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Subject: Submittal of Licensing Topical Report NEDO-33275, ESBWR Human Factors Engineering Training Development Implementation Plan, Revision 3

The purpose of this letter is to submit Revision 3 of the GE Hitachi Nuclear Energy (GEH) Licensing Topical Report NEDO-33275, "ESBWR Human Factors Engineering Training Development Implementation Plan" in accordance with the corresponding HFE program element identified in Reference 1.

Enclosure 1 contains Licensing Topical Report NEDO-33275, ESBWR Human Factors Engineering Training Development Implementation Plan, Revision 3.
If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

Reference:

1. NUREG-0711, Revision 2, *Human Factors Engineering Program Review Model*, issued February 2004

Enclosure:

1. MFN 09-304 - Licensing Topical Report NEDO-33275, ESBWR Human Factors Engineering Training Development Implementation Plan, Revision 3

cc:	AE Cubbage	USNRC (with enclosures)
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	eDRF Section	0000-0052-9519

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Enclosure 1

Licensing Topical Report NEDO-33275

ESBWR Human Factors Engineering Training Development Implementation Plan

Revision 3

GE Hitachi Nuclear Energy

NEDO-33275
Revision 3
Class I
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May 2009

Licensing Topical Report

ESBWR HUMAN FACTORS ENGINEERING TRAINING DEVELOPMENT IMPLEMENTATION PLAN

PROPRIETARY INFORMATION NOTICE

This document NEDO-33275, Revision 3, contains no proprietary information.

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please read carefully

The information contained in this document is furnished as reference to the NRC Staff for the purpose of obtaining NRC approval of the ESBWR Certification and implementation. The only undertakings of GE Hitachi Nuclear Energy (GEH) with respect to information in this document are contained in contracts between GEH and participating utilities, and nothing contained in this document shall be construed as changing those contracts. The use of this information by anyone other than that for which it is intended is not authorized; and with respect to any unauthorized use, GEH makes no representation or warranty, and assumes no liability as to the completeness, accuracy, or usefulness of the information contained in this document.

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SUMMARY OF CHANGES (NEDO-33275, REV 3 VS. REV 2)

Item	Location	Change	Comment
1	3.1.4.1	Added sentence at end of section pointing to Appendix B for simulator definitions.	RAI 18.10-1 S03
2	Appendix B	Added Appendix	RAI 18.10-1 S03

1. OVERVIEW

Training of plant personnel is an essential factor in ensuring safe and reliable operation of nuclear power plants. The ESBWR training program provides assurance that plant personnel have the knowledge, skills, and abilities to properly perform their roles and responsibilities. In this way, training supports the safety culture of the plant organization including operations, maintenance, engineering, radiation control personnel, and other plant staff.

Training program development information is gathered through coordination among training development and other elements of the Human Factors Engineering (HFE) design process. For example, Task Analysis (TA) provides a systematic analysis of safety-related job and task requirements that are then used to shape training requirements. These plant operator tasks become an integral part of the Human-System Interface (HSI) training for safely managing ESBWR events.

Human factor improvements in the HSI, coupled with effective training in their use, help to prevent and mitigate human error. To support the objective of eliminating human error, training ensures that plant personnel clearly understand information presented by the HSI. Thorough understanding of HSI data presentations ensures the information can be used to assess plant status at any time.

A similar understanding of the HSI controls and the use of procedures enable plant personnel to control plant operation under normal, abnormal, and emergency conditions. As shown in Figure 1, the ESBWR is designed using a systematic process for integrating human factor engineering principles into the system design using focused inputs and processes. The foundation for human factored training is established in the DCD, Chapter 18, and is supported by DCD Chapters 13 and 19. The HFE methods employed by the ESBWR project yield the core fundamentals of the training program. The series of human factors subject matter plans provide the substance for training program development.

Training modules are developed using industry best practices to reflect the ESBWR design and operating philosophy and its unique characteristics such as natural circulation and passive cooling. As the details of the HSI are finalized, the Verification and Validation (V&V) process, shown in Figure 1, supports an integrated evaluation of the HSI, procedures, and training. To ensure complete integration and consistency, human factors principles are applied to the development of HSI hardware, software, procedures, and training. Mock-ups, part-task simulators, and full-scope simulators are used to validate the integrated design.

1.1 PURPOSE

The training development implementation plan presents the processes, methods, and criteria for systematically incorporating information from the HFE design process into the training program for ESBWR personnel. The ESBWR training program is based on the following five systematic training activities:

- Systematic analysis of the tasks and jobs that are triggered by cues from the HSI design, operational analysis, procedures, or feedback from V&V, design implementation, and human performance monitoring
- Development of learning objectives derived from analysis of requisite performance
- Design and implementation of training based on the learning objectives
- Evaluation of trainee mastery of the learning objectives during training
- Evaluation and revision of the training based on the performance of trained personnel in the job setting

This plan addresses methods, processes, and criteria for verifying that plant training is consistent with accepted ESBWR HFE practices and principles. The HFE team uses the training development process to ensure that human factor principles are incorporated into the development and updating of training. Through this process, applicable requirements of NUREG-0800 Section 13.5 and NUREG-0711 R2 are met. The training development process demonstrates how the HFE team uses results from other HFE tasks and feedback from the other HFE plans to institute training improvements. The goal of training process improvements is to reduce the potential for human error in keeping with the ESBWR design and operating philosophy.

The training development program, approved by the HFE team, generates training modules that match the ESBWR HSI design and procedures. The V&V of training results ensures that all functions and tasks assigned to plant personnel are included in the integrated training program and have been mastered by plant personnel. Additionally, the overall HSI implementation process validates the training for normal operations, transients, and emergencies using mockups, part-task simulator, and full-scope simulator. The HFE team provides evidence of the acceptable incorporation of HFE principles through signoff on training modules and documentation of the identification and resolution of HFE issues.

1.2 SCOPE

The training program provides training for both licensed and non-licensed plant staff. Training and retraining programs incorporate operating experience. The training programs include all phases of plant operation including preoperational and low-power operation. The ESBWR HFE design organization is responsible for providing information on operator tasks that impact plant safety at the component, system, and integrated plant level and for incorporating this information into the training program.

The HFE training development implementation plan describes how training information and issues developed through other HFE activities become inputs to specific elements of the training program. Information and issues relevant to the development of operator training are identified early in the HFE program during the operational analysis process, which includes functional analysis, allocation of functions, and task analysis. As the HFE Design process continues, other HFE activities including Staffing and Qualifications, Procedures Development, V&V, and HPM identify other training inputs.

The following items provide a systematic approach for training elements that are developed and supported by the HFE design team:

- General training approach - uses results of the systematic job/task analysis performed by the HFE team and described in the procedures
- Organization of training - addresses training modules that are required by the NRC, basic knowledge, and operational training on ESBWR systems. Training includes normal, postulated abnormal, and emergency conditions using plant-specific procedures and full-scope simulator
- Learning objectives - are derived from an analysis of desired post-training performance including content required by the NRC, lessons learned from operating plant experiences, plant specific ESBWR features, and special issues collected in the Human Factor Engineering Issue Tracking System (HFEITS)
- Content of training program - includes design and implementation of training based on the learning objectives according to:
  (1) The schedule and content of NRC guidelines
  (2) Key safety actions that are required for functions, systems, and tasks as defined and allocated in operational analysis
  (3) Risk-important human actions needed to manage accident sequences defined by the Human Reliability Analysis /Probabilistic Risk Analysis (HRA/PRA)
- Evaluation of training - addresses evaluation of trainee mastery of the learning objectives including performance assessment of unique HRA/PRA scenarios on the plant full-scope simulator
- Periodic requalification training - incorporates evaluation and revision of the training program based on the performance of trained personnel in the job setting. The scope and frequency of re-training focuses on the training elements provided at the end of the HSI implementation process and risk significance of subject matter.

The overall scope of training is defined by the training development process and supported by the HFE design team. The HFE training scenario inputs include:

- Normal operation training modules – normal training includes specific operational activities (for example, startup, normal, and shutdown operations; maintenance; testing; and surveillance actions) that exercise the use of System Operating Procedures (SOPs), technical specifications, and pre-initiator actions in the HRA/PRA
- Abnormal operation training modules – postulated transients or abnormal events and key HRA/PRA sequences that occur during specific plant conditions (for example, normal operation, startup, shutdown, and refueling) that exercise decision making and use of Abnormal Operating Procedures (AOPs) and Integrated Operating Procedures (IOPs)
- Emergency operation training modules – design basis accidents and key HRA/PRA sequences that occur during specific plant conditions (for example, normal operation, startup, shutdown, and refueling) that exercise decision making and use of Emergency Operating Procedures / Severe Accident Guidelines (EOPs/SAGs)

- Key human action response modules – inputs to the accident training modules are defined for cues from the HSIs (for example, in the main control room, remote shutdown station, local control stations) using emergency, abnormal, and system operating procedures

Training addresses the following:

- Plant personnel, including licensed and non-licensed personnel, whose actions may affect plant safety
- Plant functions and systems with emphasis on those that are risk-important
- The full range of plant conditions (for example, normal, abnormal, emergency)
- HSIs (for example, main control room, remote shutdown panel, risk-important local control stations, display space navigation, operation of "soft" controls) over the full range of plant conditions. Emphasis is placed on those that are risk-important
- Specific operational activities (for example, operations, maintenance, testing, startup, shutdown, and refueling)
- Key actions as required by cues from the HSI (for example, MCR, RSS, and LCSs)

1.3 DEFINITIONS AND ACRONYMS

Several terms are defined to provide a common basis for developing training recommendations referred to in this plan.

1.3.1 Definitions

Abnormal Operating Procedures (AOPs): Procedures that specify steps that operators take to restore an operating variable to its normal controlled value when it departs from its normal range or to restore normal operating conditions following a transient.

Emergency Operating Procedures (EOPs): Emergency condition procedures that direct actions necessary for the operators to mitigate the consequences of transients and accidents that cause plant parameters to exceed the predetermined symptom based thresholds developed in either the Emergency Procedure Guidelines or related site-specific Plant Specific Technical Guidelines.

Full-Scope Simulator (FSS): A high-fidelity simulation environment that includes the physical layout, environmental conditions, and controls and displays for the environment to be simulated. This typically refers to the main control room simulator and meets the requirements of Regulatory Guide 1.149 and ANS-3.5.

HFE Design Team: The HFE Design Team (Design Team) is a team of engineers, as defined in NEDO-33217, Man-Machine Interface System and Human Factors Engineering Implementation Plan, responsible for the design of the HSI systems.

HSI requirements: The validated HSIs and their characteristics that satisfy the task analysis information and control needs. This input is obtained from the revised HSI report resulting from the HSI Design activity and amended by the HF V&V.

Human Action (HA): A manual response to a cue involving one person to achieve one task or objective. Potentially risk important actions that affect equipment or physical systems. Single human actions can be represented as an event in a fault tree or branch point in an event tree.

Human error: Can be defined as a mismatch between a performance demand and the human capability to satisfy that demand.

Human Factors Engineering (HFE): The application of knowledge about human capabilities and limitations to plant, system, and equipment design. HFE ensures that the plant, system, or equipment design, human tasks, and work environment are compatible with the sensory, perceptual, cognitive, and physical attributes of the personnel who operate, maintain, and support the system.

HFE Issue Tracking System (HFEITS): An electronic database used to document human factors engineering issues not resolved through the normal HFE process and human engineering discrepancies (HEDs) from the design verification and validation activities. Additionally, the database is used to document the problem resolutions.

Human Interaction: A human action or set of actions that affects equipment or physical systems, or an action that influences other human actions. Human interactions can be represented as an event in a fault tree or branch point in an event tree.

Human Reliability Analysis (HRA): A structured approach used to identify potential human failure events and to systematically estimate the probability of those errors using data, models, or expert judgment (ASME PRA Std).

Human System Interface (HSI): HSI encompasses all instrumentation and control systems provided as part of the ESBWR for use in performing the monitoring, controlling, alarming, and protection functions associated with all modes of normal plant operation (that is, startup, shutdown, standby, power operation, and refueling) as well as off-normal, emergency, and accident conditions. Specifically, the HSI is the organization of inputs and outputs used by personnel to interact with the plant, including the using of alarms, displays, controls, and job performance aids.

Human task: The activity of a human required to accomplish a function. For example the human user conserves, reduces, or adds information, and supplies or controls energy.

Local Control Station (LCS): An operator interface related to nuclear power plant (NPP) process control that is not located in the main control room. This includes multifunction panels, as well as single-function HSIs such as controls (e.g., valves, switches, and breakers) and displays (e.g., meters) that are operated or consulted during normal, abnormal, or emergency operations.

Normal Operating Procedures: Plant operating procedures that provide instructions for energizing, filling, venting, draining, starting up, shutting down, changing modes of operation, preparing for maintenance or modification, performing maintenance, returning to service following maintenance and testing (if not contained in the applicable testing procedure), and other instructions appropriate for operation.

Operating Experience Review (OER): A systematic review, analysis and evaluation of operating experience that can apply to the development of the HSI design.

Operational analysis: An iterative process that describes plant, system, and component state changes as a series of tasks including supporting information requirements. This is accomplished through performance of system functional requirements analyses, allocation of functions, and task analyses. The analysis process determines what must be done, who does it (man, machine, or shared), and how it is to be done (for example, controls, indications, supporting information). Results of the analyses are design requirements for the HSI, procedures, and training.

Performance Shaping Factor: A factor that influences human error probabilities as considered in a PRA's human reliability analysis and includes such items as level of training, quality/availability of procedural guidance, time available to perform an action, etc. (ASME PRA Std).

Risk-important human actions: Actions that are performed by plant personnel to provide assurance of plant safety. Actions may be made up of one or more tasks. There are both absolute and relative criteria for defining risk-important actions. From an absolute standpoint, a risk-important action is any action whose successful performance is needed to provide reasonable assurance that predefined risk criteria are met. From a relative standpoint, the risk-important actions may be defined as those with the greatest risk in comparison to all human actions. The identification can be done quantitatively from risk analysis and qualitatively from various criteria such as task performance concerns based on the consideration of performance shaping factors.

Risk-significant Local Control Station: A local control station at which risk-important human actions are performed or which controls safety-related equipment.

Systematic Approach to Training: A training program that includes the following five elements:

(1) Systematic analysis of the jobs to be performed

(2) Learning objectives derived from the analysis which describe desired performance post training

(3) Training design and implementation based on the learning objective

(4) Evaluation of trainee mastery of the objectives during training

(5) Evaluation and revision of the training based on the performance of trained personnel in the job setting [from 10 CFR 55.4]

Training simulator: A facility which contains one or more of the following components; a full-scope simulator; or a simulation device, including part-task and limited scope simulation devices. These are used for either the partial conduct of operational tests for Reactor Operators (ROs), Senior Reactor Operators (SRO), and future operator license applicants, or to establish on-the-job training (OJT) and experience prerequisites for operator license eligibility [from 10 CFR 55.4].

Validation: The process of evaluating a system or component (including software and human interactions) during or at the end of the development process to determine whether it satisfies specified requirements [adapted from IEEE 610].

Verification and Validation (V&V): The process of determining whether the requirements for a system or component (including software and human interactions) are complete and correct. The products of each development process fulfill the requirements or conditions imposed by the previous process, and the final system or component (including software) complies with specified requirements [adapted from IEEE 610].

Verification: The process of evaluating a system or component (including software and human interactions) to determine whether the products of a given development process satisfy the requirements imposed at the start of that process [adapted from IEEE 610].

1.3.2 Acronyms

The following is a list of acronyms used in this plan.

Acronym	**Description**
ABWR	Advanced Boiling Water Reactor
AOF	Allocation of Function
AOP	Abnormal Operating Procedure
ARP	Alarm Response Procedure
BRR	Baseline Review Record
BWR	Boiling Water Reactor
CBP	Computer Based Procedure
COL	Combined Operating License
DCD	Design Control Document
D3	Defense-in-Depth and Diversity
FRA	Functional Requirements Analysis
EPGs	Emergency Procedure Guidelines
EOP	Emergency Operating Procedure
GPP	General Plant Procedure
HFEITS	Human Factors Engineering Issue Tracking System
HA	Human Action
HFE	Human Factors Engineering

HRA	Human Reliability Analysis
HPM	Human Performance Monitoring
HRA	Human Reliability Assessment
HSI	Human System Interface
INPO	Institute of Nuclear Power Operations
JPM	Job Performance Measures
LCS	Local Control Station
MCR	Main Control Room
MMIS	Man Machine Interface System
NRC	Nuclear Regulatory Commission
OER	Operating Experience Review
OJT	On-the-Job Training
PRA	Probabilistic Risk Assessment
ROs	Reactor Operators
RSR	Results Summary Report
RSS	Remote Shutdown System
S&Q	Staffing and Qualifications
SAG	Severe Accident Guidelines
SOPs	System Operating Procedures
SROs	Senior Reactor Operators
TA	Task Analysis
V&V	Verification and Validation
VDU	Video Display Unit

2. APPLICABLE DOCUMENTS

Applicable documents include supporting documents, and supplemental documents. Codes and standards are also provided in this section. Supporting documents provide the input requirements to this plan. Supplemental documents are used in conjunction with this plan. Codes and standards are applicable to this plan to the extent specified herein.

2.1 SUPPORTING AND SUPPLEMENTAL GEH DOCUMENTS

2.1.1 Supporting Documents

The following supporting documents were used as the controlling documents in the production of this plan. These documents form the design basis traceability for the requirements outlined in this plan.

(1) ESBWR DCD, Chapter 13, (GE 26A6642BL).

(2) ESBWR DCD, Chapter 18, (GE 26A6642BX).

(3) NEDE-33217P and NEDO-33217, Rev 4, ESBWR Man-Machine Interface System and Human Factors Engineering Implementation Plan.

(4) NEDE-33226P and NEDO-33226, Rev. 3, ESBWR I&C Software Management Program Manual.

2.1.2 Supplemental Documents

The following supplemental documents are used in conjunction with this document plan:

(1) NEDO-33219, Rev. 3, ESBWR HFE Functional Requirements Analysis Implementation Plan.

(2) NEDO-33220, Rev. 2, ESBWR HFE Allocation of Function Implementation Plan.

(3) NEDO-33221, Rev. 2, ESBWR HFE Task Analysis Implementation Plan.

(4) NEDO-33262, Rev. 2, ESBWR HFE Operating Experience Review Implementation Plan.

(5) NEDO-33266, Rev. 2, ESBWR HFE Staffing and Qualifications Plan.

(6) NEDO-33267, Rev. 3, ESBWR HFE Human Reliability Analysis Implementation Plan.

(7) NEDO-33268, Rev. 3, ESBWR HFE Human System Interface Design Implementation Plan.

(8) NEDO-33274, Rev. 3, ESBWR HFE Procedures Development Plan.

(9) NEDE-33276P and NEDO-33276, Rev. 2, ESBWR HFE Verification and Validation Implementation Plan.

2.2 CODES AND STANDARDS

The following codes and standards are applicable to the HFE program to the extent specified herein.

(1) ANSI/ANS 3.1 Selection, Qualification, and Training of Personnel for Nuclear Power Plants, 1993(R1999).

(2) ANSI/ANS 3.2 Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants, 1994(R1999).

(3) ANSI/ANS 3.4, Medical Certification and Monitoring of Personnel Requiring Operator Licenses for Nuclear Power Plants, 1996.

(4) ANSI/ANS 3.5, Nuclear Power Plant Simulators for Use in Operator Training, American Nuclear Society, 2005.

(5) IEEE 338, Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems, 1993.

(6) IEEE 603, Criteria for Safety Systems for Nuclear Power Generating Stations, 1991.

(7) IEEE 610, IEEE Standard Glossary of Software Engineering Terminology, 1990.

2.3 REGULATORY GUIDELINES

(1) IP 41500, Training and Qualification Effectiveness, NRC, periodically updated.

(2) NUREG-0711, Rev. 2, Human Factors Engineering Program Review Model, 2004.

(3) NUREG-0737, Clarification of TMI Action Plan Requirements, Supplement 1, Requirements for Emergency Response Capability, 1983.

(4) NUREG-0800, Standard Review Plan, Section 13.2.1, Reactor Operator Training, 2002.

(5) NUREG-0800, Standard Review Plan, Section 13.2.2, Training for Non-licensed Plant Staff, 2002.

(6) NUREG-0800, Standard Review Plan, Section 13.5.2.1, Operating and Emergency Operating Procedures, 2002.

(7) NUREG-1021, Rev. 9, Operator Licensing Examination Standards For Power Reactors, 2004.

(8) NUREG-1123, Rev. 2, Knowledge and Abilities Catalog for Nuclear Power Plant Operators: Boiling Water Reactors, 1998.

(9) NUREG-1220, Rev. 1, Training Review Criteria and Procedures, 1993.

(10) Regulatory Guide 1.149, Rev. 3, Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examinations, 2001.

(11) Regulatory Guide 1.8, Rev. 3, Qualifications and Training of Personnel for Nuclear Power Plants, 2000.

(12) 10 CFR 50.120, Training and Qualification of Nuclear Power Plant Personnel.

(13) 10 CFR 52.78, Contents of Applications: Training and Qualification of Nuclear Power Plant Personnel.

(14) 10 CFR 55, Operators Licenses.

2.4 DOD AND DOE DOCUMENTS

None.

2.5 INDUSTRY / OTHER DOCUMENTS

(1) AP-921, Systematic Training Process Description, INPO, 1997.

(2) EPRI, Advanced Light Water Reactor Utility Requirements Document, Vol. II, ALWR Evolutionary Plant, Chapter 10, 1992.

(3) IAEA-Technical Report Series, TECDOC-525, Guidebook on Training to Establish and Maintain the Qualification and Competence of Nuclear Power Plant Operations Personnel, 1989.

(4) IEA-Technical Report Series, TECDOC-668, The Role of Automation and Humans in Nuclear Power Plants, 1992.

(5) Rasmussen, J, Information Processing and Human-Machine Interaction, An Approach to Cognitive Engineering, 1986.

3. METHODS

3.1 SYSTEMATIC APPROACH TO TRAINING

3.1.1 Background

Industry experience has shown that well-trained plant personnel are critical to safe and reliable operation of nuclear power plants. Incorporation of human factors in the development of training programs ensures consistency, completeness, usability, and alignment with procedures and HSI design.

3.1.2 Goals

The training program provides assurance that personnel have the qualifications commensurate with job performance requirements.

3.1.3 Requirements

The training approach follows applicable guidance in NUREG-0800 Section 13.2 Training, as defined in 10 CFR 55.4, and as required by 10 CFR 52.78 and 50.120. Categories of personnel trained in the ESBWR training program are in accordance with 10 CFR 50.120 and are listed in Table 1. The training program satisfies the training program design requirements and the guidance contained in ANSI 3.5 and Regulatory Guide 1.149. The training program is based on the systematic approach to training and is an integral part of the overall HFE design process, as shown in Figure 1.

3.1.4 General Approach

The training program follows a systematic approach to training and includes classroom, simulator, and OJT. This approach provides assurance that trainers and plant personnel have the knowledge, skills, and abilities to discharge their responsibilities. A systematic approach to the training of plant personnel is illustrated in Figure 2. It also shows HFE design inputs to the training program including inputs developed and incorporated into the HSI as described in Section 4. Other plant personnel such as administrative staff responsible for the elements listed in Tables 2 to 6 are also trained.

3.1.4.1 Organization of Training

The HFE design process shown in Figure 1 and the training development process shown in Figure 2 outline the steps that will be taken to design the MMIS and develop the supporting Staffing and Qualifications requirements, procedures, and training. The training development process will be performed by GE Hitachi Nuclear Energy (GEH) and supported by COL Applicant participation through the completion of training material development specific to the ESBWR. GEH has the ability to provide ESBWR training to the COL Applicant's Instructors.

Training implementation and evaluation is the responsibility of COL Applicants. GEH has the ability to support the COL Applicant's training program.

Training materials are developed and implemented using existing sources of information and design specific information from the ESBWR HFE design team. The role of the HFE design team is to provide input to the training program and, if requested, to conduct specific training modules. For example, the ESBWR design team supplies system descriptions, planned operator tasks, and the Emergency Procedure Guidelines (EPGs), which are integrated into specific training programs.

The Staffing and Qualifications implementation plan for the ESBWR establishes the required responsibilities, skill sets, and qualifications of plant personnel. The training development process establishes the organization and processes required to achieve and maintain the qualifications and certifications of plant personnel. Initial and requalification training are provided to establish and maintain proficiency in required job tasks.

Resources such as part-task, full-scope, and training simulators are used in the ESBWR HFE implementation process for both design verification and training. These facilities and resources include features of the HSI that are based on the inputs of the HFE team. Simulator definitions are provided in Appendix B.

3.1.4.2 Learning Objectives

The training program establishes learning objectives derived from the analyses of jobs, tasks, and operator responses. The learning objectives establish desired performance capabilities for personnel after completion of initial training.

The learning objectives include training needs identified in the following:

- Licensing basis - Final Safety Analysis Report, system descriptions, system operating manuals and operating procedures, facility license and license amendments, licensee event reports, and other documents identified by the ESBWR design team and the COL Applicants as being important to training
- Operating Experience Review – lessons learned from events and previous training deficiencies and operational problems. This information is maintained in the OER/BRR database and is used to improve overall training effectiveness and trainee mastery of the learning objectives.
- Functional requirements analysis and allocation of functions - functions are broken down into individual tasks and are allocated to the appropriate performance regimen (human, machine, "machine, human limited", etc.)
- Task Analysis - ESBWR tasks identified during task analysis that pose unusual demands, including new or different tasks and tasks requiring a high degree of coordination, high workload, or special skills
- Human Reliability Analysis - coordinating individual roles to reduce the likelihood and/or consequences of human error associated with risk-important HAs and the use of advanced technology in the ESBWR

- HSI design – ESBWR design features, the purpose or operation of which may be different from the past experience or expectations of personnel
- Plant procedures - tasks that have been identified during procedure development as being problematic (for example, procedure steps that have undergone extensive revision as a result of plant safety concerns)
- Conduct of operations – typical administrative processes for daily operation of the facility, as provided in Table 3
- Equipment control – typical administrative requirement topics associated with managing and controlling plant systems and equipment, as shown in Table 4
- Radiation Protection – provision for training employees and non-employees whose assistance may be needed in a radiological emergency, as required by 10 CFR Part 50, Appendix E, and Section II.F. Administrative requirements needed for understanding and controlling radiation hazards and protection (of plant personnel and the public) are shown in Table 5.
- Emergency plan - provision for training licensed operators, employees and non-employees in different levels of the facility's emergency plan including, as appropriate, the responsibility of the SRO to decide whether the plan should be executed and both RO and SRO duties assigned under the plan. Example topics are shown in Table 6.
- Security – provision for training of nuclear plant security personnel who must undergo extensive training before they are permitted to begin work and who must complete retraining following each year of service. Security personnel are trained and regularly tested in tactics to repel intruders.
- Fire protection - fire protection training for construction personnel includes periodic drills during construction. Initial fire protection training is completed for the operating staff before fuel is received at the site. Detailed fire protection training is developed for the fire brigade, the control room staff, and other on site personnel following the Standard Review Plan (NUREG-0800 Section 13.2.2).
- Verification and Validation (V&V) - training concerns identified during V&V, including HSI usability concerns identified during validation or suitability verification and operator performance concerns (for example, misdiagnoses of plant events) identified during validation trials
- Implementation Feedback – training concerns identified during plant construction, initial training, initial testing, etc., prior to operation
- Human Performance Monitoring (HPM) – training concerns identified as plant personnel interface with the HSI, plant equipment, procedures, etc, after design implementation

Learning objectives also address the knowledge and skill attributes associated with all relevant dimensions of the trainee's job, such as interaction with the plant, the HSIs, and other personnel. Table 7 provides an example of skill and knowledge dimensions.

3.1.4.3 Content of Training Program

The key elements of the training program include methods for conveying learning objectives, factual knowledge, skill development, and rules for decision-making to the trainees. The trainees include individual applicants for NRC license and non-license positions.

3.1.4.3.1 Training Design

The design of the training program specifies how learning objectives are achieved through:

- The use of classroom, simulator, and OJT to convey particular categories of learning objectives
- Specific plant conditions and scenarios used in training programs
- Training implementation, which establishes the temporal order and schedule of training segments

3.1.4.3.2 Factual Knowledge

Factual knowledge is taught within the context of actual tasks so that personnel learn to apply it in the work environment. The context of the job is defined and represented meaningfully to help trainees link knowledge and skills to the job's requirements. Training also addresses how theory is integrated with training in using procedures.

3.1.4.3.3 Skill Development

The training program is structured for developing skills so that the training topics build upon the level of skill already mastered. Training programs for developing skills are structured so that the training environment is consistent with the level of skill being taught. It supports skill acquisition by allowing trainees to manage cognitive demands. For example, trainees are not to be placed in environments teaching high-level skills, such as coordinating control actions among crewmembers, before they have mastered requisite, low-level skills, such as how to manipulate control devices. Additionally, the plan is adaptive and allows for scenario development to challenge even well-trained crews.

3.1.4.3.4 Decision-Making Rules

Training addresses rules for decision-making related to plant systems, HSIs, and procedures. The training program uses symptom-based training strategies supported by the development of rules for decision-making related to plant systems, HSIs, and procedures. The symptom-based training includes rules for identifying cues, confirming actions and interpreting information. The training program covers acquiring new decision-making rules for interpreting symptoms of failures associated with the systems and HSIs that are a direct result of the ESBWR passive design and operating philosophy.

3.1.5 Application

3.1.5.1 Development of Training Materials

The unique ESBWR training materials are derived from the specific system and function tasks allocated to operators and tasks allocated to the machine that operators must interface with or back up. These HFE inputs are provided to procedure developers and form the basis for the choices made in the HSI design. Thus, the results of HFE task analysis and HRA/PRA risk evaluations provide significant information to the trainers in developing the training modules according to the systematic approach to training defined in Section 3. The HFE inputs support development of learning objectives, and definition of risk issues, which are included in the scope of training.

3.1.5.2 Preoperational Training

The preoperational training period coincides with the initial simulator training for candidates for the licensed ROs and SROs. During this training period, HFE issues are likely to be identified by the operators using the HSI for cues and feedback while applying the emergency operating procedures in dynamic simulations. This operational feedback during training is used to improve the HSI by adjusting the software controlling the displays, changing the procedure layout, or revising training modules based on crew/operator performance. The process of using the full-scope simulator to evaluate events continues through plant construction, startup, and operation. HFE issues are identified, tracked, and resolved. Issues that cannot be resolved using the normal iterative HFE design processes are entered into HFEITS for tracking and resolution.

3.1.5.3 Evaluation and Modification of Training

The station training program has both fixed and dynamic elements. For example, the fixed elements of Operator training include basic engineering theory for nuclear, mechanical, and electrical systems, equipment startup and shutdown procedures, basic accident sequence simulator training, and administrative controls. The dynamic elements include incorporation of lessons learned from operational events experienced at both ESBWRs and other plants into simulator training.

The evaluation process determines if the training program is accurate, complete, and effective and if trainees are mastering the training elements. Evaluation criteria for mastery of training objectives during individual training modules are defined in the training program plan. Methods for assessing overall proficiency are defined and coordinated with applicable regulations for licensed personnel.

3.1.5.4 Periodic Retraining

The training program addresses the content and schedule for periodic retraining of both licensed and non-licensed plant personnel. The COL Applicant provides changes to retraining content and frequency following plant modernization programs, industry/ESBWR OER, or design changes that have a safety impact or require procedural changes.

4. IMPLEMENTATION

4.1 SYSTEMATIC APPROACH TO TRAINING IMPLEMENTATION

The systematic approach to training for plant personnel is supported by the HFE tasks, as shown in Figure 2. The HFE design team generates training process guidelines. Training materials and delivery plans are then generated using the guidelines and requirements generated in operational analysis, HSI design, Staffing and Qualifications, and procedure development. The V&V process evaluates the results of training and generates feedback and training revision needs. After revision and re-validation, training is monitored and revised over time through the HPM and plant design change processes.

4.1.1 Assumptions

ESBWRs are operated as a standardized fleet of nuclear plants.

The training program and procedures are generic to the ESBWR. All plants in the ESBWR fleet use the same training program, procedures, and Staffing and Qualifications, as defined in DCD, Tier 2, Chapter 18.

- All normal plant operating and emergency procedures use the same names and numbering of plant equipment and controls used by the plant operators
- All ESBWR plants meet the standards developed
- The ESBWR is designed to operate with many passive systems
- The control systems for the ESBWR have a high level of automation. All systems are automated unless regulation or HFE analysis results dictate otherwise.
- CBPs are accessible anywhere the HSI can be accessed

4.1.2 Inputs

ESBWR training development draws upon industry best practices including use of classroom, simulator, and OJT techniques to achieve desired training results. Training modules are created to address the technical basis and operating boundaries for passive cooling and natural circulation processes. The Operating Experience Review provides lessons learned that are applied to training as well as to system design features.

Training is developed and provided to ensure safe, efficient, and reliable operation using the following inputs:

(1) Regulatory requirements - Regulations set many of the minimum standards for training that guide the analysis and development of training and are direct inputs to the training development process.

(2) HSI design - HSI Design requirements including controls, component IDs, indications, VDU screen format, human interaction mechanisms and options, queues, alarms, etc, are a direct input to the training development process.

(3) Operational analysis - Operational analysis results support priorities in developing the HSI design for tasks impacting safety. They also become risk-based requirements for V&V of the HSI and training of plant personnel. These requirements are a direct input to the training development process.

(4) Procedure development - Procedures are a direct input to the training development process and are used to ensure classroom and simulation training accurately present the ESBWR design and operating philosophy.

(5) Staffing and Qualifications - The Staffing and Qualification process generates numbers, skill types, and qualification portfolio requirements for plant personnel that are inputs to the analysis portion of the training development process.

(6) Verification and Validation - V&V training enhancements are a feedback input into the training development process. The revised training results are then put through the V&V process again to validate the adequacy of the changes.

(7) Human Performance Monitoring - Human Performance Monitoring training enhancements are a feedback input into the Procedure Revision process. The revised training results are then put through the V&V process again to validate the adequacy of the changes.

4.1.3 Process

The training development process follows the top down approach to MMIS HFE, as shown in Figure 2. The process results in the creation and delivery of the training as shown in the HFE implementation plan and is an integral part of the MMIS and HSI development. Training materials generated include instructor guides, lesson plans, OJT materials, simulator guides and scenarios, exam banks, and both initial and requalification training requirements and frequencies. Training is delivered in the venue most appropriate for the desired learning including classroom, mockup, part-task simulator, full-scope simulator, walk-through, laboratory, drills, and OJT.

Training is provided for all plant conditions and exercises the applicable procedures including:

- GPPs for normal operation
- SOPs for system level operations
- Maintenance and modification procedures for performing preventative and corrective maintenance with actions that impact the main control room, RSS, or risk significant LCS
- Radiation control procedures
- Calibration, testing and inspection procedures for surveillance testing
- ARPs to help operators respond to alarms
- AOPs to help operators restore abnormal plant variable indications to normal conditions
- EOPs for addressing plant emergencies

Of the procedures presented in training, the EOPs are the most important for protecting the Defense-In-Depth barriers in the ESBWR.

Inputs to the operational analysis include:

- Experience from previous BWR and ABWR designs through the OER/BRR
- Technical guidance, derived from plant design bases
- System-based technical requirements and specifications
- Risk-important human actions identified in the HRA/PRA

Detailed Functional Requirements Analyses (FRA), Allocations of Functions (AOF), and Task Analyses (TA) are performed during operational analysis. The results of the operational analyses are inputs to the HSI Design process, the procedure development process, and the training process governed by this plan. Using the training process guideline, training is developed and delivered. Training results serve as input to the V&V. The V&V identifies any training program enhancements needed and feeds this information back into the training development process. ESBWR training continues to be revised over time as the HPM analysis process identifies enhancements necessary for safe operation of the plant. Additionally, training is maintained up to date as the plant is modified.

4.1.3.1 Analysis

The analysis portion of training development receives input and feedback from the other HFE processes. The analysis process is governed by a training process guideline that ensures it meets the requirements set forth in NUREG-0800 Chapter 13; NUREG-1220; Regulatory Guide 1.8; ANSI/ANS 3.1; and other applicable regulations. This portion of the process uses systematic analysis to evaluate the aggregate input data. The analysis generates the requirements for the knowledge and skills to be presented by training. These requirements ensure that trainees meet job performance requirements and that they have the knowledge, skills, and ability to safely perform their assigned tasks. Inputs to this process include:

(1) Operational analysis – HRA/PRA inputs including risk-important human actions, OER/BRR experience and lessons learned, DCD specifications, System Design Specifications, and the Defense-in-Depth and Diversity report. The process also receives feedback input from the other HFE processes including Staffing & Qualifications, HSI Design, Training, Procedure Development, Verification and Validation, and ultimately, Human Performance Monitoring. These inputs are processed through Functional Requirements Analyses, Allocations of Functions, and Task Analyses. Operational analysis ultimately generates procedure, training, and HSI requirements. These requirements form the backbone of the direct inputs to training development.

(2) Staffing and Qualification – Generates numbers, skill types, and qualification portfolio requirements that are direct inputs to the analysis portion of the training development process

(3) HSI design – Comprises the controls, displays, and alarms needed by operators in the main control room, the RSS, and risk-important LCSs. This design is determined using the following inputs:

- Analysis of the operation strategies specified in the ESBWR Emergency Procedure Guidelines (EPGs)
- Determination of significant operator actions by the HRA/PRA
- Completion of Functional Requirements Analyses, Allocations of Functions, and Task Analyses

The HSI design team evaluates the design requirements and implements them when selecting and configuring equipment and software. Additionally, the team evaluates human factors and human-machine interfaces to ensure that HFE principles are built into the HSI. The final HSI design including controls, component IDs, indications, VDU screen format, human interaction mechanisms and options, queues, and alarms, is a direct input to the analysis portion of the training development process.

(4) Procedure development – The procedure development process starts with example procedure writer's guides from existing BWRs and ABWRs and EPG/SAG Rev 2. The HFE design team uses these documents to generate ESBWR HFE infused writer's guides for station procedures. The procedure development team then uses the writer's guides to properly combine and structure the HSI design and operational analysis inputs and other required information into useable procedures. The procedures are direct inputs into the training process for use in the development and presentation of training to ensure classroom and simulation training accurately present the ESBWR design and operating philosophy.

(5) Regulatory requirements – Training development is governed by a training process guideline that ensures it meets the requirements set forth in NUREG-0800 Chapter 13; NUREG-1220; NUREG-1021; Regulatory Guide 1.8; ANSI/ANS 3.1; and other applicable regulations. These regulations set many of the minimum standards for training and are direct inputs that guide the analysis.

(6) Training evaluation – Written and oral tests and review of personnel performance during walkthrough job performance measures (JPMs), simulator exercises, and on-the-job observation. Training evaluation assesses the overall effectiveness of the training programs and trainee mastery of training objectives as defined in training design and development. This process generates training enhancements designed to improve the content or delivery of training.

(7) Verification and Validation – Once ESBWR training is complete for a given subject, it is validated and verified using talk-through, walk-through, mock-ups, part-task simulators, and the full-scope simulator. V&V training enhancements are feedback inputs into the procedure revision process. The resulting revised training results are then put through the V&V process again to validate the adequacy of the changes.

(8) Human Performance Monitoring – During the design process, Human Factor Engineering addresses a wide range of potential causes of human error to produce training that matches the HSI and procedures. However, a good operational safety culture from the COL

Applicant encourages the continuing identification of issues for improvement including further reducing the potential for human errors. The potential for improvements to the HSI, procedures, and training continue into the operational phase. Thus, when the plant is turned over to the COL Applicant improvements to training are still sought, evaluated, tracked and resolved through the HPM process. HPM training enhancements are a feedback input into the procedure revision process.

Using the inputs outlined above, training needs analyses are performed using a systematic method to objectively and consistently determine performance and training requirements. These requirements are input into the design function within the training development process.

4.1.3.2 Design

The design portion of training development process takes the performance and training requirements generated in training analysis and begins the process of creating the details and supporting documents that support training implementation. An additional input to training design is the knowledge and abilities requirements of NUREG-1123. Using these inputs, training design generates training outlines containing the following requirements:

- Trainee qualification and the requirements for documenting qualification equivalencies where allowed
- Sequence of training and the frequency of requalification training
- Target groups for training
- Organization owning the training
- Learning objectives
- Training venue including classroom, mockup, part-task simulator, full-scope simulator, walk through, laboratory, drills, and OJT
- Training presentation duration
- Test criteria and performance monitoring method
- Remediation process used to improve trainee performance and address unacceptable performance

Using the inputs and criteria above, the training design develops objectives that support reliable and successful performance of the tasks identified in the operational analysis process and the training needs analysis. The objectives provide the conditions and standards against which learning is assessed. Additionally, training design generates the outline plan for meeting the performance and training requirements specified in training analysis. These outline plans are direct inputs to training development.

4.1.3.3 Development

The development portion of the process uses the outline plans generated in training design and produces the final detailed course material. Materials are generated (for example, lesson plans, simulator scenarios, and OJT documents) incorporating the required training design features and containing the following attributes:

- Course material content supports mastery of the subject learning objectives
- Course materials are structured to provide consistent presentation
- Course material presentation sequence supports effective learning
- Course materials support successful presentation in their specified venue including classroom, mockup, part-task simulator, full-scope simulator, walk-through, laboratory, drills, and OJT
- Instructor certifications and training required to present training is specified for each course and supports successful presentation in the required venue
- Exam question banks and examination structure and content are developed and adequately evaluate and document trainee mastery of the course and job performance objectives associated with the training

Using the inputs and criteria above, training development produces course materials that support reliable and successful performance of the tasks identified in the operational analysis process and the training needs analysis. The course materials are used to deliver training in the implementation phase and associated course test material supports training evaluation. These course materials are direct inputs to training implementation and test materials are direct inputs to training evaluation.

4.1.3.4 Implementation

The implementation portion of the training development process uses the course materials generated in training development and presents the material in the venue, sequence, and manner specified. The final stage of implementation is the verification of trainee mastery of training objectives through the administration of the appropriate form(s) of evaluation.

4.1.3.5 Evaluation

Methods for evaluating the overall effectiveness of the training programs and trainee mastery of training objectives are defined in training design and development. These include written and oral tests and review of personnel performance during walkthrough job performance measures (JPMs), simulator exercises, and on-the-job observation. Evaluation criteria for training objectives are defined for individual training modules. Methods for assessing overall proficiency are defined and coordinated with regulations, where applicable. Completed training courses and trained and qualified personnel are outputs of the process that input to both the V&V and HPM processes.

4.1.3.6 Verification and Validation

The V&V process verifies that the information presented in training is correct, meets HFE requirements, and produces qualified personnel who can safely and efficiently perform their job tasks. V&V also ensures that training does not conflict with procedures and processes that take place in parallel with the tasks governed by the training.

Training for all normal, abnormal, and emergency operating conditions is validated through simulator testing where applicable, or through talk/walk-through. NUREG-0711, Rev 2 sets forth test objectives and test-bed validation requirements that are discussed further in NEDO-33276, ESBWR HFE Verification & Validation Implementation Plan. As shown in Figure 1, the V&V process supports HFE evaluation of the HSI design; all normal, abnormal, and emergency operating procedures and their CBP equivalents; and the output of the training plan. V&V is performed using a variety of means including part-task simulators, talk-through evaluations, walk-through evaluations using mock-ups; and full-scope simulators. The process includes dynamic simulation of startup, power operation, and shutdown.

Any issues identified during the V&V process are provided as feedback to the originating process for resolution. Based upon the nature of the issue, procedures may be revised, HSI design may be modified, or the issue becomes an input to the training program so that operators are taught the conditions necessary for consideration during plant operations. The priority for modifying training in response to a human factor discrepancy is guided by an assessment of risk impact from the HRA/PRA interface.

If a V&V issue cannot be resolved using the iterative processes shown in Figures 1 and 2, the HFEITS process is used for resolution.

When a training issue is resolved, the V&V process is applied again to validate the adequacy of the solution.

4.1.3.7 Human Performance Monitoring

During the design process, Human Factors Engineering addresses a wide range of potential causes of human error to produce training and procedures that match the HSI. However, a good operational safety culture from the COL Applicant encourages the continuing identification of issues for improvement including further reducing the potential for human errors. The potential for improvements to the HSI, training, and procedures continues into the operational phase. Thus, when the plant is turned over to the COL Applicant, improvements to the HSI, training, and procedures are still sought, evaluated, tracked, and resolved through the HPM process. This process ensures training practices, materials, and presentations are refined over time as a result of industry/ESBWR OER and modifications to the plant.

4.1.4 Outputs

The training development process is an integral part of the MMIS HFE design process for the ESBWR. The process outputs include training program guidelines, qualification requirements, training needs analyses, training course materials, facility requirements, and ultimately, trained personnel. Training evaluation, V&V, and HPM verify that trained plant staff can competently, safely, and efficiently operate and maintain the ESBWR during normal, abnormal, and emergency conditions.

4.1.4.1 Training Program Guidelines

The training program guidelines delineate the overall structure of the program, documents, and processes, including the following:

- The roles of all organizations involved in the development of training, including requirements, training information sources, and materials
- The roles of all organizations involved in the implementation of training
- The qualification requirements for organizations and personnel developing or conducting training and the process for documenting compliance with these requirements
- Breakdown of ownership for various training types including licensed and non-licensed operators, fire protection, engineering and technical, maintenance, and radiation control
- Process descriptions for program implementation, including analysis, design, development, implementation, and evaluation
- Generic process descriptions and requirements for different training venues, including classroom, part-task simulators, mock-ups, full-scope simulator, and OJT
- Course material editorial, content, and structure requirements to ensure consistency and quality
- Instructor qualification and certification processes
- Course material document control requirements to ensure only controlled and current materials are presented to trainees
- Trainee and training program evaluation processes including instructor/trainee feedback, observations, tests, V&V, and HPM
- Industry/ESBWR OER and plant design change training input processes to ensure training remains refined, up-to-date, and accurate
- Remediation processes for unsatisfactory trainee performance

4.1.4.2 Position Specific Qualification Requirements

Each plant staff position has minimum qualification and experience requirements specified. Any sub-divisions/certifications within a staff position classification have minimum qualification and experience requirements specified. Requirements that can have equivalencies performed in lieu of the specified attribute are identified. Processes for performing and documenting such equivalencies are specified.

4.1.4.3 Position Specific Training Needs Analysis

Training needs analyses are performed that establish requirements for both initial and requalification training, including:

- Training needed to develop and maintain proficiency with the core tasks that the position requires

- Training needed to develop and maintain proficiency with specialty tasks/certifications
- Re-qualification training structure, content, and frequency

4.1.4.4 Course Materials

All course materials have specified learning objectives and methods established to objectively verify that the learning and skill development associated with the objectives has taken place. They include lesson plans, simulator scenarios, on-the-job-training materials, mock-ups, and exam banks. They support the efficient and effective delivery of training in the specified venue. They are reviewed for accuracy, controlled, and refined over time as a result of industry/ESBWR OER and modifications to the plant. Re-qualification course materials support skill and knowledge retention over time.

4.1.4.5 Training Facility Requirements

Training facility requirements are generated and contain the required attributes for each course including classrooms, mock-ups, laboratories, part-task simulators, and full-scope simulator. Tools and equipment that must be in the venue to support training are also specified (for example, electrical tools, meters, and specific types of spare breakers for electrical maintenance breaker training).

4.1.4.6 Qualified Personnel

The training program produces plant personnel that have the knowledge, skills, and abilities to properly perform their roles and responsibilities in a consistent, reliable, and safe manner. The proficiency, knowledge, and skills of personnel are maintained over time through a structured and effective requalification program that is revised and updated as needed.

5. RESULTS

5.1 RESULTS SUMMARY REPORT

The results of Training Development are summarized in a Results Summary Report (RSR). This report is the main source of information used to demonstrate that efforts conducted in accordance with the implementation plan satisfy the applicable review criteria of NUREG-0800. The report contains the following:

- General approach including the purpose and scope of training development
- The roles of organizations involved and the facilities and resources needed to satisfy the needs of the training
- The process for developing learning objectives
- The organization and content of the training program
- The methods for verifying the accuracy and completeness of training course materials
- The process for refining and updating the content and conduct of training
- Plans for periodic retraining of personnel

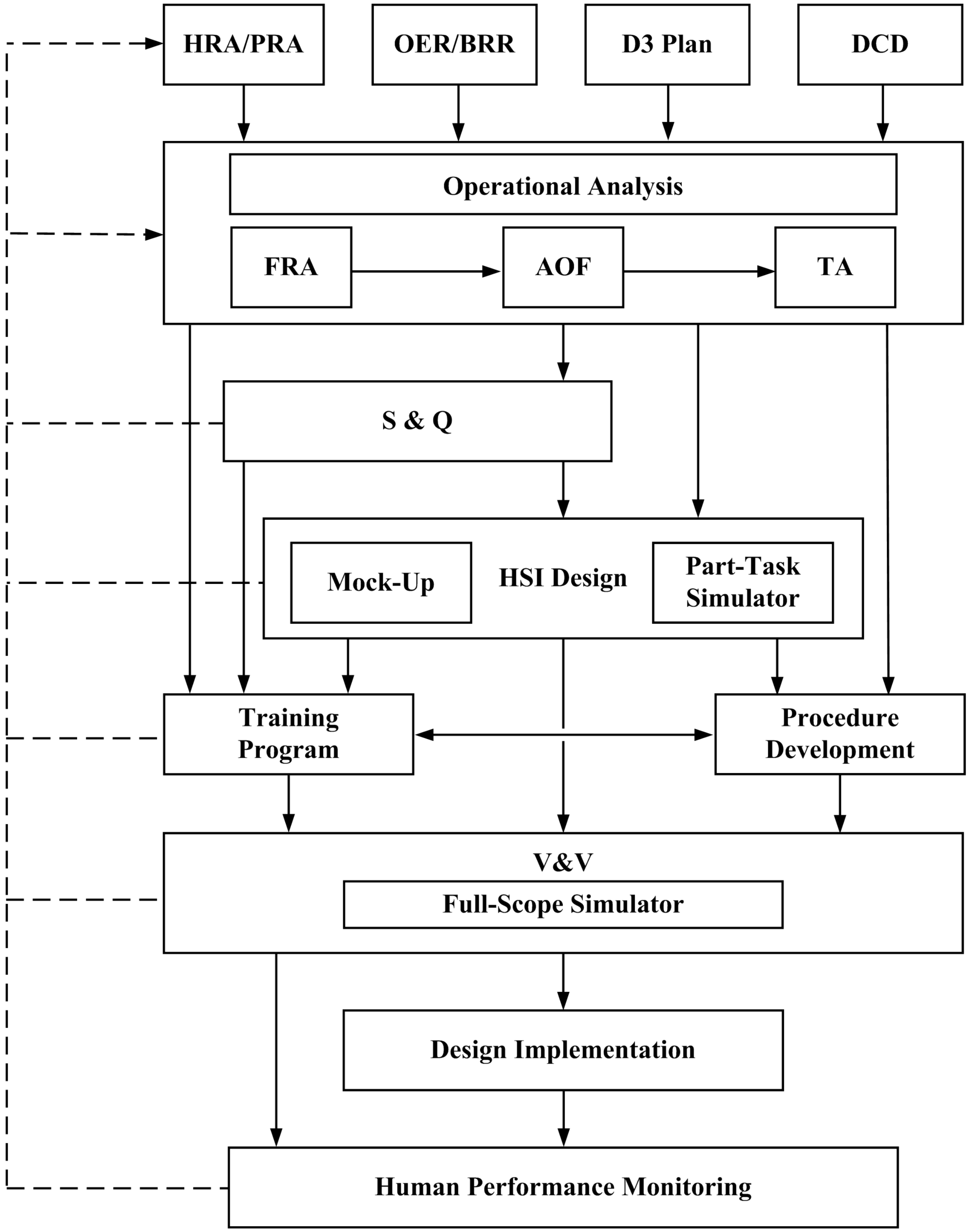

Figure 1. HFE Implementation Process

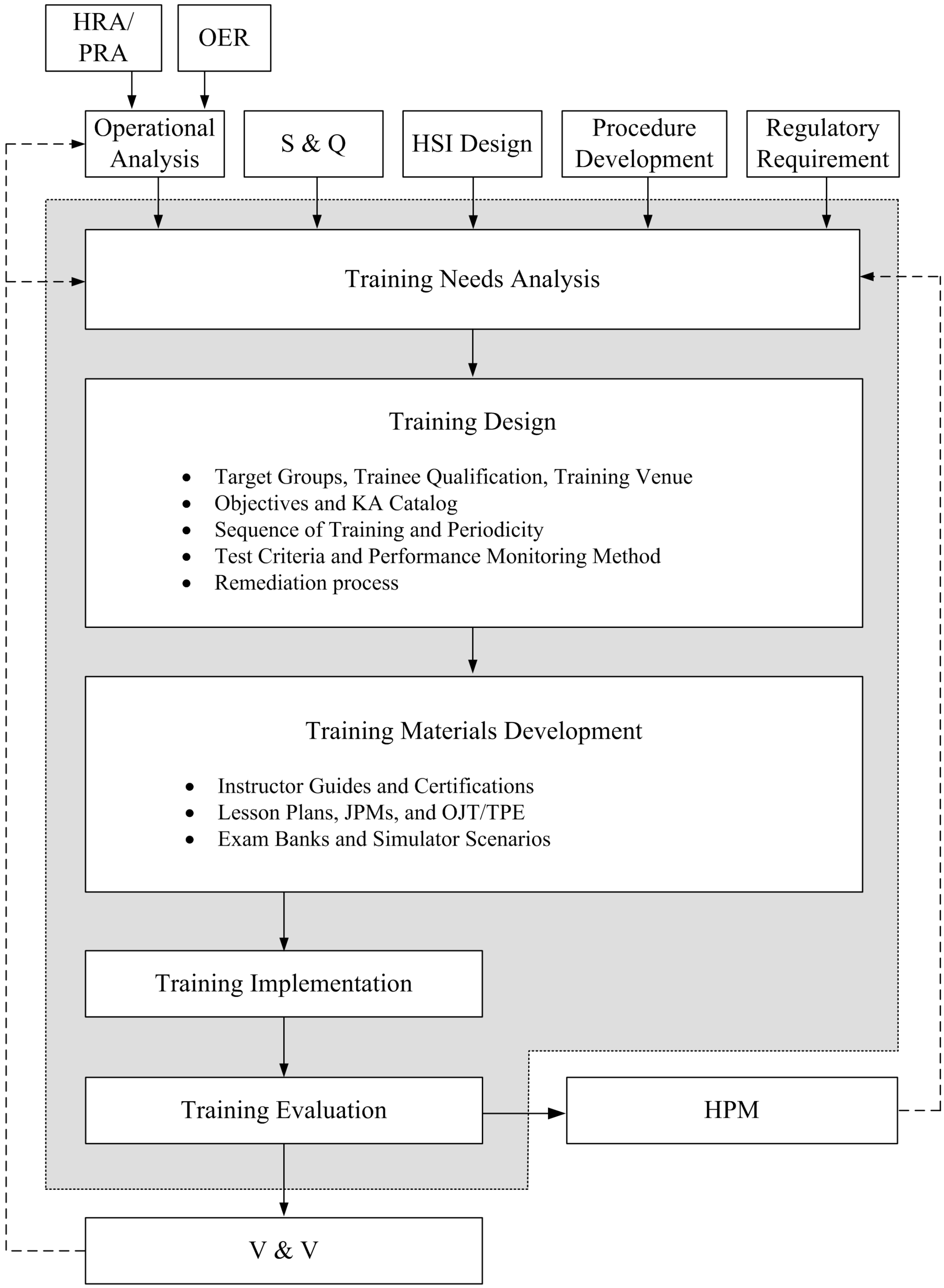

Figure 2. Training Implementation Plan Process Flow Chart

Table 1
ESBWR Technical Training Categories

Category of Trainee [1]	
1	Licensed reactor operator
2	Licensed senior reactor operator
3	Shift technical advisor
4	Shift Supervisor
5	Non-licensed operator
6	Instrument and control technician
7	Electrical maintenance personnel
8	Mechanical maintenance personnel
9	Radiological protection technician
10	Chemistry technician
11	Fuel handling specialist
12	Engineering support personnel

[1] 10 CFR 50.120

Table 2
General Administrative Process Training Categories

General Administrative Control Training[1]	
1	Procedure review and approval process
2	Equipment control
3	Control of maintenance and modifications
4	Fire protection
5	Crane operation
6	Temporary changes to procedures
7	Temporary procedures
8	Special orders of a transient or self-canceling character
9	Standing orders to shift personnel[2]
10	Assignment of shift personnel to duty stations
11	Shift relief and turnover
12	Control room access
13	Limitations on working hours
14	Feedback of operating experience
15	Shift supervisor administrative duties
16	Verification of correct performance of operating activities

[1] NUREG–0800 13.5.1

[2] Includes authority and responsibility of the shift supervisor, senior operator in the control room, control room operator, and shift technical advisor.

Table 3
Conduct of Operations Training Categories

Conduct of Operations[1]	
1	Shift turnover
2	Shift staffing requirements
3	Temporary modifications of procedures
4	Reactor plant startup requirements
5	Mode changes
6	Plant parameter verification [estimated critical position (ECP), heat balance, etc.]
7	Short-term information (e.g., night and standing orders)
8	Key control
9	Security (awareness and familiarity)
10	Familiarity with and use of piping and instrument drawings

[1] Listing from NUREG-1021

Table 4
Equipment Control Training Categories

Equipment Control[1]	
1	Surveillance testing
2	Maintenance
3	Tagging and clearances
4	Temporary modification of systems
5	Fuel handling

[1] Listing from NUREG-1021

Table 5
Radiation Control Training Categories

Radiation Control[1]	
1	Use and function of portable radiation and contamination survey instruments and personnel monitoring equipment
2	Knowledge of significant radiation hazards
3	The ability to perform procedures to reduce excessive levels of radiation and to guard against personnel exposure
4	Radiation exposure limits and contamination control, including permissible levels in excess of those authorized
5	Radiation work permits
6	Control of radiation releases

[1] Listing from NUREG-1021

Table 6
Emergency Plan Training Categories

Emergency Plan[1]	
1	Lines of authority during an emergency
2	Emergency action levels and classifications
3	Emergency facilities
4	Emergency communications
5	Emergency protective action recommendations

[1] Listing from NUREG-1021

Table 7
Example 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 tasks.
Personnel Interactions (In the control room and in the plant)	Understanding information requirements of others, how actions should be coordinated with others, policies and constraints on crew interaction.	Skills associated with crew's interactions (i.e., teamwork).

NOTE: Listing from NUREG-0711r2

APPENDIX A SUMMARY OF NRC REQUIREMENTS FOR LICENSED OPERATOR TRAINING

A.1 BACKGROUND

The Nuclear Regulatory Commission licenses two categories of individuals who operate the controls of a nuclear power plant (1) a reactor operator (RO), and (2) a senior reactor operator (SRO). A RO or SRO controls the reactor during all modes of plant operation including fuel loading and refueling, shutdown, startup, normal operation, and emergency situations. A SRO is a supervisory position overseeing the work of the ROs. The license for an RO or SRO is issued after the individual passes both a written examination and an operating test. The SRO examination also measures the ability of the individual to direct the activities of licensed ROs.

The NRC determines the required qualifications of individuals applying for an operator's license, prescribes uniform conditions for licensing those individuals, and issues licenses as appropriate. Additionally, the NRC provides guidance for training and qualifying nuclear power plant operators, including requirements governing the administration of requalification examinations and operating tests at nuclear power plant simulators. These requirements are provided in Part 55, “Operators’ Licenses,” in Title 10 of the Code of Federal Regulations (CFR). Detailed NRC policies, procedures, and guidelines that pertain to those regulations are published in NUREG-1021, “Operator Licensing Examination Standards for Power Reactors.”

A.2 INITIAL LICENSING PROCESS

Before the NRC licenses an individual to operate or supervise the controls of a nuclear power reactor, the applicant must have several years of related experience and complete extensive classroom, simulator, and OJT covering reactor theory, thermodynamics, power plant components, system design and operation, integrated plant operations, and emergency response. The licensed operator training programs at power reactors are developed and implemented using a systematic approach to training that:

- Sequentially analyzes the jobs to be performed
- Derives learning objectives based upon the job requirements
- Develops training materials to implement the stated learning objectives
- Evaluates the operators’ mastery of those learning objectives
- Uses feedback to revise the training based on the operator’s performance on the job

The National Nuclear Accrediting Board reviews and accredits the operator training programs. The Board operates under the auspices of the Institute of Nuclear Power Operations (INPO) and its activities are monitored by the NRC.

When prospective operators have completed their training, they must complete an application that describes their qualifications and requires the COL Applicant for which the applicant works to certify that the applicant has satisfied the training and experience requirements to be a licensed RO or SRO. License applicants must also undergo a physical examination and be certified physically and mentally fit to be an operator. If the NRC determines that the applicant's qualifications and physical condition are acceptable, the applicant is scheduled to take the NRC licensing examination.

The examination process begins with a written exam covering reactor theory, thermodynamics, and mechanical components. This generic fundamentals NRC examination is administered early in the training program and is a prerequisite for taking the site-specific ESBWR license examination. The site-specific ESBWR license examination consists of a written examination covering the nuclear power plant systems, procedures, and administrative requirements, and an operational test that includes a plant walk-through and a performance demonstration on the COL Applicant’s simulator. The written examinations and operational tests are prepared, administered, and graded using the guidance in NUREG-1021.

In 1999, the NRC amended its regulations to allow COL Applicants to draft the site-specific written examinations and operating tests and submit them to the NRC for review and approval prior to use at the site or to request the NRC to prepare the tests.

If an individual applicant passes the written examinations and operational tests, the NRC issues a license containing any conditions that it considers appropriate and necessary.

A.3 LICENSE CONDITIONS

Each licensed operator is subject to a number of conditions regardless of whether they are stated in the license. For example, all licensed ROs and SROs are required to:

- Observe all applicable rules, regulations, and orders of the NRC
- Maintain their proficiency and complete their facility licensee's requalification training and examination program
- Have a medical examination by a physician every two years, and determine if a permanent physical or mental condition could adversely affect the performance of their duties

Moreover, all licensed ROs and SROs are required to participate in their facility licensee's drug and alcohol testing programs, and they are prohibited from using, possessing, or selling illegal drugs and from performing licensed duties while under the influence of alcohol or any prescription, over-the-counter, or illegal substance that could adversely affect their performance.

A.4 REQUALIFICATION TRAINING

The NRC-approved operator requalification training programs are run on continuous cycles that may not exceed 24 months in duration. Each operator must successfully complete the program and pass a comprehensive written examination and an annual operating test developed and administered by the facility licensee. The NRC actively monitors the operator requalification programs as part of its Reactor Oversight Process, with each program receiving a standard inspection every other year. The inspection:

- Verifies that the facility licensee's program adequately evaluates how well the operators and crews have mastered the training objectives
- Assesses the facility licensee's ability to evaluate and revise the program based on the operator’s performance
- Assesses whether the operators at the facility satisfy the conditions of their licenses
- Assesses the adequacy of the facility licensee's simulation facility
- Determines the need for additional inspections or NRC-conducted requalification examinations at the facility

A.5 LICENSE RENEWAL

Operator licenses expire six years after the date of issuance or upon termination of employment with the facility licensee. If an RO or SRO submits a renewal application to the NRC at least thirty days before the expiration date of the existing license, the license does not expire until the NRC determines the final disposition of the renewal application. The renewal process requires the applicant to provide written evidence of his or her experience under the existing license, a certification from the facility licensee that the applicant is a safe and competent performer who has satisfactorily completed the requalification program for the facility, and certification that the applicant's medical condition and general health are satisfactory. The NRC renews the license if, on the basis of the application and certifications, it determines that the applicant continues to meet the regulatory requirements.

APPENDIX B SIMULATOR DEFINITIONS

B.1 PART TASK SIMULATOR

B.1.1 Purpose

The Part Task Simulator (PTS) is a tool used by the Human Factors Engineering group for the development and testing of Human System Interface display screens, initial development and testing of the plant normal, abnormal, and emergency operating procedures, and the initial development of operations training material.

The PTS has the plant and system fidelity deemed necessary to allow for simulating normal plant operation, including plant heatup and startup, maneuvering at power, and plant shutdown and cooldown. Additionally, the PTS will simulate plant responses to design basis Abnormal Operational Occurrences (AOOs) and accidents.

On a case-by-case basis, for the systems modeled with the required fidelity, PTS can be shown to be high fidelity (in accordance with ANSI 3.5 and Reg Guide 1.149)

B.1.2 Properties

The simulation software for the PTS contains the simulation models resulting from the initial system design of the systems deemed necessary for the PTS, and generic or simplified models of the remainder of the plant systems.

The hardware for the PTS consists of enough table/desk space and Visual Display Units (VDUs) to simulate one console section of the preliminary ESBWR control room design and the required input devices and computers.

The PTS has an instructor station providing the required basic functions (establishing desired initial conditions, backtracking, snap-shot storage, and trending) as determined by the HFE group.

B.1.3 Scope

The PTS software contains the initial system design simulation models for the systems deemed necessary for normal plant operations and generic or simplified models as required for the remaining systems. The systems selected as necessary for the PTS include the normal BWR heat cycle and required auxiliaries, control and protection systems, and ECCS systems.

The PTS contains the initial Human System Interface for the plant systems and includes VDUs and input devices.

B.2 FULL SCOPE SIMULATOR

B.2.1 Purpose

The Full Scope Simulator (FSS) is a high fidelity (in accordance with ANSI 3.5 and Reg Guide 1.149) ESBWR simulation tool used by the Human Factors Engineering group for the validation of the control room design, the validation of plant normal, abnormal, and emergency operating procedures, and the validation of operations training material.

The FSS is able to perform normal, abnormal, and emergency plant operations, and is ANSI 3.5 certified. Those full scope simulators that are used for training are also Regulatory Guide 1.149 compliant.

B.2.2 Properties

The simulation software for the FSS contains the simulation models for the ESBWR plant systems included in the detailed system design along with generic or simplified models of the remainder of the plant systems.

The hardware for the FSS consists of a full-scale mockup of the ESBWR control room.

The FSS has an instructor station providing the full functionality required for ANSI 3.5 certified training simulators.

B.2.3 Scope

The FSS contains the simulation models for the ESBWR plant systems.

The FSS contains the ESBWR Human System Interface for the plant systems, including VDUs and input devices.

B.3 SITE SPECIFIC TRAINING SIMULATOR

B.3.1 Purpose

The site-specific training simulator provides a full scope simulation tool for conducting licensed operator training activities, completing control manipulations for operator license applicants, and conducting license operator operating tests.

In addition to the systems contained in the ESBWR design, the site-specific training simulator simulates site support systems and infrastructure necessary for the operation of the ESBWR. The site-specific training simulator is ANSI 3.5 certified and Reg Guide 1.149 compliant.

B.3.2 Properties

The simulation software for the site-specific training simulator provides the plant operational functionality and fidelity required by ANSI 3.5 certified and Reg Guide 1.149. The software for the systems simulates the detailed system design. The remaining systems are modeled either statically or using simplified models.

The hardware for the site-specific training simulator is developed using the same control room design, and the same materials and manufacturing techniques as the actual ESBWR control room hardware.

The Site Specific Training Simulator has an instructor station providing the full functionality required for ANSI 3.5 certified training simulators.

B.3.3 Scope

The site-specific training simulator is an ANSI 3.5 certified and Reg Guide 1.149 compliant full scope simulator for operator training and testing.

The site-specific training simulator contains consoles and panels with the same form, fit, and feel as the ESBWR main control room.