

**Development of Human Factors Engineering Program Plan (HFEPP)
for MMIS Design of KNGR**

Kyung-Ho Cha, Geun-Ok Park, Sang-Moon Seo
Se-Woo Cheon, and Bong S. Sim
Korea Atomic Energy Research Institute

Abstract

Human factors principles and evaluation methodologies are applied to design the MMIS of the KNGR. Human factors issues identified from the previous MMIS design of a nuclear power plant are considered in the development of the HFEPP. To manage human factors issues in the MMIS design of the KNGR, a conceptual Human Factors Issue Tracking System (HFITS) is also considered.

1. INTRODUCTION

The human factors issues on the MMIS design of NPP is to minimize the likelihood of human errors and to improve system performance[1]. The ultimate goals of plant design, the minimization of human error probability and the maximization of system performance including safety, can be effectively achieved when human factors principles are systematically applied and plant personnel are properly supported through the MMIS design[1]. The NRC requires plant design based on human factors principles as part of the certification process for NPP designs and published NUREG-0711 as a guideline for developing a Human Factors Engineering Program Plan (HFEPP)[2]. The NUREG-0711 is used to identify the human factors issues on the MMIS design of the KNGR. According to these identified human factors issues, the KNGR MMIS is designed with the basis of current engineering procedures and practices for ALWR systems. The objectives of the KNGR MMI development are as follows:

- (1) to facilitate operator's decision-making and control by grouping related control and monitoring information appropriately and by supplying operators with useful information on a timely basis,
- (2) to perform tasks assigned to operators within human capabilities (e.g., the cognitive and physical workload),
- (3) to accomplish design with attention to operator training program and qualification levels,
- (4) to support high degree of operator's situation awareness,
- (5) to provide feedback in response to control actions of operators,
- (6) to improve human error tolerance, cost reduction, and easy maintainability.

The KNGR MMIS design is approached as shown in Figure 1.

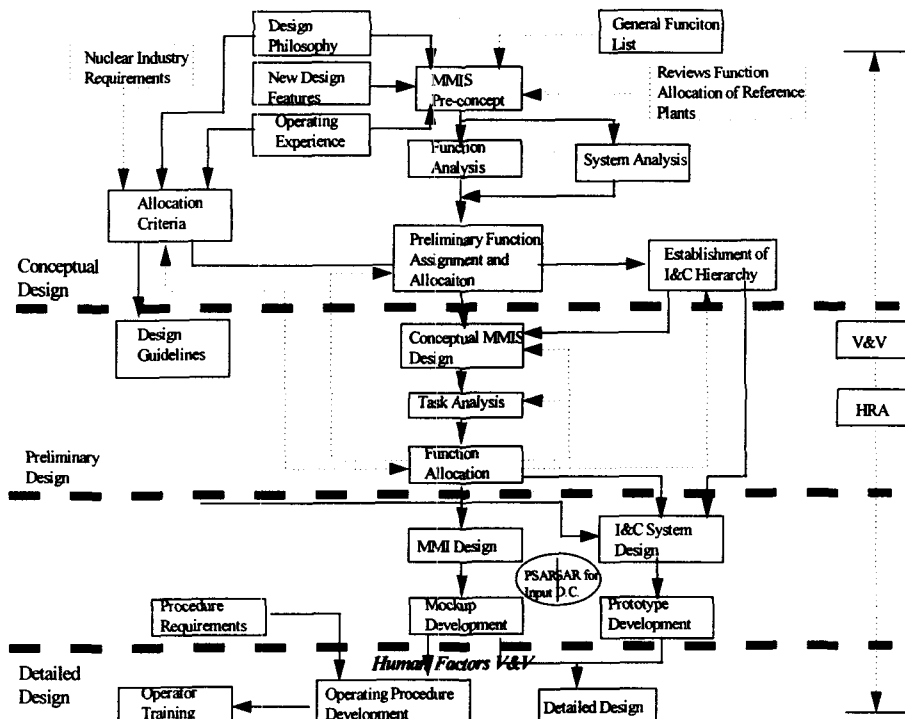


Figure 1. Design Approach for the KNGR MMI

To meet the design objectives of the KNGR MMIS, the HFEP for the KNGR MMIS design, which is composed of 11 human factors tasks, was developed[3].

2. HUMAN FACTORS TASKS

Human factors tasks for the KNGR MMIS design was identified by referencing NUREG-0711 and the major human factors issues are considered with the design processes of the KNGR MMIS.

2.1 Operating Experience Review

Operating experience review for the KNGR MMIS design is performed by using issue data unresolved safety/generic safety, NRC generic letters and information notices, office for Analysis and Evaluation of Operational Data(AEOD) studies, low-power and shut-down, and applicable operating plant event reports(e.g., license event reports, outage analysis reports, modifications to technical specifications, license internal memoranda and reports, etc.). These data will be organized and managed by HFITS through the KNGR MMIS design.

2.2 Function Allocation

Advanced MMIS features in recent plant design is a shift of operator's function from direct control to supervisory control and system monitoring[1]. These technological trends in the MMI design of a Main Control Room (MCR) requires the consideration on reliability sources including poor situation awareness, loss of operator vigilance, highly cognitive workload, and workload transition difficulties. The function allocation analysis for the KNGR MMIS design will be performed for sensitivity, precision, time and safety-related requirements, required reliability, and the number and level of skills of personnel required to operate and maintain the system. Well allocated functions, considering human capabilities and limitations, will improve operator's performance and it is the ultimate goal of KNGR MMIS design. The task analysis is performed with the objective to identify the behavioral requirements of the tasks required to perform by plant personnel.

2.3 Staffing

The staffing evaluation for the KNGR MMIS design is performed with the identification of staffing issues, data collection, and evaluation of staffing levels in correspondingly. The iterative evaluation of staffing levels is performed, that is, the initial staffing goals will be reviewed and modified as the evaluations associated with other human factors tasks are completed. The staffing levels will be evaluated by using mockup, simulator, or MMIS prototype. In the staffing evaluation for the KNGR MMIS design, the criteria of performance measures are selected as a minimum including:

- (1) subjective workload,
- (2) situation awareness,
- (3) crew performance, and
- (4) team performance.

2.4 Human Reliability Analysis

Human error is an important factor to accidents and incidents in an operational environment of a NPP. The purpose of human reliability analysis in the KNGR MMIS design is to evaluate the potentials for and mechanisms of human errors that may affect the overall KNGR safety.

3.5 MMI Design

The evaluative objective is to ensure that the functional and task requirements have been appropriately translated into the detailed MMIS design through a systematic evaluation methodology which human factors principles and criteria are applied [1]. The KNGR MMIS is designed with the considerations on human performance and

usability with the KNGR MMIS characteristics including:

- (1) capability with the cognitive and physiological capabilities of plant personnel,
- (2) minimization of the demands of secondary tasks,
- (3) support of the use of MMIS, and
- (4) accommodation of human performance under the full range of conditions.

The evaluation of the KNGR MMIS design is focused on the advanced MMIS features because the KNGR is designed as evolutionary type.

2.6 Procedure and Training

Procedures are developed after the MMIS design and they are retrofitted to suit the designed interfaces. Thus, human factors problems on procedure development are originated from the designs of individual utilities and the changed characteristics after the MMIS was designed. Identification, assessment, interpretation, and validation of procedures are considered on the KNGR procedure development. In the development of the HFEPP for the KNGR MMIS design, training program development is included. The overall effectiveness of the training program will be evaluated through formal reviews, simulator exercises, and walk-through.

2.7 Human Factors Verification and Validation

Human factors verification and validation evaluates that the MMIS design follows human factors principles and that it enables plant personnel to successfully perform their tasks to achieve plant safety and other operational goals [1]. The human factors verification and validation for the MMIS design include the followings:

- (1) availability verification,
- (2) suitability verification of the human factors design,
- (3) Integrated system validation, and
- (4) human factors issue resolution verification.

Availability verification is to ensure that MMIS components are provided to address all identified personnel tasks. Suitability verification is to ensure whether the design of each MMIS components have been designed according to human factors principles, standards, and guidelines. Human factors issue resolution verification is to ensure that the human factors issues identified during the design process have been acceptably addressed and resolved.

3. HUMAN FACTORS ISSUE TRACKING SYSTEM (HFITS)

The HFITS is considered to control HFE issues and problems on the KNGR MMIS design. These issues and problems have been known to the nuclear industry and will be identified throughout the life-cycle of the KNGR MMIS design, development, and evaluation. The overall issues and problems related to the human factors design of the KNGR MMIS will be entered into the HFITS and be tracked until elimination or reduction to an acceptable level. The HFITS will contain at least the following information including identified issues, first date identifying an issue or problem, task team or personnel responsible for resolving the raised one, guiding information regarding resolution acceptance, resolver (e.g., task team or personnel), final resolution results of an issue or problem, and closing date of an identified issue or problem.

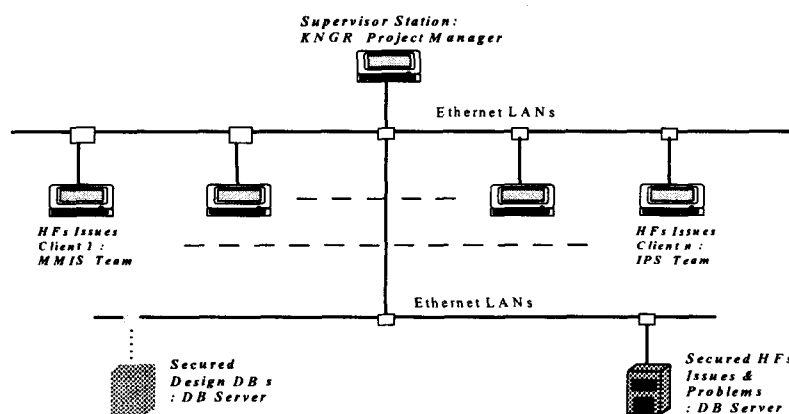


Figure 4. Conceptual HFEITS Structure

4. DISSCUSION

Human factors issues in the KNGR MMIS design as an evolutionary type are focused on the function and task allocation, human factors evaluation of the advanced MMIS features, and an integrated human factors verification and validation. The HFEPP for the KNGR MMIS design has been developed for performing these human factors issues with a systematic methodology and the conceptual HFITS is being suggested for managing human factors issues through the evolutionary KNGR MMIS design. For the in-depth HFs evaluation of the evolutionary KNGR MMIS design the static and dynamic mockups, simulator-based evaluations should be considered.

ACKNOWLEDGEMENT

The work has been performed as part of the MMIS development of the KNGR.

REFERENCES

1. NRC, "NUREG-0711:Human Factors Engineering Program Review Model," 1994.
2. NRC, "NUREG-700:Human-System Interface Design Review Guidelines(Rev.1),"

- 1995.
3. K.H. Cha, G.O. Park, S.W. Cheon, and S.M. Seo, "Human Factors Engineering Program Plan for Korean Next Generation Reactor (Rev. 0)," Internal draft, Human Factors Research Team, Korea Atomic Energy Research Institute, January 13, 1996.
 4. KAERI, "Korean Standard NPP Design Documents (Chapter 10)," April 1994.
 5. KAERI, "Functional Requirements for KNGR MMI," KAERI Internal Document, 1996.
 6. EPRI, "EPRI-ALWR URD: Advanced Light Water Reactor Utility Requirements Document, Vol. II, Evolutionary Plant(Rev.4)," 1992.