Upgrade Plan of Instrumentation and Control System for HANARO

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ABSTRACT

The instrumentation and control system for HANARO has been designed as a hybrid concept having hard-wired analog systems as well as computer-based digital systems. The reactor protection system is an analog system while the reactor regulation system is a digital system. All the process systems are controlled by a digital control system through an Operator Work Station (OWS). Thanks to their comprehensive and robust design, the I&C systems of HANARO have been working very well without any critical failures since 1992.

Modern control techniques and computer science forms a part of the new I&C systems design. Obsolescence of the components is posing maintainability problems. These require appropriate modifications, and an optimization and replacement of the aged systems. In order to overcome the components obsolescence and to enhance the reliability of the systems an upgrade plan was set up. Based on the upgrade plan the HANARO I&C systems and components shall be gradually upgraded over the next decade. As a first step, the OWS has already been replaced with a new window-based system. The second upgrade of the OWS is being considered to establish an integrated control of the whole facilities of HANARO by the operator in the control room. A direct digital control system installed in 1992 for the reactor regulation system also faces the same problem and requires a provision to cope with this situation. As a mid-term plan, this control system is to be replaced with a state of the art computer based digital control system. Lastly, as a long-term plan, the analog protection system will also be refurbished with a safety grade digitalized computer system.

1. Introduction

The HANARO is a 30 MW open-tank-in-pool type multi-purpose research reactor. The first criticality was achieved in February 1995. The HANARO, with a maximum available thermal neutron flux of 5×10^{14} n/cm^2·sec, uses 20% U_3Si-Al fuels. The core is

cooled by an upward forced convection of light water and is surrounded by a large heavy water reflector tank. The Instrumentation and Control system for HANARO is divided into two major systems - Reactor Regulation System (RRS) and Reactor Protection System (RPS). The RPS is a hard-wired safety grade system to provide a protection against a number of postulated accidents. The RRS has to start up, control and shut down the reactor in a safe and controlled fashion, using a microprocessor-based MLC (Multi-Loop Controller).

There are a lot of experimental facilities around the HANARO reactor for doing neutron beam research and irradiation application research. Some have already been vigorously used by many-sided users. Some are being developed. A research project – Fuel Test Loop (FTL) is in the phase of a detailed design and the hardware will be installed in the HANARO reactor in 2006. Another project – Cold Neutron Source (CNS) is in the basic design stage, which will be completed in 4 years. A provision for implementation of the control system for both projects should be prepared well by considering an optimal integration with the existing I&C system of the reactor.

It was finally decided, through an engineering review process that the construction of an integrated control station would be the best option, to improve the general man-machine interface, to reduce the human errors, and to increase the safety and availability of the plant. There are a few constraints in the accomplishment of the integrated control system. The new control systems to be used for the experimental facilities will be installed at different times and the reactor shutdown time should be maintained as minimal as possible. Considering all these situations, a master plan for the integrated I&C system shall proceed with a step-wise upgrading philosophy.

2. Current I&C systems of the HANARO

There are three Multi-Loop Controllers (MLC) which are linked with dual High Level Data Links (HLL) for the control of the HANARO. Two PC-based control workstations with 3 monitors are connected to the MLCs through protocol interfaces called Fast Independent Computer Interface (ICI) which connects the pc server to the HLL. The overall structure of the current I&C system is in Figure 1. The urgent problem was the old and inconvenient operator workstations. It was hard to find compatible devices like low frequency monitors, 8.5 inch floppy disk drivers, etc. In 2002, the old version of the workstation was replaced with a PC-based workstation, which was supplied by the manufacturer of the original system.

The HANARO control room is complex with monitors for the workstations, CCTV monitors, general PC's, and monitors for the radiation monitoring system. So the

installation of more workstations would make the environment more complex and an added workload to the operators. These situations may danger the safety of the reactor operation. To reduce the moving path and physical workload, it is better that the existing control system is upgraded to include the control function of the FTL and other future facilities like the CNS facility. But the upgrade may cause the possibilities of human errors due to increased information and a software complexity.

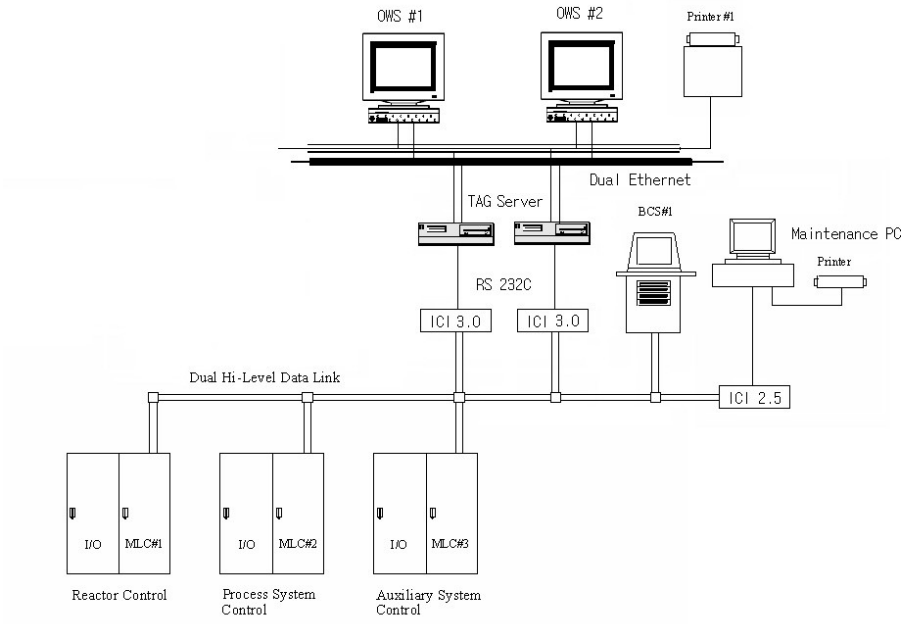

Figure 1. Overall structure of current I&C system

3. Gradual upgrade plan

I&C systems will be upgraded step by step. There are two major projects which are under development for the utilization of the HANARO. One is the Fuel Test Loop (FTL) project and the other is the Cold Neutron Source (CNS) project. The project milestones are not the same. It means that some modification of the existing I&C system should be made at each step of the installation of the facilities. The FTL will be installed at the end of 2006 and the CNS will be installed at the end of 2008. The upgrade plan is paced with the progress of both projects. And the aging problem was considered first for the planning.

As a first step, the change of the operator workstation to a PC-based system was completed in 2002. These operator workstations will be modified and extended at the installation of each of the projects. So the second change is scheduled for the

completion of the FTL installation. The replacement of the MLCs for the non-safety control system will be started in parallel with the third step modification of the workstation for the CNS project. Refurbishment of the safety control system, RPS will start around year 2010 after the qualification of the digitalized proto type of the RPS. Figure 2 shows the major milestones for the upgrading.

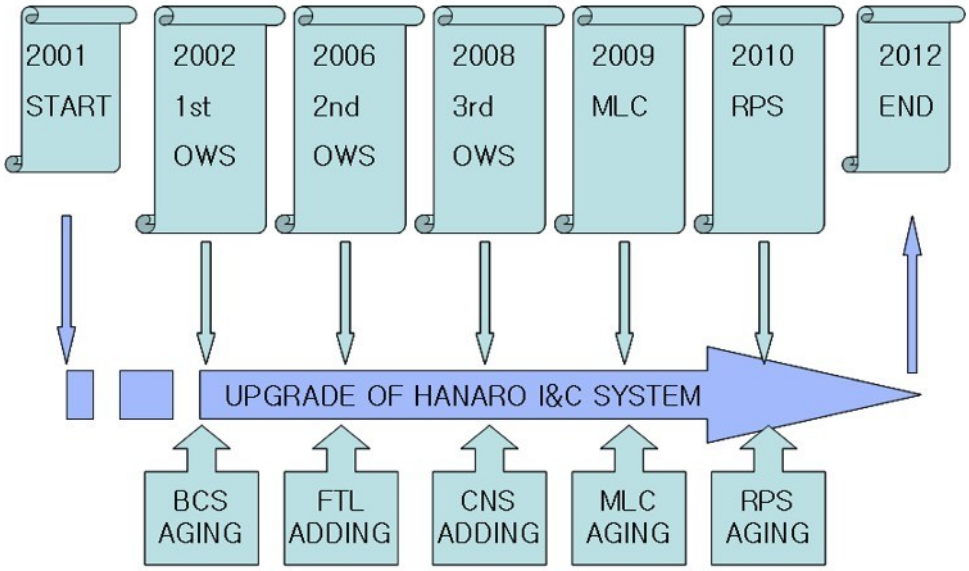

Figure 2 Upgrade plan

3.1 Human-Machine Interface (HMI)

The current operator workstation (OWS) based on the PC with Microsoft NT was upgraded in 2002 and it will be upgraded again in 2006. The current HMI was developed by the OEM version of Wonderware Intouch Tool. The HMI software shall have three essential features in addition to the dedicated functions of each project to incorporate other facilities like Neutron Transmutation Doping of Silicon (NTD), Radiation Monitoring System (RMS), Nutron Activation Analysis (NAA), etc. Three requirements of the software for the integration are an openness, flexibility, and compatibility. So the general HMI tools using open protocols shall be used for the workstations. The controller shall also have communication functions using open protocols. A design of a screen will be changed to include other facilities in addition to the reactor facility and to incorporate the recommendations from the human engineers

for the current OWS. After the second upgrade of the OWS, the FTL can be controlled both at the HANARO control room and at the FTL control room with the same HMI. But operators will have different access rights according to their responsibilities.

In the third step, the CNS will be included in the OWS and the others like NTD will be connected to the system. A display using a large flat screen like a LCD will replace the existing mimic panel installed on the wall. The contents of a large display are the same as the screen of an OWS designed especially for the purpose of a presentation.

3.2 Control and protection system

Three MLCs control the plant including the reactor facility. Reactor control algorithms are implemented in to the two MLCs and the other systems are controlled by a MLC. The existing controllers can not accommodate more inputs and outputs because the functional blocks for the programming and I/O of the MLC are generally used. It is another reason for a refurbishment of the MLCs in addition to the aging problems. Experimental facilities like FTL, CNS, and NTD have dedicated controllers. All the controllers shall be integrated using open protocol and general HMI tools to be an integrated I&C system. All the OWS can access information and the controllers using dual control networks. The OWS for the experimental facilities will be installed at the dedicated control area, outside the HANARO control room. The operator can control all the systems linked to the integrated I&C system anywhere according to the access level assigned to them. Figure 3 is the overall architecture of the integrated I&C system for the HANARO research reactor at the end of 2012.

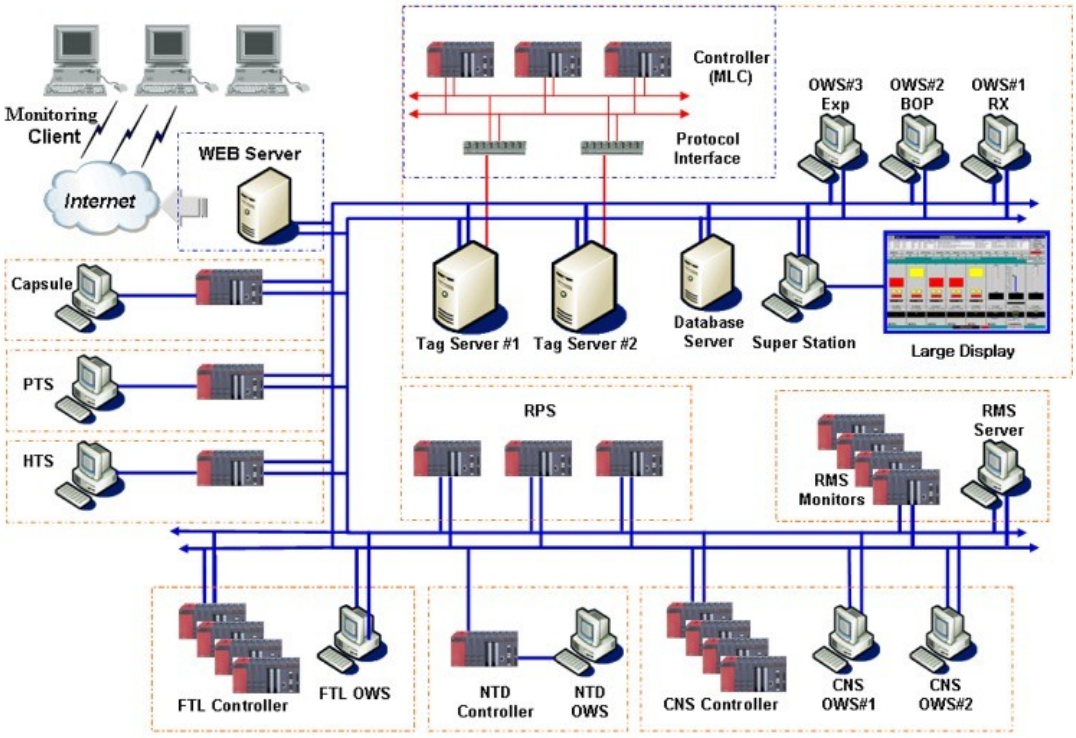

Figure 3. The integrated I&C system.

The safety system, reactor protection system will be upgraded to a digital system and connected to the integrated I&C system using safety grade interface devices. It will be done at the final stage of the plan because the system is still in a good condition.

4. Conclusion

Upgrades of the I&C system for the HANARO were started in 2001. The master plan spread over about 10 years will be implemented gradually by considering the budget and the priorities of the upgrades of the systems. The main purpose is an integration of the information and control distributed over the plant. Operators in the control room can control all the facilities connected to the system including the reactor, effectively by using an OWS and the facility operator can also access information about the reactor and the other facilities. It may improve the safety of the reactor, the capability of the operators, and the effectiveness of the operation and the maintenance.