# DEVELOPMENT OF AN INTELLIGENT OPERATOR DECISION SUPPORT SYSTEM FOR ABNORMAL STATES IN NUCLEAR POWER PLANTS

Jae Min Kim[1], Young Ho Chae[1], Seo Ryong Koo[1]

[1] *Affiliation Information: Korea Atomic Energy Research Institute, Daedeok-daero 989 beon-gil/111, Yuseong-gu, Daejeon, 34057, jaemink@kaeri.re.kr*

## EXTENDED ABSTRACT

Nuclear power plants are operated by human operators following predefined procedures based on plant conditions. In abnormal or emergency situations, unlike general operating procedures used to maintain or change plant states during normal conditions, quick and accurate selection of the appropriate procedure is essential to prevent core damage [1]. This cognitive process—situation assessment, decision-making, and action—can be mapped to Rasmussen's Decision Ladder [2], as shown in Fig. 1. This study aims to support this process by providing key information and analysis to enhance decision speed and reliability.

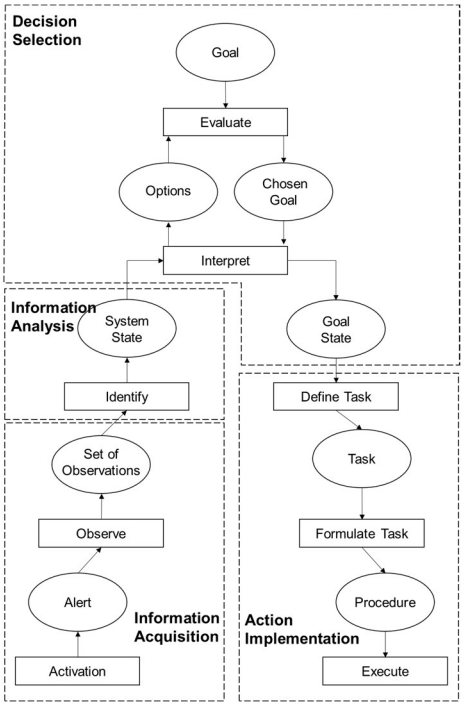


**FIGURE 1. Decision ladder and functions of the support system**

To address the challenges in operator decision-making, we are developing an Intelligent operator Decision Support System (IDSS) [3, 4]. The overall structure of the IDSS is shown in Fig. 2. The system is designed to support the operator's cognitive process by structuring the response into four distinct stages. The process begins with an early warning stage, which provides proactive warnings based on plant data even before official alarms are triggered. This is followed by the abnormal operating procedure (AOP) selection stage, where the system presents its own analysis on the appropriate AOP to aid the operator's selection. During the Procedure Execution Stage, the system guides the operator through the required steps by clearly displaying relevant information and checklists, while also issuing timely alerts to prevent a potential reactor trip. Finally, the post-response stage supports a safe and efficient plant shutdown if it becomes necessary.

The system performs these functions using several core modules. These include artificial intelligence (AI) diagnostics with supporting evidence, prediction of trip-related parameters, preventive action support based on AOP or system state, and

ensuring data reliability by masking faulty signals [5]. These functions are handled by dedicated modules for diagnosis, prediction, preventive action support, and signal validation and verification, respectively. Specifically, the diagnosis module employs a hybrid algorithm combining convolutional neural networks and fuzzy logic; the prediction module utilizes a Transformer-based model; and the signal validation module incorporates a variational autoencoder architecture built upon recurrent neural networks.

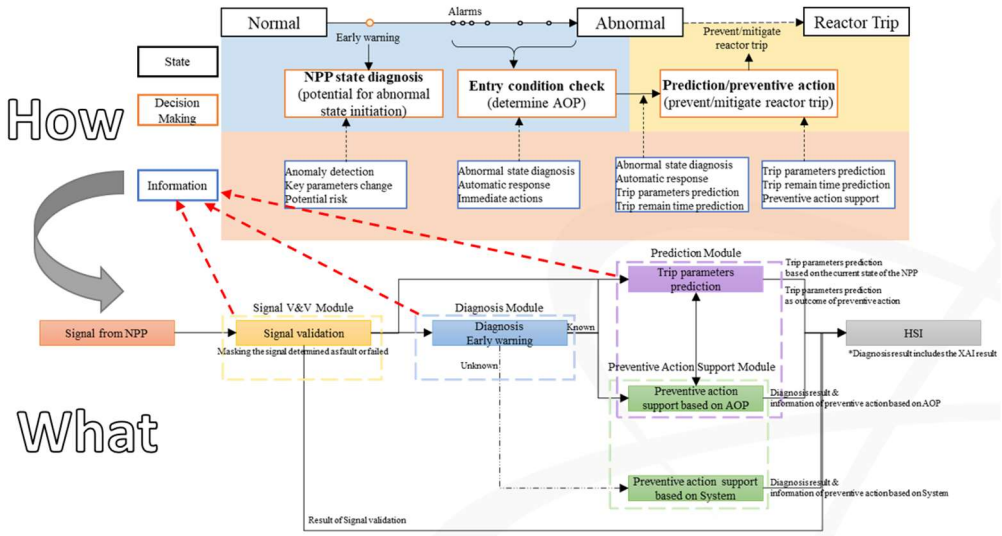


**FIGURE 2. Overall structure of intelligent operator decision support system**

The research has now reached the prototype stage, with each core module developed and functional. Our current work focuses on implementing the user interface, which involves identifying the essential information for operators and designing its optimal presentation. To this end, we have conducted a detailed analysis of operating procedures to map operator tasks and to structure the information to be delivered through the IDSS.

By providing stage-specific information, the system aims to reduce human errors observed in past incidents. It enhances situational awareness and supports accurate operator decisions during abnormal conditions. To prevent cognitive overload from the additional information, a dedicated training program will be needed to ensure proper system use. Building on this, ongoing research focuses on presenting filtered AI-generated results in a way that highlights the most relevant information, helping operators respond more effectively and contributing to safer plant operations.

## ACKNOWLEDGMENTS

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