implemented on both platforms
- Platform independent information in DCD Tier1 and ToR
- Design information common to both platforms in DCD Tier2 and TeR
- Adequate architecture and system level design details in DCD
- Specific platform to be decided at COL stage
- Detail designs (SKN 3&4 and SUN 1&2) to be provided for NRC information and review
- Platform specific detailed design information to be provided later during ITAAC closure

# Safety I&C Licensing Plan

## Platform Independent (PI) approach (Process)



# Safety I&C Licensing Plan

## Platform Independent approach (ITAAC)

System	Design Area	DC Phase
Safety System - RPS - ESF-CCS - CPCS - QIAS-P - Data Comm.	System Description	DD & ToR
	Design Bases	DD & ToR
	Functional Design	DD & ToR
	Software Program Manual	DD & TeR
	Application Software	ITAAC
	Set-point Calculations	ITAAC
	Reliability Analysis	ITAAC
HSI System - Safety HSI - HFE Process	System Description	DD & TeR
	Design Bases	DD & TeR
	HFE Design Process	DD & TeR
	Detail Display Design	ITAAC
Defense-in-Depth and Diversity		DD & ToR

[Note] DD: Detail Design, ToR: Topical Report, TeR: Technical Report

# Safety I&C Licensing Plan

## Platform Independent approach (ITAAC)

System	Design Area	DC Phase
Digital Platform for Safety System	Hardware component detail design <ul style="list-style-type: none"> <li>• Response time</li> <li>• Uncertainty</li> <li>• Deterministic communication</li> <li>• Capacity, reliability and data precision of data communications</li> </ul>	ITAAC
	Data communication independence	ITAAC
	Equipment qualification	ITAAC
	Commercial grade dedication	ITAAC

Platform will be selected at COL stage and platform specific ITAAC will be closed during construction.

### 3 Technical Issues

- Diversity and Defense-in-Depth (ISG-02)
- Augmented Quality Plan
- AMI Parameter (RG 1.97 rev.4)

# Technical Issues

## Diversity and Defense-in-Depth (ISG-02)

- Regulatory guidance (ISG-02) and APR1400 compliances
  - Adequate diversity (diverse backups)
    - Backup DAS (DPS+DIS+DMA Switches) with sufficient quality
  - Manual operator actions incl. action times
    - Analysis of manual operator actions (ISG-05)
  - BTP 7-19 position 4 challenges (displays and control)
    - System level diverse manual ESF actuation switches (7 switches)
  - Effects of CCF (failure to actuation and spurious actuation)
    - Analysis of spurious partial ESFAS actuations (RTS not concerned)  
and prevention of DAS spurious actuation

# Technical Issues

## Diversity and Defense-in-Depth (ISG-02)

- Regulatory guidance (ISG-02) and APR1400 compliances
  - CCF applicability (diversity and testability)
    - Sufficiently diverse DAS by D3 analysis
  - Four echelon of defense
    - D3 analysis with total CCF of integrated RPS and ESFAS
  - Single failure not applicable to digital system CCF
    - Best-estimate technique for D3 coping analysis
- APR1400 MMIS diversity design features

# Diversity Design Feature

PPS : DPS

QIAS-P : DIS

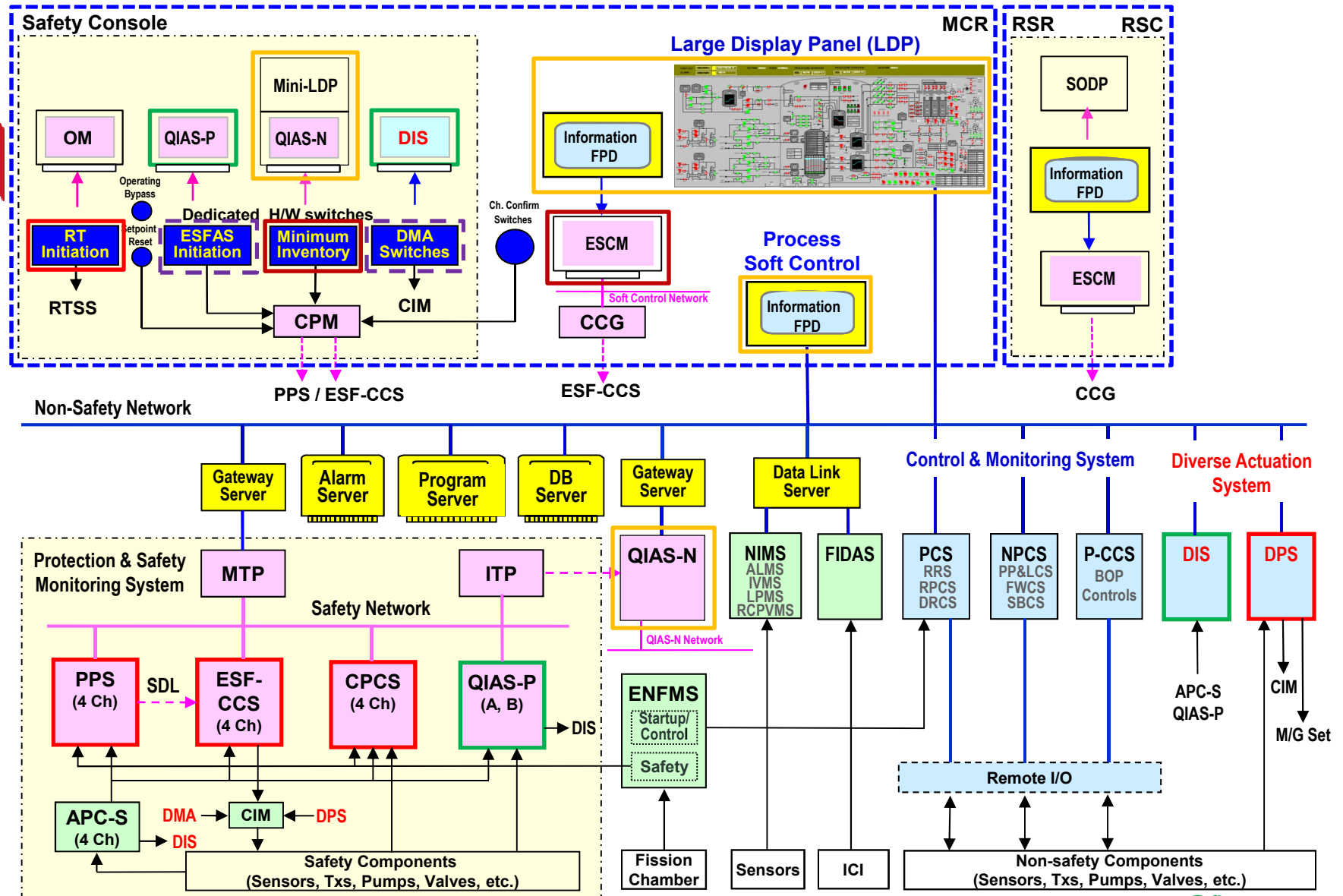
ESFAS : DMA

ESCM : MI

IPS : QIAS-N

MCR : RSR

ESCM : ESF-CCS Soft Control Module  
IPS : Information Processing System  
RSR : Remote Shutdown Room  
SODP : Shutdown Overview Display Panel



7<sup>th</sup> Pre-application Review Meeting

# Technical Issues

## Augmented Quality Plan

- Regulatory Requirements (GL 85-06)
  - Less stringent QA guidance compared to safety-related equipment
  - Guidance comparing with 10 CFR 50 Appendix B
- APR1400 Design
  - Augmented quality class : A
  - Augmented S/W classification : ITS (Important to Safety)
  - Seismic and Environmental Qualification
  - Automatic testing during power operation
- Compliance
  - Augmented quality system complied to GL 85-06

# Technical Issues

## Augmented Quality Plan (DAS)

Classification	Augmented Quality Plan	DPS	DIS	DMA SW.	Available control systems assumed in D3 analysis
Quality Class	A	A	A	Q	A
Safety Class	Non-safety	Non-safety	Non-safety	Safety	Non-safety
Software Class	ITS	ITS	ITS	-	ITA
Environmental Qualification	Yes	Yes	Yes	Yes	-
Seismic Category	II	II	II	I	-
EMI/EMC	Yes	Yes	Yes	-	-
Electric Class (Power Source)	Non-Class 1E	Non-Class 1E	Non-Class 1E	Class 1E	Non-Class 1E

# Technical Issues

## AMI Parameter (RG1.97)

- Regulatory Requirement (IEEE 497-2002 endorsed by RG1.97, rev.4)
  - Type A : Primary information for manual actions to perform safety function as assumed in the safety analysis (DBE)
  - Type B : Primary information to assess critical safety functions
  - Type C : Primary information to indicate the potential for breach
  - Type D : Indicates the performance of safety systems for mitigation of DBE and other systems to achieve safe shutdown
  - Type E : Used for determining the magnitude of the release of radioactive materials and assessing such releases

# Technical Issues

## AMI Parameter (RG1.97)

### ● APR1400 Design

#### – Type A variables

- Variables defined for operator actions by DBE and BDBE analysis
- No event requires operator actions within 30 minutes after DBEs
- Some events require operator actions after 30 minutes

#### – Type B, C, D and E variables

- Variables defined by analyzing Functional Recovery Guideline and Emergency Operation Guideline

### ● Compliance

- AMI parameters are selected in accordance with RG 1.97, rev.4

# Technical Issues

## AMI Parameter (RG1.97)

- Basis for Type A variables

Parameter	DBE	Beyond DBE	Required Manual Action
PZR Pressure	LOCA SGTR		RCP Stop SI Isolation
PZR Level	SGTR		SI Isolation
Hot Leg Temp.	SGTR		SI Isolation
Cold Leg Temp.		TLOFW	POSRV Open
SG Pressure	SLB/FLB SGTR		SG Identification/Heat Removal Heat Removal
SG Level	SLB/FLB SGTR	TLOFW MSGTR	SG Identification SG Isolation POSRV Open SG Blow down

## 4 Licensing Submittals

7<sup>th</sup> Pre-application Review Meeting

# Licensing Submittals

## Safety I&C system related documentation

- DCD Tier 1
  - Design description
  - ITAAC
- DCD Tier 2
  - Chapter 7 of FSAR
- Topical Report (ToR)
  - Safety I&C
  - Diversity and defense-in-depth (D3) analysis
- Technical Report (TeR)
  - Software program manual
  - Uncertainty and set-point methodology
  - D3 coping analysis

## 5 Summary

# Summary

- APR1400 has two safety I&C platforms
  - WEC Common Q for SKN 3&4 and BNPP 1,2,3&4
  - DOOSAN POSAFE-Q for SUN 1&2 and SKN 5&6
- Platform independent approach
  - Platform independent information from SKN 3&4 and SUN 1&2
  - Platform specific detail designs to be provided
- ITAAC items for safety I&C system
  - Digital safety I&C platform
  - Platform specific MMIS detail designs incl. application software
  - HSI Detail display design
- Three technical issues presented
- Two ToRs and three TeRs to be submitted with DCD