Scoping of the Supportive Function of an Operator Support System from Operational Procedures

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1. Introduction

Automation of nuclear power plant operation is an inevitable trend, but it is too early to apply it widely right now. Prior to the application of a complete automation system, there may be a development strategy that applies the operator support system first and promotes high-level driving automation through the results obtained from its performance. Therefore, the operator support system is also an inevitable method when promoting the step-by-step application of automation system.

This paper suggests a method for determining the development scope of the operator support system.

2. Methods and Results

2.1 First step: Analysis of operational procedures

Nuclear power plant operational tasks can be divided into skill-based, rule-based, and knowledge-based from the perspective of the operator's task (refer to Fig. 1.). It is understood that the knowledge-based task is a high-level activity that consumes more cognitive resources than the skill-based task. Nuclear power plants are complex systems, but they are basically operated by procedures, indicating that most of the operator's task are rule-based. In situations such as beyond-DBA (design basis accident), which must be operated only by steps or instructions in some guidelines, the knowledge-based task must be performed mostly. In the case of rule-based task, behaviors such as comparison or judgment are mainly required, but knowledge-based tasks require atypical activities such as decision-making and planning. Most operator support systems are being developed for knowledge-based task that require high-level cognitive activities, and in fact, operator support for skill-based and rule-based tasks can be effective to reduce the number of human errors. This is because the largest percentage of operational tasks performed by operators in nuclear power plant operations belongs to the rule-based task.

From this point of view, when developing an operator support system, it is also the basis for development to analyze the operational procedure and seek supportive measures for rule-based tasks. It is to decompose each step of the operational procedure into task units and distinguish whether it is skill-based, rule-based, or even knowledge-based for the decomposed task. Determining whether to provide support functions for the collected rule-based tasks can determine the development scope of the operator support system to be developed.

In this case, the scope of development may include a considerable number of support functions unrealistically. Therefore, it is necessary to adjust the scope of support in consideration of the weight of the support function.

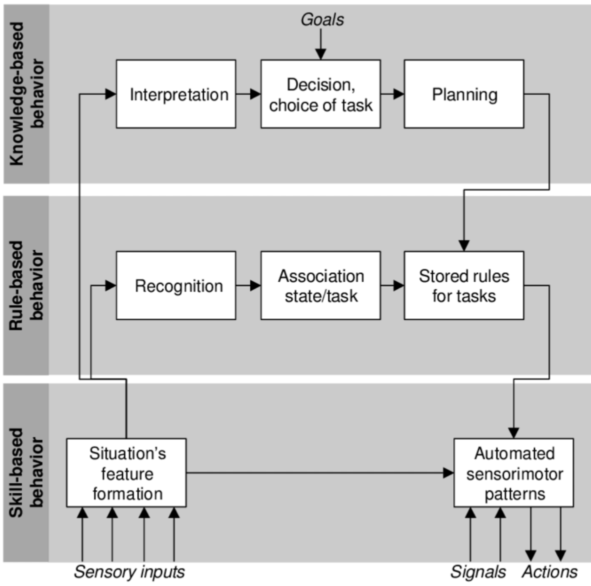

Fig. 1. Rasmussen SRK model [1]

2.2. Second step: Adjusting the development scope based on the operational limits

One of the criteria that can be used to adjust the scope of support is the frame related to the operation limit. Figure 2 shows an example of displaying the safety limit, safety system settings, and the range of normal operation according to the coolant temperature.

The range of state operation means a stable operating condition in an area containing acceptable fluctuations. In this state, the operator support system shall indicate ‘normal operation’. Curve 1 is a situation in which the coolant temperature exceeds the alarm setting value, but does not exceed the operational limit due to the appropriate intervention of the operator. This situation corresponds to the case where the operator support system needs to provide support functions most intensively. The timely and accurate content of operator intervention will be important functional requirements of an operator support system. It will also be necessary to provide a monitoring function for the trend of variables after intervention.

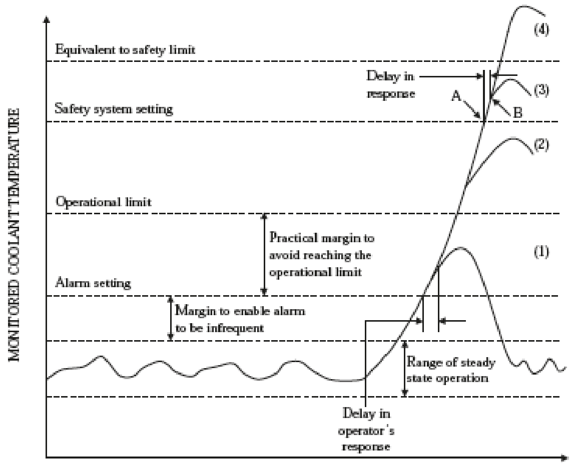

Fig. 2. Safety limit and operator interventions [2]

Curve 2 is the result of the operator taking appropriate actions to control the transient without activating the safety system. It would be the case where the transient is controlled due to the proper performance of the AOP (abnormal operating procedure) before entering the EOP (emergency operating procedure). Since the operator support system can provide a support function challengingly and it is generally an urgent situation for operator action, so operator support functions often are urgently provided.

Curve 3 is a situation in which the nuclear power plant emergency operation procedure is applied and the safety system is operated. Since it can include cases where human errors have already occurred, the operator support system should also take them into account.

Curve 4 is a severe accident situation that deviates from the design basis, and accident management measures must be applied. In fact, in this case, knowledge-based operational behavior accounts for the majority, thus the operator support system needs to have intelligent support functions which can provide operational strategies or plans.

When determining a task to be supported by the operator support system, it would be most effective to select a task that can bring out situation such as curve 1 or 2 rather than 3 or 4.

3. Conclusions

Determining which task to support is a question that requires much effort. As one of approach to scope the development range for the operator support system, a two-step method based on operational procedures and operational limit is suggested in this paper. This method is expected to be applicable to support rule-based operator tasks, and other methods should be sought to support knowledge-based tasks.

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