THE EFFECT OF SUPPORT FUNCTIONS IN A COMPUTERIZED PROCEDURE SYSTEM ON INTERFACE MANAGEMENT TASKS

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ABSTRACT

By adapting digital and computer technology, the design of main control rooms (MCR) in nuclear power plants has been changed. When operators operate a nuclear power plant, the tasks using soft controls in advanced MCRs include primary tasks and secondary tasks. Primary tasks are to control nuclear power plant devices and secondary tasks are to find appropriate screens or devices by screen navigations and selections before performing the primary task. The secondary task including interface management tasks is newly introduced in advanced MCRs. In this paper, the tasks are analyzed based on the simulation data of APR1400 which is one of the digitalized nuclear power plants. For analyzing tasks, the unit tasks are divided into three types: navigation, manipulation, and acknowledgement. The primary task represents the manipulation of devices and the secondary task indicates the navigating screens, opening control panels, closing control panels, and confirming the acknowledging alarms. To analyze the effect of support functions of a computerized procedure system (CPS), one of the functions which is expected to have a significant effect on the secondary tasks was considered, that is 'related screen link button.' Two factors, 'ratio of screen alteration' and 'ratio of using screen link button', were used to see the effect of 'related screen link button'. From the task analysis result, it was observed that the secondary tasks which is one of the unique features in advanced MCRs have a quite much portion than that of the primary tasks.

Key Words: advanced MCR; soft control; human error; secondary task;

1 INTRODUCTION

Advanced main control room (MCR), unlike conventional main control room, include digital systems and computer technology. Advanced main control room is composed of large display panel (LDP), computerized procedure system (CPS), soft controls (SC), and advanced alarm systems, etc. Operational environment of advanced MCR change unlike conventional main control room. Therefore, operator performance assessment should be re-analyzed with regard to the operational environment changed. Especially, for SC, digital monitor is put to use for operation and it require interface management task, which has not been done in conventional MCR. For such reason, additional task like interface management task should be performed for operation which use SC. SC task in advanced MCR is classified to primary task, which gives control input directly, and secondary task, which performed additionally like interface management task. Thus, to evaluate the operator performance in advanced MCR, detail analysis and effect evaluation on secondary task is indispensable. In this research, for the SC operation assessment in advanced MCR, operational task was analyzed base on simulation data. The evaluation of 'Screen Link Button',

which is convenient for an operator to move on to the required screen by one-click without navigation, is performed among the operator support functions to reduce the secondary tasks required in the soft control.

2 TASK ANALYSIS OF ADVANCED MCR

The operation tasks also change with the change in operational environment. Task of advanced MCR consist of cognitive activity, communicative activity, and operational activity. Operational activity is classed as primary task and secondary task. Cognitive task is the cognitive activities of the operator which must be carried out to operate the plant and to cope with the situation. Communicative task is the communicative activities that occur for the operation and management of the plant, such as exchange of information and instructions between operators. Operational task is the actions of the operator to perform cognitive activities and it can be divided into primary task to directly control plant equipment and secondary task. Unlike tasks that are common to the two types of MCRs, the secondary task in the operational activity is a new additional task that is applied only to the advanced MCR. The secondary task is interface management tasks such as screen navigation and controller selection for finding and selecting controller to perform primary tasks for giving control input to a plant equipment.

Table I. Detailed classification of operational task

Classification	Activity Name	Contents
Navigation	**SWITCH_SCR**	Activities that change the screen to identify or manipulate system state
	OPEN_CTRPNL	Activities that pop up operation windows on IFPD or ESCM for operation of particular system
	CLOSE_CTRLPNL	Activity to close the operation window on the IFPD or ESCM for the operation of a particular system
Manipulation	**CLICK_EXECUTE**	Activities to manipulate particular system
	CLICK_REGU_UPDN	Activity to press up and down arrow buttons during operation to adjust particular system
	CLICK_ENABLED	Activity to press ‘enable’ button on an interface for operation of particular system
	CLICK_MANUAL	Activity to press ‘manual’ button on an interface for operation of particular system
Acknowledgement	**CONF_STEP**	Activities confirming the completion of the step in procedure

	CONF_SUBSTEP	Activities confirming the completion of each instruction in the step of procedure
	ACK_ALARM	Activity to check alarms and clear the alarm
	CONF_CHANN	Activity to press 'channel check' button on an interface for identify the channel before operation of particular system

Operational task using soft control are classified into navigation, manipulation, and acknowledgement as shown in Table 1. The non-safety soft control is operated using a mouse in Information Flat Panel Display (IFPD), and the safety soft control is operated using ESC-CCS Soft Control Module (ESCM) designed as touch independent screen.

3 TASK ANALYSIS USING SIMULATOR DATA

In this research, task conducted practically by operator analyzed by conduct simulation video data. The analyzed video data record the emergency scenario operation which conducted over 3 times at advanced MCR in APR1400 training center. 14 Steam Generator Tube rupture (SGTR) data and 6 Station Blackout (SBO) data were analyzed.

Operator configuration is identical with conventional MCR. The operators who conduct the emergency operator procedure (EOP) was composed of Shift Supervisor (SS), Reactor Operator (RO), Turbine Operator (TO), Electric Operator (EO), Safety Technical Advisor (STA). In this research, analysis was focused only on RO and TO who are mainly perform operational task.

3.1 Analysis Result

The soft controller operational tasks performed by the RO and TO were analyzed using the simulator video data in SGTR and SBO. All operational activities of the operators were analyzed in detail. Based on the analysis results, detailed classification of primary task and secondary task. Figure 1 shows the number of

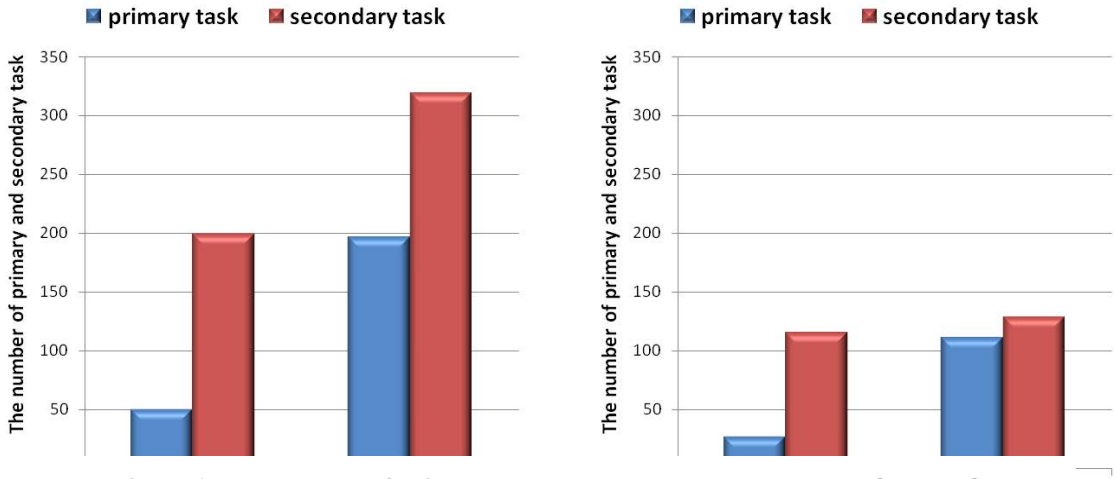
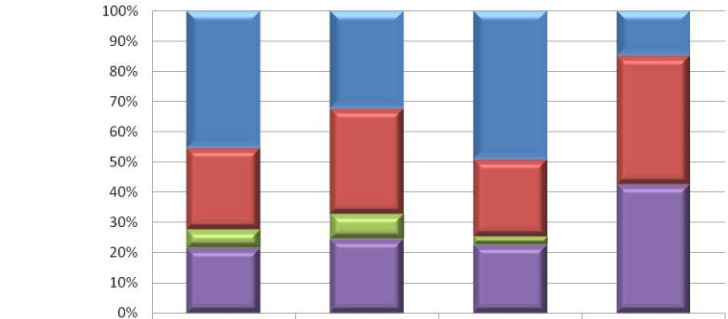


Figure 1. The number of primary task and secondary task about RO and TO

primary and secondary task performed by the operator. As shown in the figure 1, the number of secondary task generally occupies a large part of the overall task performance although there are some differences among the operators. It shows that there are more secondary task to perform primary task than primary task.

Figure 2 shows each operational activities in the secondary task. It can be seen that 'SWITCH_SCR', screen navigation, is relatively high among the operational activities of the secondary task.



	SGTR_RO	SGTR_TO	SBO_RO	SBO_TO
SWITCH_SCR	90	103	52	22
OPEN_CTRLPNL	54	111	27	63
CLOSE_CTRLPNL	12	27	3	0
CONF_CHANN	43	78	24	63

Figure 2. Percentage of each activity within secondary task

4 THE EFFECT OF SUPPORT FUNCTION

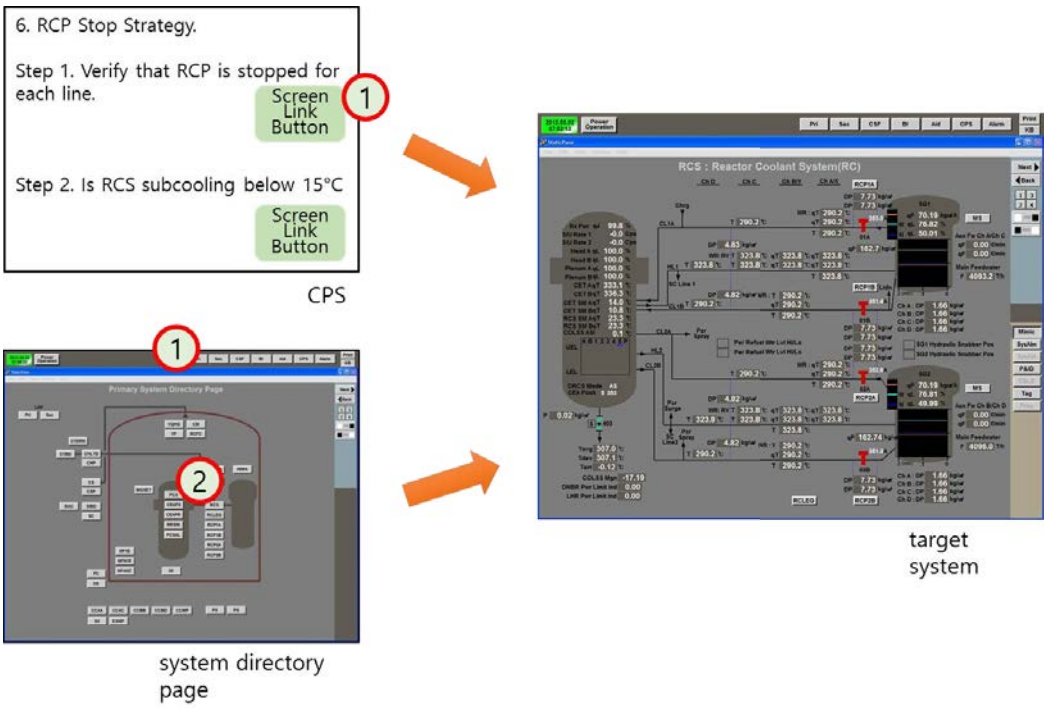


Figure 3. Screen navigation method.

As shown in the previous analysis, the number of secondary task is considerably larger than the number of primary task. It can't be concluded that secondary task affect the performance of the operator, but the possibility of the negative effect about excessive secondary task on operator performance can't be ruled out. Therefore, studies are being conducted to reduce the number of unnecessary secondary task or to minimize the amount of secondary task by using the operator support function, and some have already been reflected in the design of the advanced MCR. In the case of APR1400, 'Screen Link Button' provided in the computerized procedure system (CPS) is an example.

Figure 3 shows two ways of screen navigation by operator. In conventional MCR, In order to go to the target screen, it need to access the system directory page. However, when the screen link button of CPS is clicked, the target screen is displayed on IFPD in one operation.

If 'screen link button' is used, the execution, it is not necessary to perform the 'screen selection' step of the soft control operation. In order to evaluate the effect of 'screen link button' in CPS on the screen navigation task of the operator, the analysis was performed using two factors, 'ratio of screen navigation' and 'ratio of using screen link button'.

4.1 Ratio of Screen Navigation

'Ratio of Screen Navigation' is proposed in order to see the ratio of the paths` number used by the operator in the actual operation. It is the value obtained by dividing the number of screen navigation performed by the operator to move to the target screen into optimal number of screen navigation in the design.

$$Ratio\ of\ Screen\ Navigation = \frac{Number\ of\ screen\ navigation\ used\ by\ the\ operator}{Smallest\ number\ of\ screen\ navigation\ by\ design}$$

4.2 Ratio of Using Screen Link Button

'Ratio of using screen link buttons' is the ratio of 'screen link button' used when the operator moves the screen. It indicates how well the operator is using the 'screen link button' designed in CPS

$$Ratio\ of\ Using\ Screen\ Link\ Button = \frac{Number\ of\ screen\ link\ button\ used\ by\ the\ operator}{Maximum\ number\ of\ screen\ link\ button\ available}$$

4.3 Analysis Result

Based on the SGTR and SBO simulator data, the use of screen link button and the number of screen navigation about RO and TO were analyzed. Through graphs of Figure 4, it can be seen that 'ratio of screen navigation' decreases as 'ratio of using screen link button'. The number of operator`s screen navigation, that is, 'SWITCH_SCR' of the secondary task is reduced due to the proper use of 'screen link button' in CPS.

The limitations of the data were that operators did not use the buttons due to operator`s unfamiliarity with 'screen link button'.

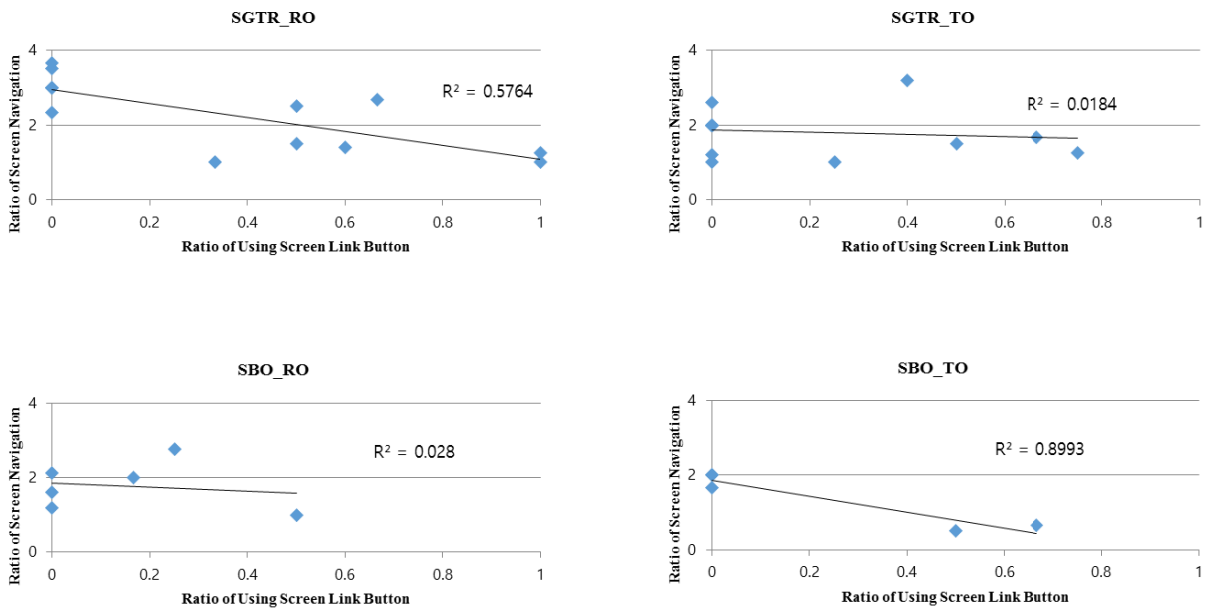


Figure 4. Ratio of screen navigation and ratio of using screen link button about each scenarios.

5 CONCLUSION

The changed operational environment of advanced MCR changes tasks of the operators. Secondary task for interface management required in operational task by using software controller is representative task newly appearing in advanced MCR. In this research, the detailed analysis of soft control operation is carried out as the base study to evaluate the influence of the operation performance using the soft controller. For detailed task analyzing about SC, form of soft control operation and the procedure of operation are analyzed by using video data of MCR advance simulator-operation.

Considering only the number of manipulations, secondary task occupies a relatively larger part than primary task, and the screen navigation ration is high among secondary task. In addition, the effect of 'screen link button' which is one of the operator support system to optimize secondary task is analyzed. As a result, it is found that operator support system helps to reduce secondary task.

The human error probability of the operator is difficult to know the exact value through the simulation data of 20 times. In order to evaluate exactly the human error probability, more data is needed to assess human error probability exactly.

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