A Levels-of-Automation Framework for Computerized Procedure Systems in Small Modular Reactors

Choi Soohyeon[a], Kim Jonghyun[b]
[a] KAIST, Daejeon, Republic of Korea, science326@kaist.ac.kr
[b] KAIST, Daejeon, Republic of Korea, jonghyun.kim@kaist.ac.kr

Abstract: Computerized Procedure Systems (CPSs) are operator-support tools that replace conventional paper-based procedures in nuclear power plants by providing procedural guidance and related operational information. By combining real-time plant data with automated logic, CPSs help operators carry out complex procedures more accurately and efficiently. Typical CPS functions include procedure presentation and selection, process information display, evaluation of procedural step logic, and access to soft controls or embedded functions. Small Modular Reactors (SMRs), which are gaining attention as a next-generation nuclear technology, are generally expected to incorporate high levels of automation along with their integral or modular designs and extensive reliance on passive safety features. In addition, many SMR concepts assume reduced staffing and the operation of multiple modules from a single control room, making advanced automation essential. In this environment, CPS is expected to play a central role, since operator activities in SMRs are largely procedure-based. As a result, CPS must evolve beyond a simple procedure reference tool into more active involvement in the operation through the automation. These SMR characteristics call for a new definition of CPS levels of automation. Although several documents, including EPRI guidance and U.S. NRC reports, describe CPS functions and classify CPS types according to the degree of implemented functions, they mainly address high-level definitions of automation and do not adequately reflect the operational characteristics of SMRs. Existing levels-of-automation frameworks were originally developed for large nuclear power plants and therefore do not fully capture the cognitive support capabilities required in highly automated SMR environments. In this light, this study proposes a practical levels-of-automation framework for CPS design in SMRs. First, CPS functions relevant to SMR characteristics are identified through a review on CPSs and SMRs. Second, these functions are allocated across automation levels to develop a revised six-level taxonomy ranging from basic procedure display to integrated soft control and procedure-based automation of operational steps. The proposed framework is intended to serve as an early-stage design reference for the development and licensing of CPSs for SMRs.

Keywords: Small Modular Reactor; Computerized Procedure System; Levels of Automation; Procedure-Based Automation; Human Factors Engineering

1. INTRODUCTION

Small Modular Reactors (SMRs) are being developed with operational concepts that differ markedly from those of large light-water reactors, combining modular multi-unit deployment, reduced operating-crew sizes, and substantially enhanced passive safety. NuScale’s standard plant manages up to twelve power modules from a single control room, and KAERI’s SMART(System-integrated Modular Advanced Reactor) couples two units within a shared compound building; both rely on passive safety systems that maintain a safe shutdown condition for extended periods without operator action. In the digital MCRs envisioned for these plants, the Computerized Procedure System (CPS) is the medium through which operators monitor plant state, assess situations, plan responses, and execute control actions. The level of automation (LOA) at which a CPS implements each of these functions therefore has direct consequences for operating efficiency, operator cognitive load, situation awareness, and the burden of regulatory review.

Two bodies of knowledge bear on this problem but have matured largely in isolation. On one side, LOA classification has been established in the human-factors and nuclear-licensing literature, from the single-dimension scale of Sheridan and Verplank [1] and the four-stage model of Parasuraman, Sheridan and Wickens [2] to nuclear-specific guidance such as NUREG-0700 Rev.3 [3] and the cross-industry adaptation of Alberti et al. [4]. On the other side, guidance on CPS functions has been codified in documents such as NUREG/CR-6634 [5] and EPRI 1015313 [6]. What is missing is a systematic bridge between the two—a framework that states which CPS function should be realized at which level of automation—and SMR-specific treatment of this question is rarer still.

This study proposes a practical levels-of-automation framework for CPS design in SMRs. First, CPS functions relevant to SMR characteristics are identified through a structured literature review on CPSs and SMRs. Second, these functions are allocated across automation levels to develop a revised six-level framework ranging from basic procedure display to integrated soft control and procedure-based automation. Section 2 reviews the relevant taxonomies, CPS function guidance, and SMR characteristics; Section 3 identifies the CPS functions; Section 4 develops the six-level framework; Section 5 presents the function-to-LOA allocation; and Sections 6 and 7 discuss implications and conclude.

2. **RELATED WORK**

2.1. Levels-of-Automation Taxonomies

The earliest quantified LOA scale, the ten-point scale of Sheridan and Verplank [1], arranges automation along a single dimension of human–computer authority; its principal limitation is that it cannot express that a system may be highly automated in information analysis while remaining manual in action execution. Parasuraman, Sheridan and Wickens [2]—hereafter P-S-W—addressed this by decomposing automation into four stages of human information processing: information acquisition, information analysis, decision and action selection, and action implementation, with a level of automation set independently for each stage. This four-stage decomposition is the cognitive foundation on which the present framework's dimensions are built. Save and Feuerberg [7] operationalized the same model as a per-function automation taxonomy, providing a methodological precedent for allocating CPS functions across automation dimensions rather than along a single scale.

Cross-industry taxonomies contribute analytical constructs that a successor framework must accommodate. SAE J3016 [8] defines six levels of driving automation and the influential notion that one inter-level transition is a qualitative "tipping point" at which fallback responsibility shifts from human to system. Alberti et al. [4] translated such constructs into a six-level scale for nuclear reactor operations, locating a tipping point at the Level 3-to-4 transition and—importantly—placing computer-based procedure systems at a relatively low automation level (Operator Assistance). This both validates the cross-industry adaptation strategy adopted here and indicates that a reactor-wide scale is too coarse to describe CPS automation, motivating a finer-grained analysis. Within the nuclear domain, EPRI 1015313 [6] describes the progression from paper procedures through electronic and computer-based procedures (CBP) to procedure-based automation (PBA), while NUREG-0700 Rev.3 [3] defines a five-level scale for nuclear-plant applications—Manual, Shared, Operation by Consent, Operation by Exception, and Autonomous—that is the current NRC reference for characterizing automated functions. We draw on both the cross-industry adaptation strategy of Alberti and the four-stage decomposition of P-S-W as the foundation of our framework.

2.2. CPS Functions

The single largest source for the CPS functions enumerated here is NUREG/CR-6634 [5], which characterizes plant procedures as "instructions to guide operators in monitoring, decision making, and controlling the plant" and frames the operator's primary tasks as monitoring and detection, situation assessment, response planning, and response implementation. This four-task structure is reiterated and made explicit in O'Hara and Higgins [9], which grounds it directly in the P-S-W [2] four-function model, and it is cited in the same form by Alberti et al. [4]. EPRI 1015313 [6] supplies the basis for soft-control integration and hold points, and concrete implementation experience is documented for the Korean APR1400 [10]. Recent work addresses the automation of surveillance and test procedures [11] and the empirical effect of CPS automation level on operator workload and trust [12].

2.3. SMR Characteristics

SMR characteristics are drawn primarily from the IAEA SMR Technology Catalogue [13], using NuScale and SMART as the two most mature representative cases, supplemented by the SMART MCR concept of operations [14]. NuScale's standard plant deploys up to twelve power modules managed from a single control room, with NRC approval for three operators controlling up to twelve reactors, and a fully passive safety case requiring "no need for operator or computer action, AC or DC power, or the addition of water." Its instrumentation and control is fully digital (an NRC-approved FPGA-based protection platform), and human factors engineering (HFE) is integrated into the design. SMART is an integral PWR (365 MW(t) / 107 MW(e)) whose passive residual-heat-removal system operates "for 72 hours without any corrective action by operators," using a digital man-machine interface within a computer-based MCR and deploying two units sharing one compound building. For CPS design, the salient common implications are: multi-unit operation requires automation to distribute operator cognitive load and to share procedure state across units; long passive-safety grace periods make a lower LOA tolerable for emergency procedures while sustaining situation awareness becomes the challenge; digital I&C makes CPS–soft-control integration feasible and expected; small crews raise the value of automatic procedure call-up; and HFE-integrated design makes CPS review part of the plant HFE program.

3. IDENTIFICATION OF CPS FUNCTIONS RELEVANT TO SMRS

To identify CPS functions relevant to SMR characteristics, we conducted a structured literature review using Google Scholar as the primary database, combining the terms "computerized procedure system," "computer-based procedure," "level of automation," and "nuclear power plant." Industry and regulatory guidelines (NUREG-0700 Rev.3, NUREG/CR-6634, EPRI 1015313) were included as foundational sources regardless of citation frequency, and SMR-specific references were drawn from the IAEA SMR Technology Catalogue [13] and design documentation for NuScale and SMART.

As shown in Table 1, The twenty-two functions identified are organized into five categories. The first four—Monitoring & Detection, Situation Assessment, Response Planning, and Response Implementation—follow the operator task structure of NUREG/CR-6634 [5], itself grounded in the P-S-W [2] four-stage cognitive model; this dual basis provides both a regulator-recognized structural rationale and the foundation for the dimensional analysis in Section 4. A fifth category, Management & Support, captures cross-cutting functions (note-taking, logging, version control, paper backup) that operate alongside the cognitive sequence rather than within a single stage.

4. CPS LOA FRAMEWORK

4.1. Limitations of Existing Taxonomies

To evaluate whether existing LOA taxonomies suffice for SMR CPS design, we derive requirements from three streams of existing literature rather than defining them: a regulatory stream (NUREG-0711 [15], NUREG-0700 Rev.3 [3], EPRI 1015313 [6]); a cognitive-automation-theory stream (P-S-W [2], Sheridan [16], Endsley and Kiris [17], Scerbo [18], Kaber and Endsley [19]); and a cross-industry stream (SAE J3016 [8], Alberti et al. [4]). The resulting seven requirements concern (R1) nuclear-domain specificity, (R2) direct applicability to CPS automation, (R3) stage-wise information-processing analysis, (R4) the Consent/Exception distinction, (R5) sub-division of cognition/decision aiding, (R6) tipping-point analysis, and (R7) support for adaptive LOA. Table 2 evaluates existing taxonomies and the present framework against the same externally derived criteria.

Table 1: CPS function taxonomy (five categories, twenty-two sub-functions).

Category	Functions
1. Monitoring & Detection (Stage 1)	F1.1 real-time parameter display & navigation; F1.2 trend graphs; F1.3 monitoring/recording of operator actions
2. Situation Assessment (Stage 2)	F2.1 entry-condition determination & notification; F2.2 step-state distinction & updating; F2.3 caution/warning display; F2.4 execution-history retrieval; F2.5 procedure-state sharing among operators
3. Response Planning (Stage 3)	F3.1 procedure prioritization & presentation; F3.2 procedure-list browsing & search; F3.3 previous/next procedure transition; F3.4 cross-procedure hyperlinking
4. Response Implementation (Stage 4)	F4.1 sequential step display; F4.2 active-step emphasis; F4.3 textual-instruction display; F4.4 completed-step check marking; F4.5 correction/override; F4.6 hold-point/break-point setting; F4.7 procedure-linked soft control
5. Management & Support (cross-cutting)	F5.1 note-taking; F5.2 automatic logging; F5.3 version control; F5.4 paper-backup transition support

Table 2: Conformance of existing taxonomies to literature-derived requirements (✓ met; △ partial; ✗ not met).

Requirement	[1]	[2]	[3]	[4]	[6]	[8]	This work
R1. Nuclear-domain specificity	✗	✗	✓	✓	✓	✗	✓
R2. Direct application to CPS	✗	✗	△	✗	✓	✗	✓
R3. Stage-wise analysis	✗	✓	✗	✗	✗	△	✓
R4. Consent/Exception	✗	✗	✓	✓	△	✓	✓
R5. Cognition/decision sub-division	✗	△	✗	✗	△	✗	✓
R6. Tipping-point analysis	✗	✗	✗	✓	✗	✓	△
R7. Adaptive LOA	✗	△	△	✓	✗	△	△

No single existing taxonomy satisfies all seven requirements; in particular, none simultaneously offers nuclear-domain specificity, direct CPS applicability, and a stage-wise decomposition. The present framework is honest about its own gaps: R6 is partial because it identifies a single tipping point (Level 3→4) rather than several, and R7 is partial because Section 6 offers static procedure-type guidance rather than runtime adaptive transitions. The framework is thus a structural and analytical foundation grounded in regulatory and theoretical literature.

4.2. Classification Dimensions and Six Levels

Because the function taxonomy follows the four-task structure of NUREG/CR-6634 (grounded in P-S-W), we use the same structure to define three LOA dimensions: an Information dimension D1 (P-S-W Stages 1+2), a Decision-support dimension D2 (Stage 3), and an Action-implementation dimension D3

(Stage 4). Stages 1 and 2 are consolidated because automated monitoring and automated assessment are typically deployed together. Each dimension takes graduated values: D1 ∈ {None, Display-only, Embedded-data, Diagnostic}; D2 ∈ {None, Alert, Advisory, Recommendation}; and D3 ∈ {Manual, Consent, Exception, Autonomous}, where Consent means the system executes after explicit approval, Exception means it executes unless vetoed, and Autonomous means it executes with the operator retaining only an intervention authority. (An earlier four-dimension version included a separate operator-supervision mode; it was removed as redundant with D3.)

From this space we identify six combinations corresponding to qualitatively distinct CPS configurations, as shown in Table 3. The progression escalates naturally—the system first enriches information, then assists decisions, and finally takes over implementation.

Table 3: CPS LOA levels (six-level framework)

Level	Name	D1 (Information)	D2 (Decision)	D3 (Action)
1	Digitized Paper Procedure	Display-only	None	Manual
2	Cognitive-Aiding Procedure	Embedded-data	Alert	Manual
3	Decision-Aiding Procedure	Embedded-data	Recommendation	Manual
4	PBA–Consent	Diagnostic	Recommendation	Consent
5	PBA–Exception	Diagnostic	Recommendation	Exception
6	Autonomous Procedure Execution	Diagnostic	(internalized)	Autonomous

Levels 1–3 keep action authority entirely with the operator while progressively aiding cognition (Level 2) and decision-making (Level 3); these intermediate, in-the-loop levels are intended to mitigate the out-of-the-loop performance problem [17]. The Level 3-to-4 transition is the framework's tipping point: D1 and D3 change simultaneously and, for the first time, the system gains action-implementation authority, shifting the operator's role from controller to approver. This transition corresponds to the introduction of PBA in EPRI 1015313 [6] and to "Operation by Consent" in NUREG-0700 Rev.3 [3], and it elevates the HFE verification-and-validation burden under NUREG-0711 [15]. The proposed levels map cleanly onto existing taxonomies—Levels 1–6 correspond approximately to NUREG-0700's Manual, Manual–Shared, Shared, Consent, Exception, and Autonomous, and to Alberti's Levels 0 through 4–5—so adopting the framework requires no redefinition of established regulatory terms.

The six levels can be summarized as follows:
Level 1 – The CPS is limited to digital presentation: the contents of paper-based procedures (PBPs) are simply ported to a digital display medium. The operator is fully responsible for interpreting, judging, and executing the procedure content, sequence, and conditional branching.
Level 2 – The CPS supports situation awareness and attention-resource allocation through procedure-progress tracking, completion check-off, current-step highlighting, and embedded process variables. It is linked to plant data (soft data link) so that plant state is automatically displayed, but judgment and execution remain the operator's responsibility.
Level 3 – The CPS automatically evaluates procedure entry conditions, recommends branch-point selections, and verifies input consistency with error warnings—for example, automatic EOP-entry diagnosis and automatic evaluation of branching logic. All control actions, however, are still performed manually by the operator.
Level 4 – Procedure-based automation begins: the system executes actions automatically only under explicit operator approval. For each automated execution block, the operator must give explicit consent (e.g., pressing an "Execute" button) before the system performs the action.
Level 5 – The system executes actions automatically unless the operator rejects them. The CPS announces an upcoming automated action and, if the operator does not reject it within a defined time window, the action is executed.

Level 6 – The CPS autonomously performs procedure selection, entry, execution, transition, and termination. The operator retains only monitoring authority and the right to intervene when anomalies occur.

4.3. ALLOCATION OF CPS FUNCTIONS ACROSS LOAS

Integrating the taxonomy of Section 3 with the framework of Section 4 yields a function-to-LOA allocation matrix as is shown in Table 4.

Table 4: Function-to-LOA allocation matrix.

Function	L1	L2	L3	L4	L5	L6
F1.1 Parameter display & navigation	✗	◐	●	●	●	●
F1.2 Trend graphs	✗	◐	●	●	●	●
F1.3 Action monitoring/recording	✗	●	●	●	●	●
F2.1 Entry-condition determination	✗	◐	◐	●	●	●
F2.2 Step-state distinction/updating	◐	●	●	●	●	●
F2.3 Caution/warning display	◐	●	●	●	●	●
F2.4 Execution-history retrieval	●	●	●	●	●	●
F2.5 Procedure-state sharing	✗	◐	●	●	●	●
F3.1 Procedure prioritization	✗	◐	●	●	●	●
F3.2 Procedure-list browsing/search	●	●	●	●	●	●
F3.3 Previous/next transition	◐	◐	●	●	●	●
F3.4 Cross-procedure hyperlinking	●	●	●	●	●	●
F4.1 Sequential step display	●	●	●	●	●	●
F4.2 Active-step emphasis	●	●	●	●	●	●
F4.3 Textual-instruction display	●	●	●	●	●	●
F4.4 Completed-step check marking	◐	◐	●	●	●	●
F4.5 Correction/override	●	●	●	●	●	◐
F4.6 Hold-point/break-point setting	◐	◐	◐	●	●	●
F4.7 Procedure-linked soft control	✗	✗	✗	●	●	●
F5.1 Note-taking	●	●	●	●	●	●
F5.2 Automatic logging	✗	●	●	●	●	●
F5.3 Version control	●	●	●	●	●	●
F5.4 Paper-backup transition	●	●	●	●	●	●

Each function is allocated on three criteria: the LOA at which it first becomes meaningful, the LOAs at which its implementation qualitatively differs, and the highest LOA at which it remains applicable. The function category provides a natural prior—Monitoring functions become meaningful once D1 reaches Embedded-data (Level 2); Situation Assessment and Response Planning functions change qualitatively when D2 reaches Recommendation (Level 3); and Response Implementation functions span the full range, with the critical change at Level 4 (D3 first non-zero). In the matrix, ✗ denotes inapplicable, ◐ partial, and ● full realization.

Specific patterns emerge on F.4.7. in Table 4. The Level 3-to-4 transition is where fundamentally new capability appears: F4.7 (procedure-linked soft control) is empty below Level 4 because D3 is Manual, and becomes non-empty exactly at the tipping point—appearing at Level 4 with per-action operator consent, becoming automatic-with-veto at Level 5, and autonomous at Level 6.

And Two functions also serve as good examples of the design logic proposed in this study. F1.1 (real-time parameter display) escalates through a four-step policy: navigation-only (Level 1), display-only (Level 2), display-plus-navigation (Level 3), and display-plus-control (Levels 4–6), so that only above the tipping point does parameter display integrate with soft control. F2.5 (procedure-state sharing) is especially critical for SMRs. According to the function-level allocation proposed in this study, Level 1 provides no situation sharing between operators, while Level 2 only indicates the extent to which each operator has progressed through the procedure. From Level 3 onward, operators are able to share procedure states in real time. Because NuScale's twelve-module configuration and SMART's two-unit shared MCR structure require simultaneous procedure execution across multiple units, real-time state sharing (Level 3 and above) is not merely an enhancement but is close to a functional requirement.

6. DISCUSSION

The allocation matrix assigns a single LOA progression per function, but the appropriate LOA also depends on the procedure type in which a function is invoked. Rather than prescribe fixed values, we note that the target LOA should be considered case by case across normal operating procedures (NOP), abnormal operating procedures (AOP), and emergency operating procedures (EOP). NOPs involve extended routine monitoring during which sustained attention degrades, so higher LOAs help reduce cognitive load; EOPs require rapid, high-stakes decisions, so a lower LOA preserves operator authority and avoids out-of-the-loop problems [17]. SMR passive safety reinforces this: the long no-operator-action grace period of NuScale and SMART means EOP functions can tolerate a lower LOA without increasing immediate safety risk, while multi-unit operation pressures NOP functions toward higher LOAs. The empirical results of Schreck et al. [12], favoring management-by-consent over management-by-exception during a simulated emergency, support the lower-LOA recommendation for EOPs.

For design and licensing, the framework is intended to serve the following purposes. It can be used as a design-stage tool for declaring a target LOA for each of the twenty-two CPS functions, and because the proposed six-level scheme corresponds to NUREG-0700 Rev.3 [3], it can help quantitatively describe automation levels in licensing documentation. Additional considerations also apply. Functions allocated to Level 4 and above—for example, F4.7 (soft control), F2.1 (entry-condition determination), and F1.1 (parameter display with control)—require enhanced human factors engineering verification and validation under NUREG-0711 [15], because automated CPS functions can add operator monitoring-and-takeover tasks and may thereby increase operator workload. Moreover, higher LOAs (Levels 4–6) may benefit from AI-enabled capabilities such as information processing, state classification, anomaly detection, and learning-based control [4]. However, applying AI to safety-related CPSs poses challenges of trustworthiness and verifiability [20], which warrant dedicated future investigation.

7. CONCLUSION

This study proposed a CPS levels-of-automation framework for SMRs, structured around the identification of twenty-two CPS functions organized into five categories based on the NUREG/CR-6634 operator task structure, and the allocation of these functions across six LOA levels with a three-dimensional characterization derived from the same structure. The framework's principal contributions are a regulator-grounded CPS function taxonomy, a six-level LOA structure with an explicit tipping point at the Decision-Aiding–to–PBA transition, and a function-to-LOA allocation matrix as an early-stage design reference. Future work will validate the allocation matrix through operator-in-the-loop simulator experiments, develop detailed human-system-interface requirements for each function–LOA cell, and address AI-enabled CPS for the higher levels. The proposed framework is intended to serve as an early-stage design reference for the development and licensing of CPSs for SMRs.

Acknowledgements

This research was supported by a grant from the Korea Atomic Energy Research Institute (KAERI) R&D Program (No. KAERI-526141-26) And This work was supported by the Korea Agency for Infrastructure Technology Advancement(KAIA) grant funded by the Ministry of Land, Infrastructure and Transport(Grant RS-2025-02222955).

References

[1] T. B. Sheridan and W. L. Verplank, "Human and Computer Control of Undersea Teleoperators," MIT Man-Machine Systems Laboratory, Cambridge, MA, 1978.
[2] R. Parasuraman, T. B. Sheridan, and C. D. Wickens, "A Model for Types and Levels of Human Interaction with Automation," IEEE Transactions on Systems, Man, and Cybernetics—Part A, vol. 30, no. 3, pp. 286–297, 2000.
[3] J. M. O'Hara and S. A. Fleger, "Human-System Interface Design Review Guidelines," NUREG-0700, Rev. 3, U.S. Nuclear Regulatory Commission, Washington, DC, 2020.
[4] A. L. Alberti, V. Agarwal, I. Gutowska, C. J. Palmer, and C. R. E. de Oliveira, "Automation Levels for Nuclear Reactor Operations: A Revised Perspective," Progress in Nuclear Energy, vol. 157, 104559, 2023.
[5] J. M. O'Hara, J. C. Higgins, W. F. Stubler, and J. Kramer, "Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance," NUREG/CR-6634, Brookhaven National Laboratory / U.S. NRC, 2000.
[6] Electric Power Research Institute, "Computerized Procedures: Design and Implementation Guidance for Procedures, Associated Automation, and Soft Controls," EPRI 1015313, Draft Report, Palo Alto, CA, 2007.
[7] L. Save and B. Feuerberg, "Designing Human-Automation Interaction: A New Level of Automation Taxonomy," in Human Factors: A View from an Integrative Perspective, Proc. HFES Europe Chapter Conference, Toulouse, 2012.
[8] SAE International, "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles," J3016_202104, Warrendale, PA, 2021.
[9] J. M. O'Hara and J. C. Higgins, "Human-System Interfaces to Automatic Systems: Review Guidance and Technical Basis," NUREG/CR-6749, Brookhaven National Laboratory / U.S. NRC, 2010.
[10] J.-H. Hong, M.-S. Lee, and D.-H. Hwang, "Computerized Procedure System for the APR1400 Simulator," Nuclear Engineering and Design, vol. 239, pp. 3092–3104, 2009.
[11] A. Pop, M. A. Rogers, and J. Barroso Martín, "Automating Execution of Surveillance Procedures for NPP Main Control Rooms," Journal of Nuclear Science and Technology, vol. 62, no. 1, pp. 17–32, 2025.
[12] J. Schreck, G. Matthews, J. Lin, S. Mondesire, D. Metcalf, K. Dickerson, and J. Grasso, "Levels of Automation for a Computer-Based Procedure for Simulated Nuclear Power Plant Operation: Impacts on Workload and Trust," Safety, vol. 11, no. 1, 22, 2025.
[13] International Atomic Energy Agency, "Small Modular Reactor Technology Catalogue 2024," IAEA, Vienna, 2024.
[14] A. Al-Qublan, S. K. Kim, and C. H. Kim, "A Concept of Operations for the SMART Main Control Room," Transactions of the Korean Nuclear Society Autumn Meeting, Yeosu, Korea, 2018.
[15] J. M. O'Hara, J. C. Higgins, S. A. Fleger, and P. A. Pieringer, "Human Factors Engineering Program Review Model," NUREG-0711, Rev. 3, U.S. Nuclear Regulatory Commission, Washington, DC, 2012.

[16] T. B. Sheridan, “Humans and Automation: System Design and Research Issues,“ HFES and Wiley, 2002.
[17] M. R. Endsley and E. O. Kiris, “The Out-of-the-Loop Performance Problem and Level of Control in Automation,“ Human Factors, vol. 37, no. 2, pp. 381–394, 1995.
[18] M. W. Scerbo, “Theoretical Perspectives on Adaptive Automation,“ in Automation and Human Performance: Theory and Applications, R. Parasuraman and M. Mouloua, Eds., Erlbaum, pp. 37–63, 1996.
[19] D. B. Kaber and M. R. Endsley, “The Effects of Level of Automation and Adaptive Automation on Human Performance, Situation Awareness and Workload in a Dynamic Control Task,“ Theoretical Issues in Ergonomics Science, vol. 5, no. 2, pp. 113–153, 2004.
[20] L. H. Gilpin, D. Bau, B. Z. Yuan, A. Bajwa, M. Specter, and L. Kagal, “Explaining Explanations: An Overview of Interpretability of Machine Learning,“ Proc. IEEE DSAA 2018, pp. 80–89, 2018.