

# Developing an Integrated HFE V&V System of MMIS for APR1400

Myeong-Soo Lee, Jeong-Kwan Suh, Seung-Ho Lee, Yong-Kwan Lee  
Korea Electric Power Research Institute, Munji 103-16, Yuseong, Daejeon, Korea, 305-380, fiatlux@kepri.re.kr

## 1. Introduction

As a support of MOCIE (Ministry Of Commerce, Industry and Energy) in Korea, Korea Electric Power Research Institute (KEPRI) is developing the integrated validation system in the participation with Korea Hydro & Nuclear Power Co. (KHNP), which is a facility that can simulate all of the dynamic functions and responses of APR1400, and measure human performances. In this paper, we describe the some of the brief status and conceptual design of the integrated HFE V&V system of MMIS for APR1400. This integrated system also has the functions to measure the plant performance, to support evaluating the situation awareness by measuring the operator's biological signals and motion tracking. This paper is described herein, the outline description of the project of integrated APR1400 HFE V&V facility.

## 2. MMIS design of APR1400

The design of new generation nuclear power plant in Korea, APR1400, is a FOAKE (First Of A Kind Engineering). APR1400 has many specific features such as passive safety features, digital I&C, and digitalized main control room (MCR) design.

The new man machine interface system (MMIS) design concepts of APR1400 have following features [1].

- The interaction with the new control principle called "soft control" via compact workstations.
- Large amounts of data may be integrated and made available for the operators via large displays(LDPs)
- Hierarchical and access to process information is sequential
- Operator aids increase including improved alarm management, computerized procedures, computerized operator support systems (COSS)

This digital-based neo-concept main control room design needs comprehensive verification and validation process to get the license for construction.

## 3. Integrated system validation

U.S. NRC developed Human Factors Engineering Program Review Model (HFE PRM) to support the advanced reactor design certification reviews [2,3]. The HFE PRM describes the twelve HFE program elements

that are necessary and sufficient to develop an acceptable detailed design spec. (Figure 1).

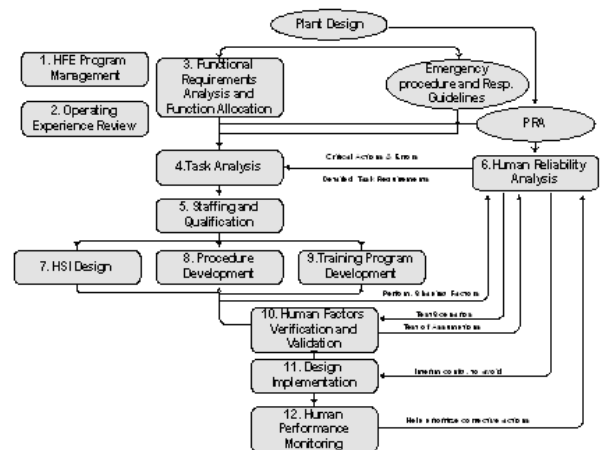


Figure 1. 12 elements of HFE PRM(NUREG0711)

One of the review elements is verification & validation (V&V), and its role is to comprehensively determine that the design conforms to HFE design principles and it enables plant personnel to successfully perform their tasks to achieve plant safety and other operational goals.

### 3.1 Code and Standards

Integrated system validation is part of this review activity and can provide evidence that the integrated design remains within acceptable performance envelopes. NUREG/CR-6393 [4] requests a) Human-System Interface (HSI) Completeness, b) Physical Fidelity c) Functional Fidelity d) Data Completeness Fidelity e) Data Content Fidelity f) Data Dynamics Fidelity g) Environment Fidelity which is out of scope in this project.

The integrated system for validation should meet the requirements of "Nuclear Power Plant Simulators for Use in Operator Training and Examination" (ANSI/ANS 3.5 1998) and support the scenarios and malfunctions based on HFE V&V requirements of SKN 3 PSAR Chapter18.

### 3.2 Dynamic Simulation System

The integrated system for validation is composed of two parts, one is dynamic simulation system which is representing dynamic characteristics of the APR1400 nuclear power plant (NPP) and the other is human factors evaluation (HFE) system. To simulate the specific phenomena of the APR1400 dynamic and design, real-time Thermal-Hydraulic (TH) simulation

code, REALP-RT, is used and modified. New emulated Distributed Control System(DCS) which could simulate Westinghouse's DCS, Ovation™, and Computerized Procedure System, is designed and developed to simulate the systems of the SKN3&4 nuclear power plant. Other paper [5] describes the detail simulation model development.

### *3.3 Human Factors Evaluation Support System*

Wide range of human factors evaluation methods to investigate the operator behavior and performance were summarized and evaluated to develop the human performance evaluation support system (HUPESS) with the co-work of Korea Advanced Institute of Science and Technology (KAIST). Some of human factors evaluation areas were selected as follows. a) Plant performance, b) Personnel task, c) Situation awareness, d) workload, e) teamwork, and Anthropometric/Physiological factors.

The conventional and subjective methods which are National Aeronautics and Space Administration-Task Load Index, NASA-TLX), KSAX and check lists were selected and used. Eye tracking system data will be used to compliment the disadvantage of the subjective method.

The physiological signal measurement system which could measure electro-cardiogram (ECG), galvanic skin response (GSR), respiration, and activity of the wrist by using wearable sensors and wireless communication technology could support evaluating anthropometric/physiological factors.

## **4. Conclusion**

An integrated system for APR1400 MMIS design validation is under development by KEPRI with the participating of KHNP.

The facility which is based on the NUREG/CR-6393 and ANS3.5 can simulate all of the dynamic functions and responses of APR1400, and measure the human factors by using conventional subject methods and measuring the operator's biological signals. This system will be useful for human factors V&V process of the PRM(NUREG0711) of APR1400 MMIS design.

## **ACKNOWLEDGMENT**

This study was supported by Ministry Of Commerce, Industry and Energy (MOCIE) in Korea.

## **REFERENCES**

- [1] Norros Leena, Savioja Paula, "Usability Evaluation of Complex Systems", STUK-YTO-TR 204, Helsinki 2004.
- [2] O'Hara et al., "Human Factors Engineering Program Review Model", NUREG-0711,rev.2, NRC, DC 2004.
- [3] O'Hara et al., "Human System Interface Design Review Guidelines", NUREG-0700, Rev.2, USNRC, DC 2002.

[4] O'Hara, J., Stubler, W., Higgins, J., Brown, W., "Integrated System Validation: Methodology and Review Criteria", NUREG/CR-6393, USNRC, DC 1996.

[5] Jeong-Kwan Suh, Jin-Hyuk Hong, Myeong-Soo Lee, Yong-Kwan Lee, "Development of a RELAP5 R/T Model for the APR1400", Proceedings of the KNS Spring Meeting, Cheju, Korea, May 26-27, 2005.