Constructing an I&C Upgrade Architecture for Korea Standard Nuclear Power Plants

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1. Introduction

We are motivated to study an upgrade of I&C systems for Korea standard nuclear power plants (KSNPs) whose I&C systems will be faced with a significant problem in maintaining the systems due to obsolescence of I&C equipment. YGN Units 3,4,5,6 and UCN Units 3,4,5,6 are called KSNP or optimized power reactor (OPR) 1000. YGN Unit 3 (YGN-3 in short) I&C systems and cabinets were analyzed in previous study [1]. From the study, it was analyzed that so many hardwires were used to transfer signals between the cabinets even though many of the systems are implemented with digitalized systems. We used the analysis results of YGN-3 I&C systems and cabinets for studying the upgrade. We established a goal for the upgrade such that digital platform-based technology should be employed to integrate the I&C systems and cabinets. Nowadays, the digital technology is advanced such as distributed control system (DCS), programmable logic controller (PLC), field programmable gate array (FPGA), etc. The technology has brought an advantage of integrating many functions into a computer or a chip so economic merits in upgrading old systems with new technology are achievable. In order to perform the study and achieve the merits, the following procedures were taken into account: (1) Selecting the digital technology for the upgrade, (2) Grouping the existing systems based on analyzing functions and signal interfaces of each system, (3) Collecting user requirements and field constraints, and (4) Employing safety and performance requirements. This paper is to present an I&C upgrade architecture for the KSNP using the analysis results of YGN-3 I&C and reflecting the above considerations.

2. Constructing the I&C Upgrade Architecture

The safety I&C systems can be designed with nuclear qualified PLCs and the non-safety I&C systems can be integrated with advantageous features of the DCS. We established a goal such that the safety I&C systems of the KSNP are upgraded with the PLC-based platform and non-safety systems with the DCS-based platform. We selected the existing safety systems to be upgraded with the PLCs as follows: NSSS PPC (NSSS Process Protective Cabinets) and BOP IC(1E) (BOP Safety Instrumentation Cabinets) are upgraded as SPIS (Safety Process Instrumentation System), PPS (Plant Protection System) is upgraded as PPS, CPCS (Core Protection Calculation System) as CPCS, ESFAS ARC (Engineered Safety Feature Actuation System Auxiliary Relay Cabinet) and ILS(1E) (Safety Interposing Logic System) are upgraded as SCCS (Safety Component Control System), and ICCMS (Inadequate Core Cooling Monitoring System), Fixed In-core Detector Amplification System (FIDAS) and PAM (Post-Accident Monitoring) are upgraded as SIAS (Safety Indication and Alarm System). Although the FIDAS is not a safety related system, it is a safety associated system because the in-core detector signal cables are assembled with core exit thermocouple temperature signal cables which are safety signals. We selected the existing non-safety systems to be upgraded with the DCS as follows: NSSS PCC (NSSS Process Control Cabinets) and BOP IC(N1E) (BOP Non-safety Instrumentation Cabinets) are upgraded as NPIS (Non-safety Process Instrumentation System), NSSS CS (NSSS Control System) as NCS (NSSS Control System), ILS(N1E) as NCCS (Non-safety Component Control System), PAS (Plant Annunciator System) as NIAS (Non-safety Indication and Alarm System), DPS (Diverse Protection System) as DPS, and PDAS (Plant Data Acquisition

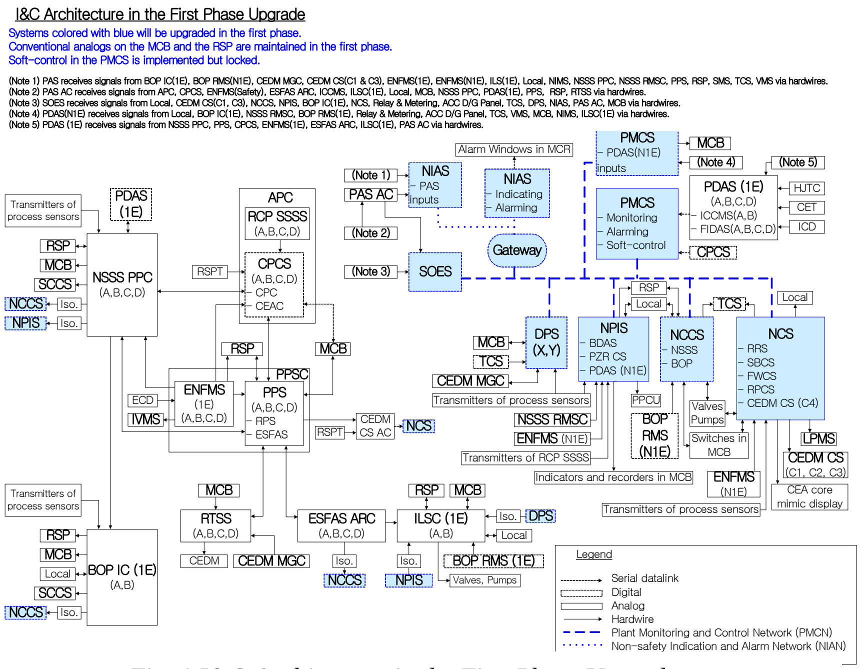

Fig. 1 I&C Architecture in the First Phase Upgrade

System) and PCS (Plant Computer System) are upgraded as PMCS (Plant Monitoring and Control System). The PMCS provides functions for monitoring the plant operating statuses and interfaces for soft-controls. The SOES (Sequence-Of-Events System) which was a part of PDAS(N1E) is upgraded as an independent system.

While discussing with utilities for the study, the following constraints are take into account: (1) Cables connected to transmitters installed inside the containment are not changed because they can operate more than 60 years and (2) 3-phase upgrade strategy is reasonably acceptable.

The 3-phase upgrade strategy is established with the following rationale: (1) It is risky that systems relating to the PLC and the DCS are upgraded in the same phase and (2) The main control room (MCR) upgrade is a big work and impacts directly to the operators of the plant. Upgrading I&C and MCR in the same phase is risky for the plant operation.

The disadvantages of a phased upgrade are as follows: (1) The cost of phased upgrade is higher than one-shot upgrade because engineering cost for each upgrade phase is required and (2) The systems to be upgraded in later phase should wait until a prior upgrade is completed.

Although their disadvantages of a phased upgrade are as above, a 3-phase upgrade strategy accounts for the safety aspects of the KSNP upgrade. The non-safety systems are upgraded with DCS in phase 1 as shown in Fig. 1. The stability of the non-safety systems upgrade is ensured during the operation of one overhaul of the KSNP. And then the safety systems are upgraded with PLCs in phase 2 as shown in Fig. 2. After the I&C upgrade is ensured, MCR is upgraded with soft-controls, flat panel displays and a large display panel in phase 3 as shown in Fig. 3. This is more safe way of upgrading the systems.

3. Conclusion

This paper presents three architectures of the KSNP I&C upgrade. The architectures are constructed with an adoption of PLCs and DCS technology and 3-phase upgrade strategy. The 3-phase upgrade strategy is established to ensure the safety of the upgrade. Based on the architecture, the cabinet configuration is being constructed. From the configuration, it is expected to figure out how to optimize the layout of the cabinets. It is required to study the performance and safety design requirements of the upgrade further.

REFERENCES

[1] Yong Suk Suh, Jong Yong Keum, et al., “Overview of a Cabinets Interface of the YGN Unit 3 I&C Systems”, Trans. of KNS autumn meeting, Korea, Oct. 25-26, 2007.

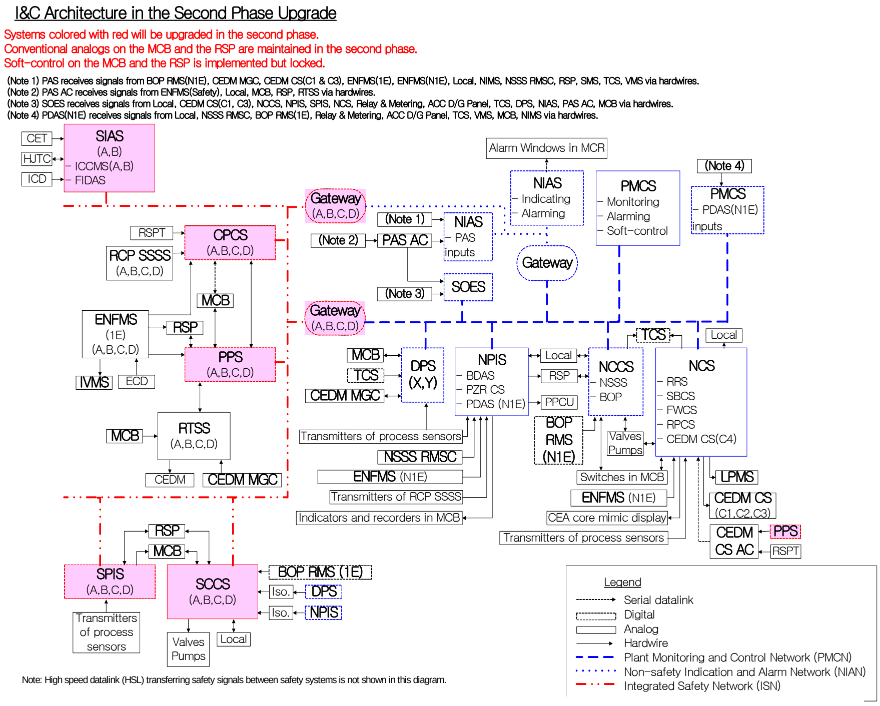

Fig. 2 I&C Architecture in the Second Phase Upgrade

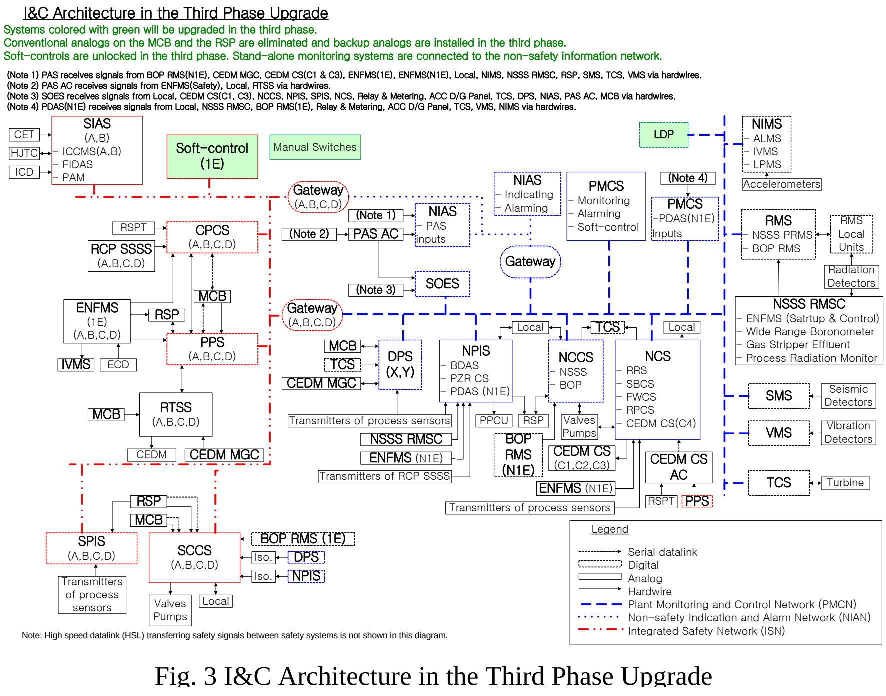

Fig. 3 I&C Architecture in the Third Phase Upgrade