Introductory review of the NUREG-0711 Rev. 3 and the relevant Guideline being under discussion in the Japan Electric Association

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初めに

- 米国では1979年TMI事故、1986年チェルノビル事故の背景に人的要因問題があるとの認識のもと1994年にNUREG－０７１１人間工学プログラムを導入。それ以来、2012年には3度めの改定Rev.3を発行している。
- 2010年代後半IAEAは米国NRCのHFE採用を反映してSSG-51を制定し、IECも同様にIEC60964を検討中。
- 日本ではIEC６０９６４（制御室設計）を下敷きにしてデイジタル化中央制御室の設計開発プロセスの設計指針JIAG4617を日本電気協会原子力規格委員会で制定し、これを使用してきた。
- 日本でも最近の国際的動向に鑑みて世界標準に合わせて関連国内規格を日本電気協会原子力規格委員会において体系の編成替えをしている。
- 本稿では　まず　米国NUREG－０７１１Rev.3の全体概要を整理して紹介し、ついで日本で進行中の体系化を紹介し、最後に双方のアプローチの相違を考察する。

I. Introduction

- In the United States, the NUREG-0711 ergonomics program was iniciated in 1994 based on the deep recognition of lack of human factors considerations behind the TMI accident in 1979 and the Chernobyl accident in 1986. Since then, the third revision Rev.3 has been published in 2012.
- In the latter half of the 2010s, the IAEA established SSG-51 to reflect the adoption of HFE by the U.S. NRC, and the IEC is considering IEC60964 as well.
- In Japan, the Nuclear Standards Committee of the Japan Electricity Association of Japan has established and used the design guidelines for the design and development process of the digitized central control room based on the IEC60964 (control room design JIAG4617).
- In Japan, in light of recent international trends, the Nuclear Standards Committee of the Japan Electric Association has reorganized the system of related domestic standards in accordance with global standards.
- In this paper, we will first introduce an overview of NUREG-0711 Rev.3 in the United States, then introduce the systematization underway in Japan, and finally consider the differences between the two approaches.

II. Overview of NUREG-0711 Rev. 3 Human Factors Engineering Program Review Model

- Manuscript Completed: September 2012 ,
- Date Published: November 2012
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II.1 Background of NUREG-0711

- One important insight from studies of the Three Mile Island (TMI), Chernobyl, and other nuclear power plant (NPP) accidents is that errors resulting from human factors deficiencies, such as poor control room design, procedures, and training are a significant contributing factor to NPP incidents and accidents.
- Plant safety requires "defense in depth" that encompasses using multiple barriers to prevent the release of radioactive materials, and employs a variety of programs to assure the integrity of barriers and related systems (IAEA, 1999).
- These programs include conservative design, quality assurance, administrative controls, and human factors.
- Human factors engineering (HFE) plays a major role in supporting plant safety and providing defense in depth. The HFE staff of the Nuclear Regulatory Commission (NRC) evaluates the HFE programs of applicants for construction permits (CPs), operating licenses (OLs), standard design certifications (DCs), combined licenses (COLs), and amendments to licenses.
- The purpose of these reviews is to support public health and safety by verifying that the applicant's HFE program incorporates HFE practices and guidelines that are acceptable to the NRC staff. The scope of the NRC staff's HFE reviews includes the design process, the final design, its implementation, and ongoing performance monitoring.

II.2 Major Usage of NUREG-0711

- Used by the staff of the Nuclear Regulatory Commission to review the human factors engineering (HFE) programs of applicants for construction permits, operating licenses, standard design certifications, combined operating licenses, and license amendments.
- The purpose of these reviews is to verify that the applicant's HFE program incorporates HFE practices and guidelines accepted by the staff as described within the twelve elements of an HFE program:

①HFE Program Management, ②Operating Experience Review, ③Functional Requirements Analysis and Function Allocation, ④Task Analysis, ⑤Staffing and Qualifications, ⑥Treatment of Important Human Actions, ⑦Human-System Interface Design, ⑧Procedure Development, ⑨Training Program Development, ⑩Human Factors Verification and Validation, ⑪Design Implementation, and ⑫Human Performance Monitoring.

- Each element encompasses five sections:

①Background, ②Objective, ③Applicant Products and Submittals, ④Review Criteria, and ⑤Bibliography.

II.3 Purpose of HFE Safety Review

1. The overall purpose of the NRC's staff's HFE program review is to verify:

①The applicant integrates HFE into the development, design, and evaluation of the plant.

②The applicant provides HFE products (e.g., HSIs) that facilitate the safe, efficient, and reliable performance of operations, maintenance, tests, inspections, and surveillance tasks.

③ The HFE program and its products reflect state-of-the-art human factors principles [10 CFR 50.34(f)(2)(iii) and 10 CFR 52.47(a)(8)], and satisfy all specific regulatory requirements.

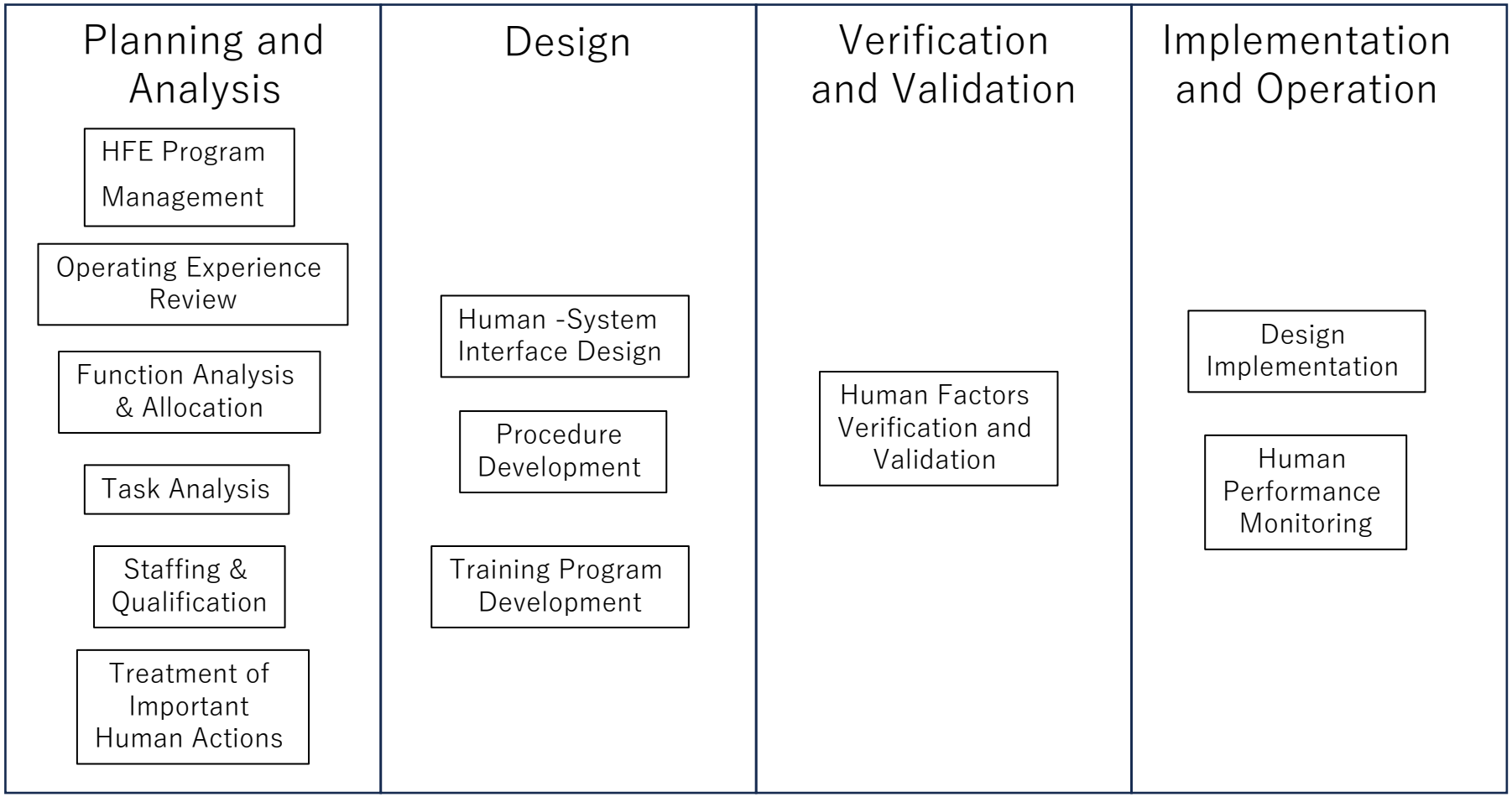
2. 10 CFR 52.47 requires that applications for design certification of new reactor designs meet the technically relevant portions of the TMI requirements in 10 CFR 50.34(f).

3. 10 CFR 50.34(f)(2)(iii) requires that a control room reflects state-of-the-art human factors principles. Also, 50.34 specifically requires several features: A safety parameter display system console; automatic indication of bypassed and operable status of safety systems; and monitoring capability in the control room of a variety of system parameters. 10 CFR 55.46 also necessitates having a plant referenced simulator capability.

II.3 Purpose of HFE Safety Review

- In this document, the state-of-the-art human factors principles are those ones currently accepted by human factors practitioners; here, "current" refers to the time when a plan or product is prepared. "Accepted" is regarded as a practice, method, or guide that is (1) documented in the human factors literature within a standard or guidance document that underwent a peer-review process, or (2) is justified through scientific research and/or industrial practices

II. 4 Arrangement of 12 Review Elements in four general activities



II.4.1.HFE Program Management

- The objective of this element is to verify that the applicant has an HFE design team with the responsibility, authority, placement within the organization, and composition to reasonably assure that the plant design meets the commitment to HFE.
- Further, a plan should guide the team to ensure that the HFE program is properly developed, executed, overseen, and documented.
- The HFE program plan describes the HFE elements to ensure that HFE principles are applied to the development, design and evaluation of HSI, procedures, and training.

II.4.2. Operating Experience Review

- The main purpose of conducting an operating experience review (OER) is to identify HFErelated safety issues. The OER should provide information on the performance of predecessor designs.
- For new plants, this may be the earlier designs on which the new one is based. For plant modifications, it may be the design of the systems being changed. The issues and lessons learned from operating experience provide a basis to improve the plant's design; i.e., at the beginning of the design process.
- The objective of this element is to verify that the applicant identified and analyzed HFE-related problems and issues in previous designs similar to the current one under review.
- In this way, the negative features of predecessor designs may be avoided in the current one, while retaining positive features.
- The OER should consider the predecessor systems upon which the design is based, the technological approaches selected (e.g., if touch-screen interfaces are planned, their associated HFE issues should be reviewed), and the plant's HFE issues.

The Role of Operating Experience Review in the HFE Program

HFE Element	OER Contribution
Functional Requirements Analysis and Function Allocation	Basis for initial requirements
	Basis for initial allocations
	Identification of need for modifications
Task Analysis, Human Reliability Analysis, and Staffing/Qualifications	Important human actions and errors
	Problematic operations and tasks
	Instances of staffing shortfalls
Human-System Interface, Procedures, and Training Development	Trade study evaluations
	Potential design solutions
	Potential design issues
Human Factors Verification and Validation	Tasks to be evaluated
	Event and scenario selection
	Performance measure selection
	Issue resolution verification

II.4.3.Functional Requirements Analysis and Function Allocation

- The purpose of this element is to verify that the applicant defined those functions that must be carried out to satisfy the plant's safety goals and that the assignment of responsibilities for those functions (function allocation) to personnel and automation in a way that takes advantage of human strengths and avoids human limitations.
- The personnel role is examined in two steps: functional requirements analysis, and function allocation (assignment of levels of automation). A functional requirements analysis (FRA) identifies those plant functions that must be performed to satisfy the plant's overall operating and safety objectives and goals: To ensure the health and safety of the public by preventing or mitigating the consequences of postulated accidents. This analysis determines the objectives, performance requirements, and constraints of the design, and sets a framework for understanding the role of controllers (personnel or system) in regulating plant processes.
- Function allocation is the assignment of functions to (1) personnel (e.g., manual control), (2) automatic systems, and (3) combinations of both. Exploiting the strengths of personnel and system elements enhances the plant's safety and reliability, including improvements achievable through assigning control to these elements with overlapping and redundant responsibilities. Function allocations should be founded on functional requirements and HFE principles in a structured, well-documented methodology that produce clear roles and responsibilities for personnel

Vertical slice through a plant's functional hierarchy for ensuring safety

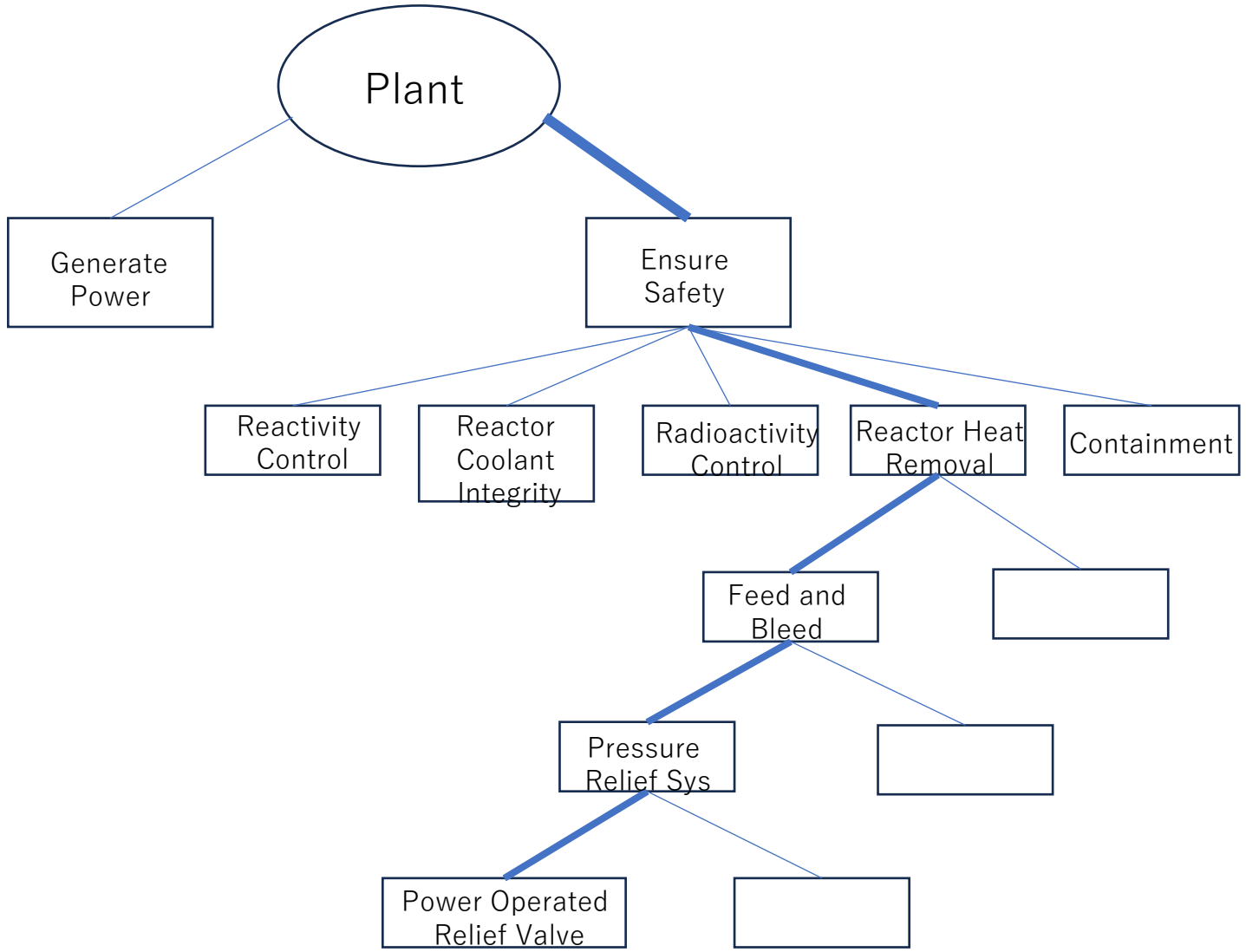
Goals

Safety Functions

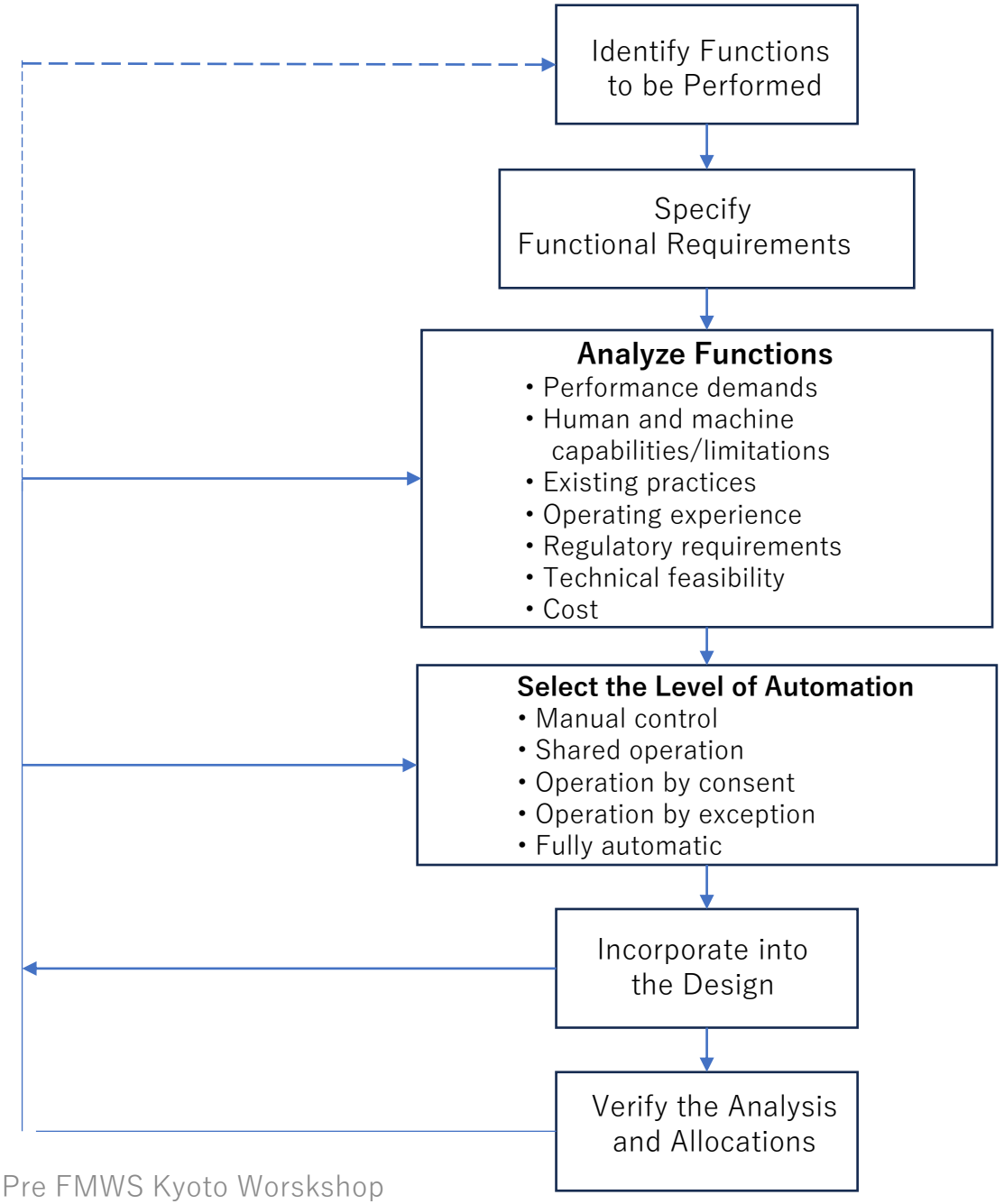
Processes

Systems

Components



Allocation of functions to personnel and automatic systems



II.4.4.Task Analysis

- The functions allocated to plant personnel define the roles and responsibilities that they then accomplish via human actions (HAs). HAs can be divided into tasks, a group of related activities with a common objective or goal.
- The objective of this review is to verify that the applicant undertook analyses identifying the specific tasks needed to accomplish personnel functions, and also the alarms, information, control- and task-support required to complete those duties.
- The results of the task analysis offer important inputs in many HFE activities: (1) The analysis of staffing and qualifications; (2) the design of HSIs, procedures, and training program; and (3) criteria for Task Support Verification.

Task Considerations

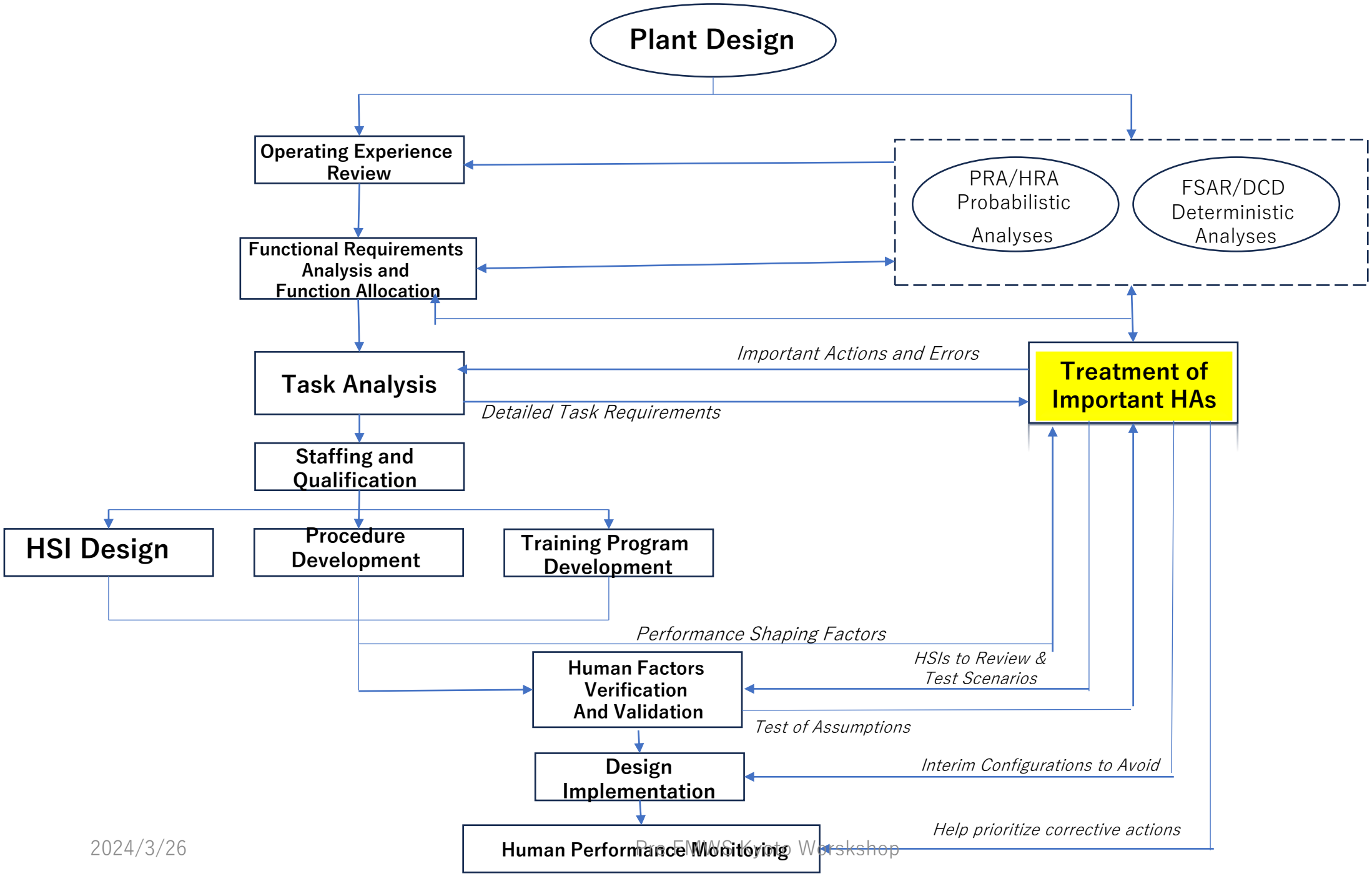
Topic	Example
Alerts	• alarms and warnings
Information	• parameters (units, precision, and accuracy) • feedback needed to indicate adequacy of actions taken
Decision-making	• decision type (relative, absolute, probabilistic) • evaluations to be performed
Response	• actions to be taken • task frequency and required accuracy • time available and temporal constraints (task ordering) • physical position (stand, sit, squat, etc.) • biomechanics - movements (lift, push, turn, pull, crank, etc.) - forces needed
Teamwork and Communication	• coordination needed between the team performing the work • personnel communication for monitoring information or taking control actions
Workload	• cognitive • physical • overlap of task requirements (serial vs. parallel task elements)
Task Support	• special and protective clothing • job aids, procedures or reference materials needed • tools and equipment needed
Workplace Factors	• ingress and egress paths to the worksite • workspace needed to perform the task • typical environmental conditions (such as lighting, temp, noise)
Situational and Performance Shaping Factors	• stress • time pressure • extreme environmental conditions • reduced staffing
Hazard Identification	• identification of hazards involved, e.g., potential personal injury

II.4.5.Staffing and Qualifications

- Plant staffing and staff qualifications are important considerations throughout the design process. Initial staffing levels may be established early in the process based on experience with previous plants, staffing goals (such as for staffing reductions), initial analyses, and NRC regulations. However, their acceptability should be examined periodically as the design of the plant evolves.
- The objective of reviewing staffing and qualification analyses is to verify that the applicant has systematically analyzed the requirements for the number of personnel and their qualifications that includes gaining a thorough understanding of the task and regulatory requirements.

II.4.6.Treatment of Important Human Actions

- Over the past several decades, a goal of the NRC's safety programs has been to use risk analyses to prioritize activities, and to ensure that regulators and licensees alike focus efforts and resources on those activities that best support reasonable assurance of adequate protection of the public's health and safety. HFE programs contribute to this goal by applying a graded approach to plant design, focusing greater attention on HAs most important to safety. Therefore, the objective of this element of an HFE program is to identify those HAs most important to safety for a particular plant design; this is accomplished through a combination of probabilistic and deterministic analyses.
- The review's objectives are to verify that the applicant has (1) identified important HAs, and (2) considered human-error mechanisms for important HAs in designing the HFE aspects of the plant. They should minimize the likelihood of personnel error, and help ensure that personnel can detect and recover from any errors that occur.


Plant Design
Operating Experience Review
Functional Requirements Analysis and Function Allocation
PRA/HRA Probabilistic Analyses
FSAR/DCD Deterministic Analyses
Task Analysis
Important Actions and Errors
Detailed Task Requirements
Treatment of Important HAs
Staffing and Qualification
HSI Design
Procedure Development
Training Program Development
Performance Shaping Factors
HSIs to Review & Test Scenarios
Human Factors Verification And Validation
Test of Assumptions
Design Implementation
Interim Configurations to Avoid
Human Performance Monitoring
Help prioritize corrective actions

II.4.7.Human-System Interface Design

- The objective of this review element is to evaluate the process used by applicants to translate the functional- and task-requirements to HSI design requirements, and to the detailed design of alarms, displays, controls, and other aspects of the HSI.
- A structured methodology should guide designers in identifying and selecting candidate HSI approaches, defining the detailed design, and performing HSI tests and evaluations. The review also addresses the formulation and employment of HFE guidelines tailored to the unique aspects of the applicants' design, e.g., a style guide to define the design-specific conventions.
- In conjunction with HIS design, NUREG-0700　Rev.3　will be separately introduced after NEREG-0711 Rev. 3.

II.4.8. Procedure Development

- Procedures are essential to plant safety because they support and guide personnel interactions with plant systems and personnel responses to plant-related events. In the nuclear industry, procedure development is the responsibility of individual utilities.
- The objective of the NRC procedure review is to confirm that the applicant's procedure development program incorporates HFE principles and criteria, along with all other design requirements, to develop procedures that are technically accurate, comprehensive, explicit, easy to utilize, validated, and in conformance with 10 CFR 50.34(f)(2)(ii). The procedures program is reviewed by NRC staff using SRP Chapter 13

II.4.9. Training Program Development

- Training plant personnel is important in ensuring the safe, reliable operation of nuclear power plants. Training programs aid in offering reasonable assurance that plant personnel have the knowledge, skills, and abilities needed to perform their roles and responsibilities.
- The objective of the training program review is to verify that the applicant has employed a systems approach for developing personnel training. Training programs are reviewed by NRC staff using SRP Chapter 13.

Some Knowledge and Skill Dimensions for Learning Objectives Identification

Topic	Knowledge	Skill
Plant Interactions	Understanding of plant processes, systems, operational constraints, and failure modes	Skills associated with monitoring and detection, situation awareness, response planning, and implementation
HSI and Procedure Interactions	Understanding of procedures and HSI structure, functions, failure modes, and interface management tasks (actions, errors, and recovery strategies)	Skills associated with interface management task
Personnel Interactions (In the MCR and in the plant)	Understanding information requirements of others, how actions should be coordinated with others, policies and constraints on personnel interactions	Skills associated with personnel interactions (i.e., teamwork)

II.4.10. Human Factors Verification and Validation

- Verification and validation (V&V) evaluations comprehensively determine that the final HFE design conforms to accepted design principles, and enables personnel to successfully and safely perform their tasks to achieve operational goals.
- This element involves three evaluations, with the following objectives:

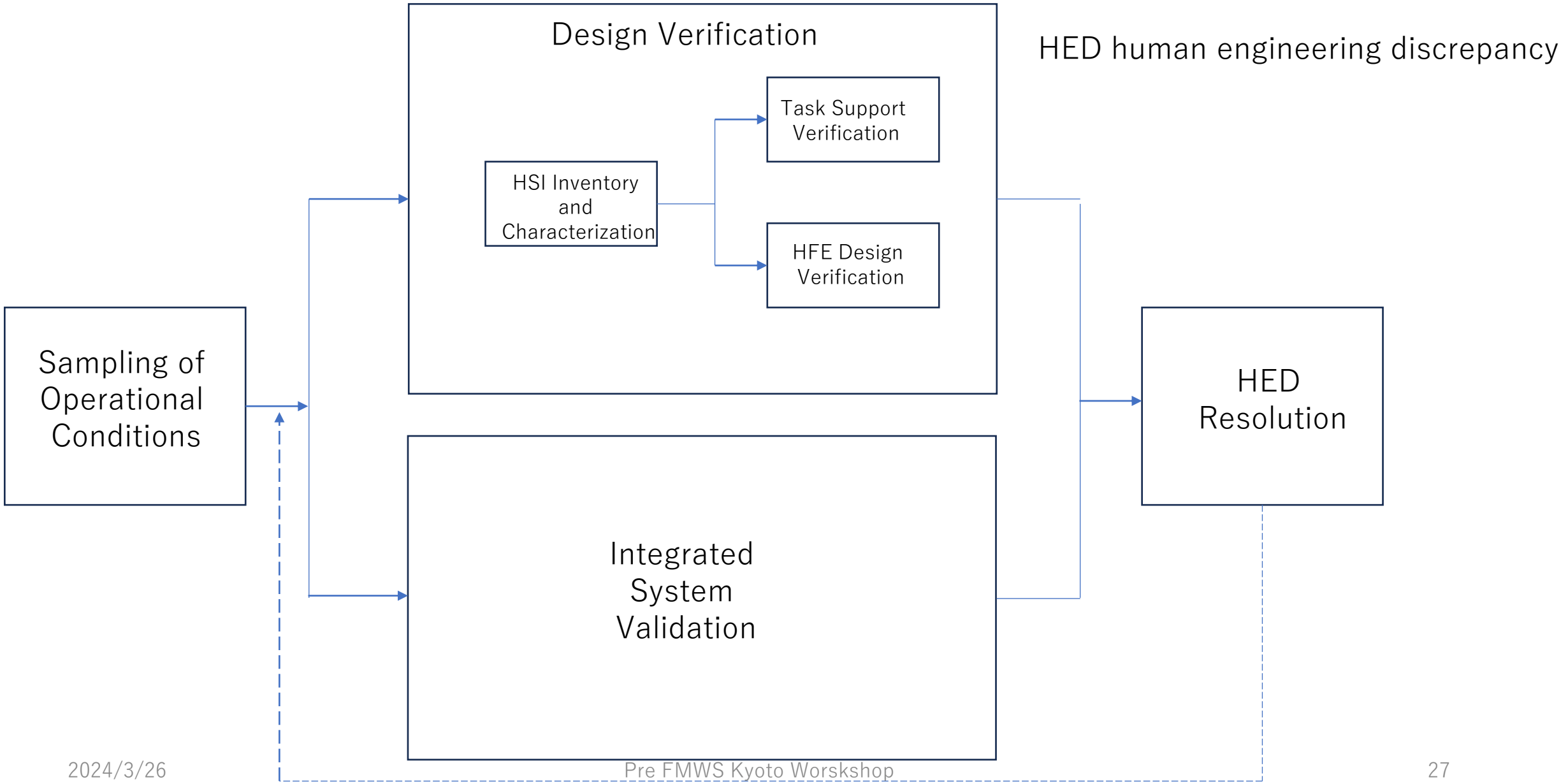
HSI Task Support Verification - the applicant verified that the HSI provides the alarms, information, controls, and task support defined by tasks analysis needed for personnel to perform their tasks.

HFE Design Verification - the applicant verified that the design of the HSIs conform to HFE guidelines (such as the applicant's style guide).

Integrated System Validation - the applicant validated, using performance-based tests, that the integrated system design (i.e., hardware, software, procedures and personnel elements) supports safe operation of the plant.

- These evaluations identify human engineering discrepancies (HEDs). The NRC staff's review of the applicant's HED resolutions verifies that the applicant assessed the importance of HEDs, corrected important ones, and that the corrections are acceptable.

Overview of verification and validation activities



Performance Measurement

- The measures chosen to evaluate personnel task performance should reflect those aspects of the task that are important to system performance, such as:

- time
- accuracy
- frequency
- amount achieved or accomplished
- consumption or quantity used
- subjective reports of participants
- behavior categorization by observer

Performance Measure Information and Validation Criteria

(1) The applicant should describe the methods by which these measures are obtained, e.g., by simulator data recording, participant questionnaires, or observation by subject-matter experts.

(2) The applicant should specify when each measure is obtained (recorded), such as continuously, at specific points during the scenario, or after the scenario ends.

(3) The applicant should describe the characteristics of the performance measures.

(4) The applicant should identify the specific criterion for each measure used to judge the acceptability of performance and describe its basis.

(5) The applicant should identify whether each measure is a pass/fail one or a diagnostic one.

Characteristics of Performance Measures

Characteristic	Meaning
Construct Validity	A measure should represent accurately the aspect of performance it is intended to measure.
Reliability	A measure should be repeatable; i.e., same behavior measured in exactly the same way under identical circumstances should yield the same results.
Sensitivity	A measure's range (scale) and its frequency (how often data are collected) should be appropriate to that aspect of performance being assessed.
Unobtrusiveness	A measure should minimally alter the psychological or physical processes that are being investigated.
Objectivity	A measure should be based on easily observed phenomena.

Basis for Performance Criteria

Criteria Basis	Meaning
Requirement	The observed performance of the integrated system is compared with a quantified performance requirement; i.e., the requirements for the performance of systems, subsystems, and personnel are defined through engineering analyses.
Benchmark	The observed performance of the integrated system is compared with a criterion established using a benchmark system, e.g., a current system is predefined as acceptable.
Norm	The observed performance of the integrated system is compared with a criterion using many predecessor systems (rather than a single benchmark system).
Expert Judgment	The observed performance of the integrated system is compared with a criterionestablished by subject-matter experts.

II.4.11.Design Implementation

- This element addresses implementation of the HFE aspects of the plant design for new plants and plant modifications. For a new plant, the implementation phase is well defined and carefully monitored through start-up procedures and testing; implementing modifications is more complex.
- The objectives of this review are to verify that the applicant's:
  - as-built design conforms to the verified and validated design resulting from the HFE design process
  - implementation of plant changes considers the effect on personnel performance, and affords necessary support to reasonably assure safe operations

Typical Advantages and Disadvantages of Different Methods of Modernization Program Implementation -Many Small Modifications

Advantages

- Minimal disruption to operations

Potential Disadvantages

- Risk of unexpectedly affecting plant operation (such as through spurious actuation). This could be a problem both for operating and shutdown plants, but potentially more serious for the former.
- Likelihood increases for inconsistency and lack of standardization of HSIs as many new, different systems are added separately to the control room (or other operations and support centers). Consequently, personnel may be unsure precisely how each HSI functions.
- Overlapping functionality; many HSIs are available for personnel to take the same actions.
- Training on small modifications may be lacking, so personnel do not use the new systems effectively or at all.

Typical Advantages and Disadvantages of Different Methods of Modernization Program Implementation -Large Modifications During a Single Outage

Advantages

- There is no potential for negative effects on personnel performance of interim configurations because the changes all are made at once.
- More economical than multiple outages because (1) interim periods do not have to be analyzed, (2) procedures do not have to be temporarily modified, and (3) personnel do not have to be trained for temporary plant configurations and HSIs

Potential Disadvantages

- Significant changes to the plant and HSIs can greatly affect the way personnel operate the plant.

Typical Advantages and Disadvantages of Different Methods of Modernization Program Implementation - Large Modifications During Multiple Outages

Advantages

- Large changes to operations can be minimized by breaking up modifications into smaller logical units.
- Plant staff can gain experience with non-safety systems (less critical), so when safety (critical) systems are modified, the plant's staff already are familiar with the HSIs

Potential Disadvantages

- Task performance can be hampered if the interim configuration requires parts of a task to be performed using the old HSI, and other parts with the new HSI.
- Interim stages between old- and new-systems especially are error prone if not fully addressed in analyses, and by training and procedural modifications.

Typical Advantages and Disadvantages of Different Methods of Modernization Program Implementation - Both Old and New Equipment are Left in Place

Advantages

- Any problems with the new system can be identified and resolved while the old HSIs are in place to serve as backups. • Operators can become familiar with the new HSIs while the old HSIs still are available.
- Old HSIs are available in an emergency (research demonstrated that personnel often prefer the familiar HSIs under stressful conditions).

Potential Disadvantages

- HSI conflicts between old and new systems (such as different values for the same process parameter).
- Control room clutter and potential distraction from two sets of HSIs.
- Different individuals may prefer to the old or the new HSIs, which may adversely impact teamwork.

Typical Advantages and Disadvantages of Different Methods of Modernization Program Implementation - New Non-functional HSIs in Place in Parallel with Old Functional HSIs

Advantages

- Operators can become familiar with the new HSIs while the old HSIs still are available

Disadvantages

- Personnel may use the new HSIs inadvertently, or because they do not realize that they are non-functional.

II.4.12.Human Performance Monitoring

- The objective of reviewing an applicant's human performance monitoring program is to verify that the applicant prepared a program to:

-adequately assure that the conclusions drawn from the integrated system validation remain valid with time

-ensure that no significant safety degradation occurs because of any changes made in the plant

- The applicant may incorporate this monitoring program into their problem identification and resolution program and their training program.

II.5 NUREG-0711 with the Relation to other guidelines

- The U.S. Nuclear Regulatory Commission (NRC) staff reviews the human factors engineering (HFE) aspects of nuclear power plants in accordance with the Standard Review Plan (NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition).
- The Human Factors Engineering Program Review Model (NUREG-0711, Revision 3, issued November 2012) contains detailed design review procedures. As part of the review process, the interfaces between plant personnel and the plant's systems and components are evaluated for conformance with HFE guidelines.
- This document, Human-System Interface Design Review Guidelines (NUREG-0700, Revision 3), provides the guidelines necessary to perform this evaluation. The review guidelines address the physical and functional characteristics of human-system interfaces (HSIs).
- Because these guidelines only address the HFE aspects of design and not other related considerations, such as instrumentation and control and structural design, they are referred to as HFE guidelines.
- In addition to the review of actual HSIs, the NRC staff can use the NUREG-0700 guidelines to evaluate a design-specific HFE guidelines document or style guide.

III. NUREG-0800　Standard Review Plan(SRP) for the Review of Safety Analysis Reports for Nuclear Power Plants

- NRCスタッフが原子力発電所の建設、改造等についての申請書を審査する際の標準手順を定めた文書。
- 立地地域の特性からプラント構成、原子炉、冷却系、ＥＣＣＳ，計測制御系、電源、補助系、廃棄物処理系などの詳細、事故解析等の全部で19章で構成される。
- HFEは18章に記載されていて45頁。2016年にREV３の改定が行われている。

III. NUREG-0800　Standard Review Plan(SRP) for the Review of Safety Analysis Reports for Nuclear Power Plants

- A document that establishes the standard procedures for NRC staff to review applications for the construction or modification of nuclear power plants.
- It consists of a total of 19 chapters, including details such as plant configuration, nuclear reactors, cooling systems, ECCS, measurement and control systems, power supplies, auxiliary systems, waste disposal systems, etc., as well as accident analysis, based on the characteristics of the area where the plant is located.
- HFE is described in chapter 18 with 45 pages. REV3 was revised in 2016.

IV. NUREG 0700 Rev.3 Human-System Interface Design Review Guidelines

Manuscript Completed: October 2019 Date Published: July 2020 Authors: J.M. O'Hara, BNL* S. Fleger, NRC Brookhaven National Laboratory* Nuclear Science & Technology Department Upton, NY 11973-5000 Office of Nuclear Regulatory Research

NUREG-0711
Brief summary of its organization

- NUREG-0700 contains 14 sections of review guidelines and four appendices, described below
- The HFE guidelines are organized into four basic parts, which are divided into sections.
- Part I contains guidelines for the basic HSI elements: information displays, user-interface interaction and management, and analog displays and controls. These elements are used as building blocks to develop HSI systems to serve specific functions.
- Part II contains the guidelines for reviewing the following HSI systems: alarm system, safety parameter display system, group-view display system, soft control system, computer-based procedure system, automation system, and communication system.
- Part III provides guidelines for the review of workstations and workplaces.
- Part IV provides guidelines for the review of HSI support (i.e., maintainability of digital systems and degraded HSI and instrumentation and control conditions).

Part I : guidelines for the basic HSI elements- Information Display

- This section provides HFE guidelines for reviewing visual displays.
- Following a section of general guidelines, specific guidelines appear in top-down fashion, beginning with display formats (such as mimic displays and trend graphs), display format elements (such as labels, icons, symbols, color, text, and coding), data quality, and update rate.

Part I : guidelines for the basic HSI elements- User-Interface Interaction and Management

- This section provides HFE guidelines for reviewing the modes of interaction between plant personnel and the HSI.
- Topics include dialogue formats (such as menus, direct manipulation, and command language), navigation, display controls, entering information, system messages, and prompts.
- This section also contains guidelines concerning methods for verifying the integrity of data accessed through the user interface.
- Guidelines cover prevention of inadvertent change or deletion of data; minimization of data loss due to computer failure; and protection of data, such as setpoints, from unauthorized access.

Part I : guidelines for the basic HSI elements- Analog Display and Control Devices

- This section provides review guidelines for conventional display control devices, such as meters, pushbuttons, and various types of rotary controls.

Part II　Guidelines for reviewing seven systems

General

- Part II contains the guidelines for reviewing seven systems: ①alarm system, ②safety parameter display system, ③group-view display system, ④soft control system, ⑤ computer-based procedure system, ⑥automation system, and ⑦ communication system.
- The guidelines include the functional aspects of the system, as well as any unique considerations for display, user-system interaction, and control that may be needed to review the system.

Alarm System

- This section provides HFE guidelines for reviewing alarm system design implementation.
- The guidelines address the selection of alarm conditions, choice of setpoints, alarm processing, alarm availability (such as filtering and suppression of alarms), unique aspects of the display of alarm information (such as organization, coding, and alarm message content), and alarm controls.

Part II　Guidelines for reviewing seven systems

Safety Parameter Display System

- This section provides HFE guidelines for reviewing displays of critical safety functions and safety parameters.

Group-View Display System

- This section provides HFE guidelines for reviewing group-view displays, including their functional characteristics and user-system interaction aspects, as well as their physical characteristics.

Part II Guidelines for reviewing seven systems

Soft Control System

- This section provides HFE guidelines for reviewing the information display and user-system interaction aspects of soft control systems.

Computer-Based Procedure System

- This section provides HFE guidelines for reviewing computer-based procedure systems, including the representation of information, functional capabilities, users' interaction with the systems, backup provisions, and the integration of such systems with other HSI elements

Part II Guidelines for reviewing seven systems

Automation System

- This section provides HFE guidelines for reviewing human interactions with automatic systems, including aids provided to personnel for situation analysis and decision making.

Communication System

This section provides HFE guidelines for reviewing speech and computer-mediated communication among plant personnel (e.g., preparing, addressing,

transmitting, and receiving messages).

Part III　Guidelines for reviewing workstations and workplaces

- Workstations, including consoles and panels, are locations where HSIs are integrated to provide an area where plant personnel can perform their tasks.
- Workstations are located in workplaces, such as the main control room and remote shutdown facilities.

Part III　Guidelines for reviewing workstations and workplaces

Workstation Design

- This section provides HFE guidelines for reviewing the design of workstation features such as control-display integration and layout, labeling, and ergonomics (e.g., vision and reach).

Workplace Design

- This section provides HFE guidelines for reviewing general workplace considerations, both for the control room and for operator interface areas out in the plant.
- The guidelines address design features such as the overall layout of the workstations and other equipment, including group-view displays within the workplace; provision of support equipment, such as ladders or tools; and environmental characteristics, including temperature, ventilation, illumination, and noise.

Part IV Guidelines for reviewing HSI support

Maintainability of Digital Systems

- This section provides HFE guidelines for reviewing the maintainability aspects of digital systems

Degraded HSI and Instrumentation and Control (I&C) Conditions

- This section provides guidance for reviewing HSI and I&C degradations and failures on HSI resources such as alarms, displays, support systems, and controls.

Appendices

Appendix A provides high-level HSI design review principles

- These principles represent generic HSI characteristics necessary to support personnel performance. While these principles are not detailed review guidelines, they serve several purposes.
- First, they were used to develop many of the detailed review guidelines in this document (see source documents).
- Second, as general principles, they can be used to support the evaluation of HSI aspects not well defined by the detailed guidelines.
- Thus, for example, they can be used in reviewing novel HSI designs, such as display formats not identified in the guidelines. Third, they can support the evaluation of the significance of individual discrepancies in the guideline.

Other appendices B,C,D

- Appendix B for additional guidance for selected HSI topics for information displays, user interface interaction and management, computer-based procedure systems, automation systems, and degraded HSI and I&C conditions.
- Appendix C describes the changes between NUREG-0700, Revision 2, and Revision 3.
- Appendix D is the glossary.

V. Corresponding activity being undertaken in Japan

Status of consideration of HFE standards by the Nuclear Standards Committee of the Japan Electric Association

人間工学プロセス
人間工学プログラムの１２の実施項目のプラントのライフサイクルへの適用

計画	分析	設計	検証及び妥当性確認	設置	運転
設計開発計画					
	運転経験のレビュー	対象設備の設計	設計開発の検証及び妥当性確認	実装に向けた確認	
	機能分析と機能配分	対象手順書の設計			ヒューマンパフォーマンスの監視
	重要なタスクの特定	教育訓練計画への反映事項の整理			
	タスク分析				
	要員の配置及び組織の分析				

日本における人間工学プログラムガイド導入により関連基準を改定する状況の展望

新規制基準

実用発電用原子炉及び付属施設の位置、構造及び設備の基準に関する規則
（第10条　誤操作の防止）

実用発電用原子炉及び付属施設の技術基準に関する規則
（第38条２　原子炉制御室での誤操作のための設備面の要求）

体系化

原子力規制委員会ガイド

人間工学設計開発に関する審査及び検査ガイド：
対象となる要員のタスクー過渡事象、事故事象、重大事象および重要な保安活動
対象設備ー中央制御室、緊急時対策所、緊急時制御室

人間工学的な観点で要求事項を整理

日本電気協会指針

JEAG4641「原子力発電所における設計開発に人間工学を体系的に適用するための指針」ー計画から運用までの全体に他する人間工学プログラムの指針で、対象タスクと設備を規制ガイドより拡大し、中央制御室だけなく、それ以外の原子炉制御盤、現場の制御盤、可搬設備まで含めている

誤操作防止のための設備面の要求事項を規程として整理

日本電気協会規程

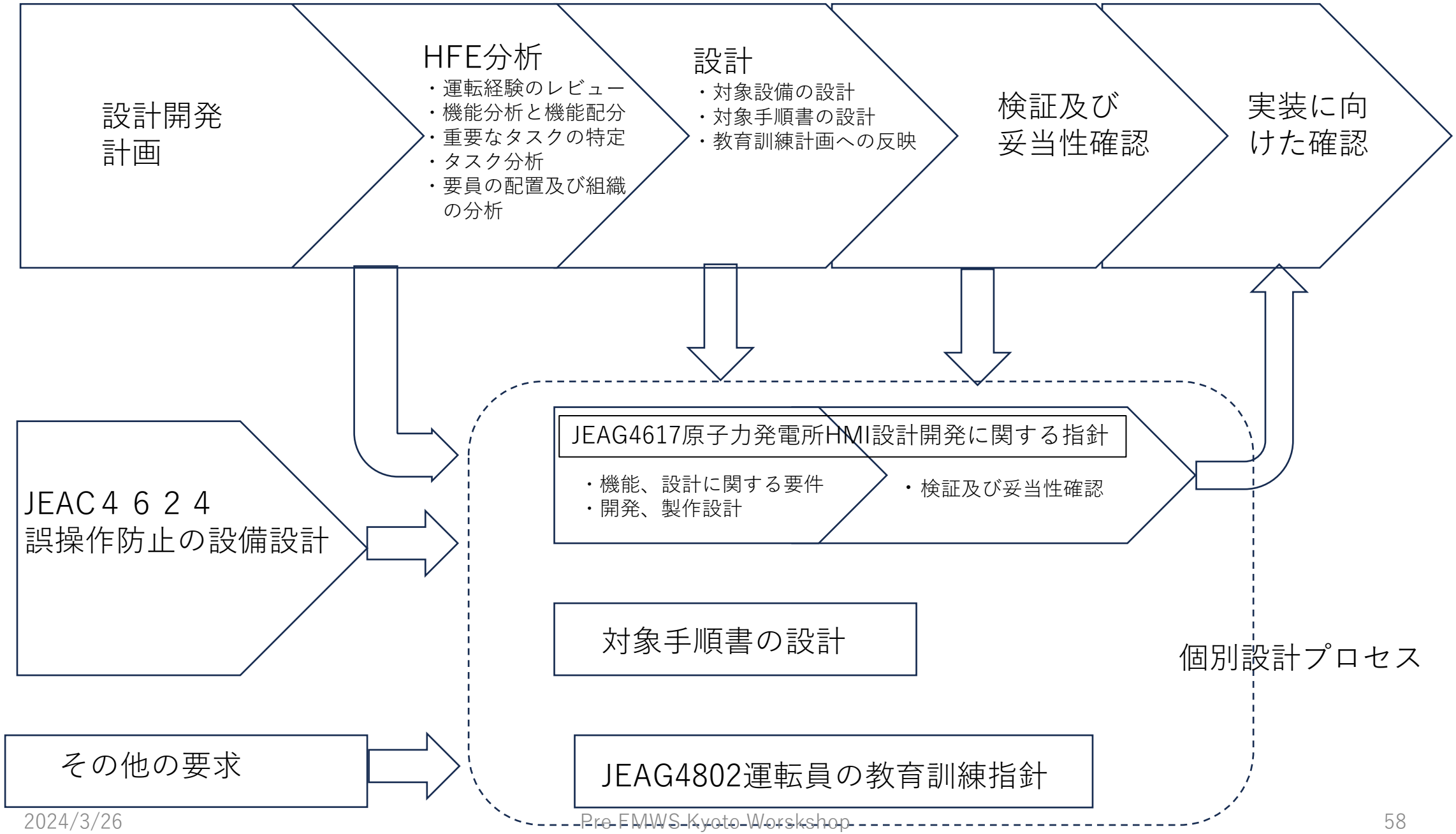
JEAC４６２４「原子力発電所の中央制御室における誤操作防止の設備設計に関する規定」

対象設備の個別設計プロセスとして整理

JEAG４６１７「原子力発電所のヒューマンマシンインタフェースの開発及び設計に関する指針」ー対象設備の設計、検証および妥当性の確認）V&V)の個別設計プロセスを対象にする。

HMI設計要件を整理

JEAG4641　人間工学プロセス全体を規定



VI. Concluding remarks

米国

- NRCのスタッフがプラントの建設や改造、廃棄のために事業者から提出される申請書を人間工学プログラムに沿ったものかどうかを審査するための基準の3層構造の判断基準
- NUREG-0800　第12章（HFEプログラムの全体的審査基準）
- NUREG-0711（HFEプログラム適用を全体としてどのように展開すべきかを示すもの）
- NUREG-0700（ヒューマンマシンシステムのハード、ソフト両面へどのようにHFEを適用すべきかを詳細に規定するもの）
- 国立原子力研究所の専門家が中心になって、科学技術の進展と原子力技術に課せられる社会の要求の両面の変化を考慮して不断に関連するNUREGの改定を行っている。

日本

- 新規制基準の誤操作防止とそのための設備に対する規則が法律として規定され、それを原子力規制庁が原子力規制委員会ガイドとして規定する。
- 事業者はこのガイドに沿って申請書を作成して再稼働申請する。
- 事業者側が審査を受けた経験を集約して、日本電気協会原子力規格委員会が規程（要求条件を含むもの）と指針（推奨事項を集積するもの）に展開している。
- 規制庁による審査ガイドラインに対して事業界側の対応が遅れている。その理由として米国流のHFEプログラムへの理解と吸収に困難なようである。
- 一方で福島事故後の再稼働に対して新規制基準により要求された具体的な過酷事故対策の追加設備とその操作手順をHFEプログラムに組み込もうとしているところに特徴がある。

VI. Concluding remarks

United States

- A three-tiered criterion for NRC Stapp to determine whether applications submitted by operators for the construction, modification or disposal of plants are in line with the ergonomics program.
- NUREG-0800 Chapter 12 (Overall Review Criteria for HFE Programs)
- NUREG-0711 (Indicates how HFE program application should be rolled out as a whole)
- NUREG-0700 (Detailed specification of how HFE should be applied to both hardware and software of human-machine systems)
- Experts from National Nuclear Research Laboratory play a central role in constantly revising the NUREG, which is related to nuclear technology, taking into account both the progress of science and technology and the changes in the demands of society imposed on nuclear technology.

Japan

- The new regulatory standards will be stipulated as a law to prevent misoperation and rules for equipment for that purpose, and the Nuclear Regulation Authority will stipulate them as a guide to the Nuclear Regulation Authority.
- The operator prepares an application document according to this guide and applies for restart.
- The Nuclear Standards Committee of the Japan Electric Association (JEA) has compiled the experience of the operators into CODE(including requirements) and GUIDE (accumulating recommendations).
- The industry has been slow to respond to the regulatory agency's review guidelines. The reason for this seems to be that it is difficult to understand and absorb the U.S.-style HFE program.
- On the other hand, it is unique in that it is trying to incorporate into the HFE program the additional equipment and operating procedures for specific severe accident countermeasures required by the new regulatory standards for the restart of operations after the Fukushima accident.