Design and Test of Navigation in a APR1400 Computerized Procedure System Display on Human Factors Engineering Issues

Yun Goo Kim
MMIS Team, Nuclear Engineering and Technology Institute, KHNP Co., Ltd.
25-1 Jang-dong, Yuseong-gu, Daejeon, Korea, 305-343
goodguy@khnp.co.kr

1. Introduction

An advanced digital main control room has many issues related to human factors engineering verification [1]. The one of the main issues for a Computerized Procedure System (CPS) concerns the difference in the physical formation between traditional paper-based procedures and computerized procedures. The concern is the manner in which the procedure will be displayed and the manner in which the operator will navigate and follow the procedures through the display screen. A display and navigation design is proposed and verified through HFE (Human Factor Engineering) tests.

2. Design for computer display issues

Many studies related to human-system interfaces and human factors engineering have shown expected limits of computer displays as well as difficulties in the navigation of these systems [1,2,4]. A number of these are discussed below.

Narrow field of view: Computer-based displays and controls tend to be serial, rather than parallel; thus, an operator can only see part of a procedure at one time in a finite display space.

Keyhole: Due to the narrow field of view, an operator cannot be aware of the overall state of the plant and may tend to prefer the current display, which does not have sufficient information for important situations at the plant.

Getting lost: An operator cannot discern the selected present display or which display is for his/her operation.

CPS is designed to cope with these limitations through a new design of views and navigation procedures. Designs are verified and proposed through Human Factors Engineering Verification (HFEV).

2.1 Human Factors Engineering Verification (HFEV)

The APR1400 HFEV facility with MMIS is used in the test. Five operators with PWR operation service ranging from 5 years to 20 years participated in the verification test. A prototype CPS was prepared for the test, and EOP, ARP, FRP were used as well.

2.2 Design of CPS view

Overview: To provide a view of the current progress of the procedures by display, completed steps and currently executing steps were shown as color-coded, preventing the operator from becoming lost.

Stepview: This was intended to provide a normal step page or a contingency step page. Traditional paper-based emergency operation procedures (EOP) have two columns, one for normal instructions and the other contingency instructions. However, a CPS displays only the normal page because as too much information is not effective for an operator and because the information on the contingency page is rarely needed in normal cases.

2.3 Design and Test of CPS Navigation

A computerized procedure has a hierarchical structure, such as the procedure, the gross step, the step and the instructions. The main design concept for navigation is that each hierarchical state provides some control for navigation. The detailed navigation processes are designed as follows:

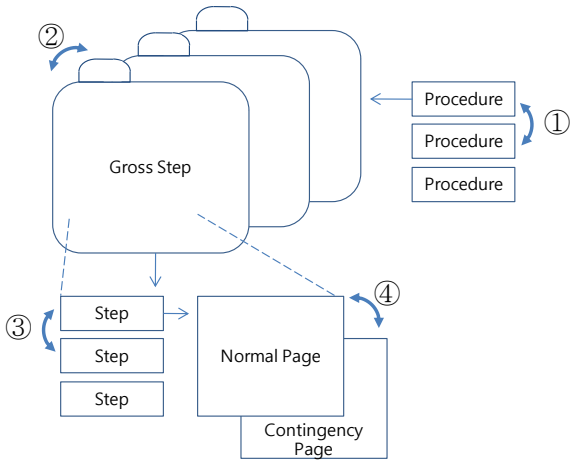

Fig. 1. Navigation between CPS views

Procedure navigation: The desk pane in the CPS display shows a list of procedures that has been opened. It also provides some navigation control between the procedures.

When they are requested, all displays exhibit the selected procedure. ① in Fig. 1 depicts this.

Gross step navigation: The originally proposed design for gross step navigation involved the use of an overview pane. A gross step usually consists of many steps; therefore, in the overview pane, a long list of steps for each gross step exists. When an operator navigates to another gross step, he/she should pass all of the steps in the current gross step by scrolling. During the HFEV test, the operator requests fast and short navigation between gross steps. Hence, a gross step tab is proposed to provide one-click navigation between the gross steps. This navigation is also necessary in the crew procedures to verify the execution of the gross step of other operators. This is shown as ② in Fig. 1.

Step navigation: There are two types of navigations in CPS. The first is a type of navigation that is followed by the execution of a procedure, and the second type of navigation involves changes of the display only for selection of the view. For the execution navigation, the operator uses the 'step complete' button and the display navigates automatically to the next step. For the view selection navigation, the overview pane contains a list of steps in the current gross step, and the operator can click the steps to navigate to that step. The selection color indicates the current steps in the list and the current step is automatically located in the center of the display. This helps the operator stay aware of the watched state, preventing the operator from *getting lost.* This is illustrated as ③ in Fig. 1.

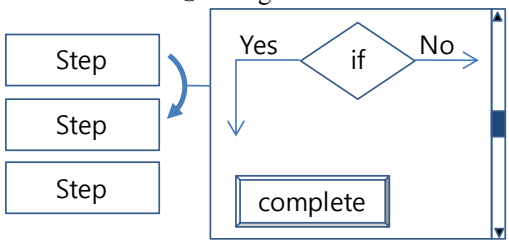

Fig. 2. Navigation between steps

Normal page and contingency page: There are two ways to navigate between a normal page and a contingency page, as in step navigation. According to the operator's request during the HFEV test, view selection buttons are given an intuitive design so as to be distinguished from the execution navigation button.
Scrolling in a step: Scrolling is one of the most familiar functions in the MS Windows environment; however, each operator may expect a different level of sensitivity while scrolling. In some cases, the click-and-drag action is proposed in place of scrolling. Scrolling sensitivity is important because the operator should not become lost or skip instructions while scrolling.
Yes/No direction of instruction: View selection navigation in each step is done by scrolling; however, execution navigation in each step according to the execution instruction is automatic. In this automatic navigation scheme, Yes/No directions for 'if' statements are fixed. For the APR1400 CPS design, the 'Yes' direction is always on the right and the 'No' direction is always on the left.

3. Conclusions

To overcome the limitations of a computer display, CPS can be a good solution. In the CPS design, six types of navigation designs between CPS views were proposed and tested. Each design provides a better solution for navigation under current situation of MCR. Another important issue which uncovered during the HFEV test is that navigation should have consistent rules and a common strategy. When training, these rules and strategies can provide a solution that addresses the limitations of displays.

REFERENCES

[1] John M. O'Hara, James C. Higgins, William S. Brown, Human Factors Considerations with Respect to Emerging Technology in Nuclear Power Plants, BNL Tech Report No. 79947-2008
[2] Integrating Digital and Conventional Human-System Interfaces: Lesson Learned from a Control Room Modernization Program, NUREG/CR-6749
[3] System Specification for Computerized Procedure Systems (DDS1) KHNP Document No. 9-797-K-464-001
[4] John M. O'Hara, James C. Higgins, Computer-based Procedure Systems: Technical Basis and Human Factors Review Guidance (NUREG/CR-6634)
[5] Jung Y. Seong P. Kim M. A Model for Computerized Procedures based on Flowcharts and Success Logic Trees. (2004) Reliability Engineering and System Safety, 83 (3), pp. 351-3