Table of Contents

1. Nuclear I&C Business
2. Development of MMIS
   1) MMIS Prototype Facility
   2) Multistage Tests
   3) Evaluation of MMIS Localization
   4) IAEA Review
3. Features of DOOSAN’s Rod Control System
4. Cyber Security
5. LDP Application
6. FPGA Application for NPP
7. Response to Fukushima disaster
8. Recommendation
1. Nuclear I&C Business

Plant in operation & construction in Korea
DOOSAN has an integrated manufacturing facility which is capable of raw material production to final assembly of components for Power Plants in Changwon, Korea.

**Total Area**: 1,100 acres

**Floor Space**: 137 acres
Nuclear I&C Business

- **New NPP**
  - SUN 1,2 Contract /MMIS: 2009/07
  - BNPP 1,2,3,4 Inverter System / MG Set / RTSS Supply Contract: 2010
  - SKN 5,6 Contract /MMIS: (2013)
  - SUN 3,4 Contract /MMIS: (2014)

- **Modernization**
  - CRCS/DRCS/CEDMCS modernization for all Korean NPP
    - KRN 1,2: 2010/06
    - YGN 3 CRCS Modernization: 2011/03
    - YGN 4 CRCS Modernization: 2012/04
    - UCN 1 DRCS Modernization: 2011/12
    - UCN 2 DRCS Modernization: 2011/06
    - YGN 5,6 / UCN 3,4,5,6 (OPR1000) CEDMCS Modernization: 2011/06
    - SKN 1,2 (OPR1000) CEDMCS Modernization: (2015)
    - SWN 1,2 (OPR1000) CEDMCS Modernization: (2015)
    - KRN 3,4 / YGN 1,2 CRCS Modernization: (2014)
  - Digitalized MMIS modernization
    - Preparing modernization for all Korean NPP in operation
  - ASTS
    - Complete for all Korean NPP in operation (20 Units)
    - Construction (SKN 1,2,3,4 / SWN 1,2)

ASTS: Automatic Seismic Trip System, CEDMCS: Control Element Drive Mechanism Control System
OL4 Proposal

- Reflecting the Finnish Licensing and Technical issues.
- New technical issues identified during LFS (Licensing Feasibility Study) are being resolved and the design completeness are enhanced
- Korea Consortium led by KHNP proposed APR1400 in Korea
- Expected formal application for a construction license be in mid-2015
- Technical and Commercial evaluation for potential bidder is proceeding
MMIS Development

1) MMIS Prototype Facility
2) Multistage Tests
3) Evaluation of MMIS Localization
4) IAEA Review
MMIS Prototype Facility

- MMIS Prototype Configuration for Design verification and Performance Test
  - APR1400 code simulator, Plant Control System, Safety systems, MCR(Main Control Room) including LDP(Large Display Panel) and network equipment
Multistage Test

◆ Performance verification program
  - Define test steps and execution for compatibility
  - Execute long term operation to ensure reliability and operating history

Test Object: 11 systems including PPS
- System Test; Functional test for each system
- Interface Test; Verification of interface status between each system and simulator
- Performance Test; Verification of interface function and performance between systems

Integration Test
- Integration Test
  - Verification of MMIS integrated performance
  - Network Load, Response Time test / MMI, Alarm Test, etc.
- Operation Test
  - Load Rejection Test
  - Unit Load Transient Test
  - Load Cycle Test
  - Reactor Power Cutback System Test
  - FWCS Valve Transfer Test

Long-Term Operation
- Multi-failure test for PS, Network, ITP, CPU
- Reliability test for functional modules
- System Reliability test for redundant architecture
- Component control function reliability with single failure

Test Step & Type
- Large Scale Integration ('08.05~'08.10E)
- Small Scale Integration ('07.7~'07.10E)
- System Test (PLC/DCS)
- Final Test ('09.02~'09.06E)
- Long Term Reliability Operation Test ('09.08~'10.06E)

System Test
- RPS
- PCS
- NIMS
- RCOPS
- ESP-CCS
- NPCS
- DIS
- IPS
- P-CCS
- QIAS-P
- QIAS-N
Evaluation of Applicability

◆ Evaluation process with customer and system designer
◆ KHNP and KEPCO E&C experts involved in the effort of technical evaluation and incorporated its review results

<table>
<thead>
<tr>
<th>Evaluation Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localization Council (Government, KHNP)</td>
</tr>
<tr>
<td>Schedule</td>
</tr>
<tr>
<td>2007.06.11 ~ 2008.11.21</td>
</tr>
</tbody>
</table>

| Evaluation of business application for SUN12 PJT (KHNP, KEPCO) |
| Schedule | Feature |
| 2008.10.01 ~ 2008.11.28 | • Evaluate of Localization activities<br>• Technical/Quality Assessment<br>• Confirmation of action items<br>• Confirmation of reliability, process of implementation and verification of each systems and network communication of PLC/DCS |

| IAEA Technical Review (IAEA, KHNP) |
| Schedule | Feature |
| 2010.02.01 ~ 2010.02.06 | • Compatibility for Design/Manufacture in compliance with IAEA Safety Guide<br>• Evaluate on the methodology and result of Integrated Test of MMIS prototype<br>• GP(Good Practice) selection |
IAEA Review

- Technical completeness of digitalized MMIS
- Self confidence on reliability and safety of MMIS
- Large scale stimulated digital MMIS prototype and more than 3 years operation and verification efforts were recognized

<table>
<thead>
<tr>
<th>No.</th>
<th>Good Practice List</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Third party review throughout lifecycle</td>
</tr>
<tr>
<td>2</td>
<td>Diversity of actuation signal path in Component Interface Module</td>
</tr>
<tr>
<td>3</td>
<td>Use of an Integrated Performance Validation Facility</td>
</tr>
<tr>
<td>4</td>
<td>Use of a Computerized Software Tool to generate the Requirements Traceability Matrix (RTM)</td>
</tr>
<tr>
<td>5</td>
<td>Redundancy of control rod control system to minimize potential for SPV</td>
</tr>
<tr>
<td>6</td>
<td>Certification of Safety Qualified Platform</td>
</tr>
<tr>
<td>7</td>
<td>Development Process for Programmable Logic Devices</td>
</tr>
<tr>
<td>8</td>
<td>Fault tolerant PPS structure of 2 BP and 3 CP</td>
</tr>
</tbody>
</table>
DOOSAN’s Rod Control System

**KRN, UCN, YGN CRCS Replacement**

- CRCS is designed for driving 3-coil type CRDM in a nuclear power plant. The CRCS controls the rod motion by driving CRDM in response to signals from the MCR and the RCS (Reactor Control System).

- CEDMCS is designed for driving 4-coil type CEDM in a nuclear power plant. The CEMDCS controls the rod motion (withdrawal, insertion or hold) by driving CEDM in response to signals from the
DOOSAN’s Rod Control System

◆ Existing CEDMCS/CRCS
  - Analog and old-fashioned design with obsolete components
  - A large numbers of SPV components
  - Difficult on-line maintenance by big drawer type and wall-mounted power module design
  - Needs for additional diagnostic facilities to keep the system healthy

Old type CEDMCS for 4-coil:
Big drawer type power module/WEC System

Old type CRCS for 3-coil:
Wall mount type power module/Areva/Framatom
DOOSAN’s Rod Control System

- Design Improvement of CEDMCS

  - Modernization Scope: Power Cabinet, Logic Cabinet, Aux Cabinet & MCB Equipment (OM, CEAP, RPCCP)

Modernization Scope
- PSA
- SCR
- Fuse
- Electronic circuit

Logic/Aux Cabinet
- Operator Module
- Logic Card Cage: Consist with ACTM, electronic card and filter panel

Core MIMIC DISPLAY

Replacement
- MG-Set #1
  - 240V/139V
  - Reactor Trip Switch Gear
- MG-Set #2
- Power Switch Cabinets C1 C2 C3
- Aux Cabinets C5 C6
- Operator Module
- CEA Position Display
- RPCCP
- Core MIMIC Display panel
- Main Control Board
- CEDM
- RSPT
- UEL, LEL, DRC

Re-Use
- Drive Coil
- RSPT
- MG-Set

CEA
DOOSAN’s Rod Control System

◆ CEDMCS Installation

- CEDMCS consists of three (3) Logic Cabinets for communication with MCB, ten (10) Power Switch Cabinets for control of CEDM, two (2) Aux Cabinets for monitoring of RSPT and one (1) DC Hold Cabinet for prevention of inadvertent trip.
DOOSAN’s Rod Control System

- Design improvement of CEDMCS/CRCS
  - State-of-the-art Design using redundancy scheme
  - Fault-tolerant Design by SPV Analysis (Zero SPV design)
  - Improvement of the rod drop protection using automatic DC hold and Double hold function
  - Improvement of on-line maintainability
  - Self-diagnostic Features

- Renovation of YGN unit 3 & 4 (4-coil type CEDMCS/WEC)
- Renovation of UCN unit 1 & 2 (3-coil type DRCS/Areva/Framatom)
- Renovation of KRN unit 1 & 2 (3-coil type CRCS)

- Retrofitting for operating NPP
  - Removal & Installation
  - Testing & Start-up Operation

- Enhancement of the Reliability
  - CEDM Mock-up & R-L Load for Test
  - I/O Simulator for Test

- Enhancement of the Maintainability
  - Easy Replacement of modules
  - MMI for Maintenance
DOOSAN’s Rod Control System

◆ Design Feature of CEDMCS (Controller)

**Obsolescence CEDMCS**
- Old-Mixed with analog and digital
- Partially redundant architecture
- Complex architecture due to hard-wired signal communication
- Weakness of diagnostic function

**Brand-new CEDMCS**
- Advanced fully digitalized controller (State-of-Art)
- Fully redundant architecture (Hot Swap applicable)
- Easy maintenance with network communication with MTP including on-line maintenance
- Enhance self-diagnostic capability
DOOSAN’s Rod Control System

◆ Design Feature of CEDMCS (Circuit)

**Obsolescence CEDMCS**

- Inadvertent trip
- Difficulty for maintenance due to complex architecture with vertical arrangement of components
- Gating power from MG-Set
- Open loop voltage control with periodic calibration
- Difficult maintenance due to heavy PSA

**Brand-new CEDMCS**

- No CGHV(Continuous Gripper High Voltage) using monitoring algorithm and redundant zero detection
- EMI Improvement/No logic card in PCM
- DC gating power
- Closed loop current control with protection circuit
- Easy replacement with light weight of PCM
Cyber Security

◆ Applicable Regulations


◆ Applicable coverage

➢ Monitoring and control system which performs safety function

➢ Digitalized equipment for development, test and analysis of safety system

➢ Cyber threat analysis to ensure that it has no impact for safety function
LDP Application

◆ Design Feature

- Monitoring the status of NPP for plant operation in MCR (Main Control Room)
- Multi-Screen (4x2) for Fixed Display Section to enhance the visibility of operator
- Seamless screen Fixed Display Section to prevent identification error of operator
- Color, Brightness, Contrast, Anti-glare spec in accordance with HFE (Human Factor Engineering) guide line
- Seismic Category II (IEEE 344)
- Seismic requirements for the operator's safety due to the missile impact by LDP screen (Reg Guide 1.29)
LDP Application

◆ Design Improvement
  ➢ Customized Design for severe seismic requirement
  ➢ Enhance maintenance ability

1. Screen Improvement
  ➢ Screen bracket changed with screen guard
  ➢ Easy replacement of the screen

2. Slide Mounting Type Screen
  ➢ Prevent cracking the screen
  ➢ Maintenance ability
  ➢ Easy replacement during operation
LDP Application

◆ Seismic Qualification
  ➢ Passed SUN1,2 FRS(5 OBE, 1 SSE)

◆ Implication
  ➢ Continuous design improvement is needed
  ➢ Reflecting advanced technology of display, regulation requirement to be specific in detail.
FPGA application for NPP

- FPGA Controller developed by DOOSAN
  - Simple circuit configuration
  - Fast calculation due to parallel architecture
  - Flexibility for design environment
  - Easy V&V for the application software due to absence of operating system
### Response to Fukushima Event

#### Description

<table>
<thead>
<tr>
<th>Safety philosophy</th>
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<tbody>
<tr>
<td>- DID strategy enhancement</td>
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<tr>
<td>- Independence of licensing body with specialty</td>
</tr>
<tr>
<td>- Safety design philosophy preventing severe accident</td>
</tr>
<tr>
<td>- design basis for natural disaster</td>
</tr>
<tr>
<td>- diversity and reliability</td>
</tr>
<tr>
<td>- Public acceptability regardless with safe design (analyzed value)</td>
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<table>
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<tr>
<th>Severe accident Ability &amp; Emergency Response System</th>
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<tbody>
<tr>
<td>- Enhance the realistic ability to cope with severe accident</td>
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<tr>
<td>- Various severe accident scenarios, including improvement of procedures</td>
</tr>
<tr>
<td>- Reinforce the monitoring system such as instruments to cope with</td>
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<tr>
<td>- Enhancing communication system for accident of NPP</td>
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<thead>
<tr>
<th>Nuclear safety foundation</th>
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<tbody>
<tr>
<td>- Constitution of safety culture and independent assessment.</td>
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<tr>
<td>- Enhancing safety Research and Development</td>
</tr>
<tr>
<td>- Promote understanding with sharing of the results</td>
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<tr>
<th>IAEA TM on AMS (Accident Monitoring System)</th>
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<tbody>
<tr>
<td>- Period : May 6-9, 2013</td>
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<tr>
<td>- Place : Doosan Heavy Industries &amp; Construction Co. Nuclear I&amp;C H/Q</td>
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<tr>
<td>- Sharing about best practices &amp; strategies of Accident Management</td>
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<tr>
<td>- Discuss about Operating experience, Knowledge, Practices, Design, Implementation and Issue &amp; the challenges of Accident Monitoring Systems</td>
</tr>
</tbody>
</table>
Recommendation

◆ Digitalized MMIS for NPP with safety, reliability and maintenance ability

◆ Modernization of NPP with digitalized MMIS
  - Based on unification design of PLC/DCS Platform, fully digitalized MMIS system replacement is recommended.
  - Considering overhaul schedule and limited installation period, the scale of target systems should be selected at each phase in detail.
  - Integrated MMIS prototype facility could be used.

◆ Licensing requirements for cyber security
  - Technical standard and strict requirement for cyber security including penetration test is essential for PJT execution in advance.

◆ Seismic requirements for LDP
  - Operator’s safety coverage during seismic event
  - Just falling down of LDP screen not be considered as missile hazard behavior

◆ 3rd party controller for NPP using FPGA platform
  - Practice for Verification method for the commercial tool for FPGA logic transplant should be shared
  - Fault detection and self-diagnostic method suited for the FPGA platform should be shared also