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Human Factors Engineering Program Management Plan

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Table of Contents

Abstract **1**
Executive Summary **2**
1.0 Purpose **3**
2.0 Human Factors Engineering Program Goals and Scope **4**
2.1 Program Goals 4
2.2 Program Scope 4
2.2.1 Assumptions and Constraints 4
2.2.2 HFE Program Duration 6
2.2.3 Applicable Facilities 6
2.2.4 Applicable Human-System Interfaces, Procedures, and Training 6
2.2.5 Applicable Personnel 7
2.2.6 Effects of Modifications on Personnel Performance 7
2.3 Abbreviations and Definitions 8
3.0 Human Factors Engineering Team, Qualifications, and Organization **10**
3.1 Responsibility 10
3.2 Organizational Placement and Authority 10
3.3 Composition 11
3.4 Team Staffing 13
4.0 Human Factors Engineering Processes and Procedures **14**
4.1 General Process Procedures 14
4.1.1 Human Factors Engineering Team Assignment 14
4.1.2 Internal Management of the HFE Team 14
4.1.3 Making Decisions on Management of the HFE Program 14
4.1.4 Making HFE Design Decisions 14
4.1.5 Controlling Changes in Design of Equipment 14
4.1.6 Review of Human Factors Engineering Products 15
4.2 Process Management Tools 15
4.3 Integration of Human Factors Engineering and Other Plant Design Activities 15
4.4 Human Factors Engineering Program Milestones 16
4.5 Human Factors Engineering Documentation 16
4.6 Subcontractor HFE Efforts 17

Table of Contents

5.0 Human Factors Engineering Issue Tracking System 18
5.1 Availability of Human Factors Engineering Issue Tracking System 18
5.2 Human Factors Engineering Issues Tracking Methodology 18
5.3 Human Factors Engineering Issues Tracking Documentation 19
5.4 Human Factors Engineering Issues Tracking Responsibilities 19
5.4.1 Supervisor, Human Factors Engineering Team 19
5.4.2 Human Factors Engineering Issue Tracking System Team Lead 19
5.4.3 Human Factors Engineering Issues Tracking System Administrator 20
5.4.4 HFE Team Member Issue Evaluator 20
5.4.5 Issue Owner 20
5.4.6 HFEITS Review Committee 20
5.4.7 Human Engineering Discrepancy Resolution 21
5.4.8 HED Process Flow 22
6.0 Human Factors Engineering Technical Program Elements 24
6.1 Operating Experience Review 24
6.2 Functional Requirements Analysis and Function Allocation 25
6.3 Task Analysis 26
6.4 Staffing and Qualifications 27
6.5 Treatment of Important Human Actions 27
6.6 Human-System Interface Design 28
6.7 Procedure Development 29
6.8 Training Program Development 29
6.9 Human Factors Verification and Validation 29
6.10 Design Implementation 29
6.11 Human Performance Monitoring 30
7.0 NUREG-0711 Conformance Evaluation 31
8.0 References 37
8.1 Source Documents 37
8.2 Referenced Documents 37
Appendix A NuScale HFE Program Design Integration A-1

List of Tables

Table 2-1 Abbreviations 8
Table 2-2 Definitions. 9
Table 3-1 Human Factors Engineering Team Member Qualifications 12
Table 4-1 Human Factors Engineering Program and Design Activity Milestones 16
Table 7-1 Conformance with NUREG-0711 31

List of Figures

Figure 5-1 Human Factors Engineering Issues System Process 21
Figure 5-2 Human Engineering Discrepancy Resolution Process. 23
Figure A-1 NuScale and Human Factors Engineering Program Design Integration A-2
Figure A-2 Human Factors Engineering Program Process A-4

Abstract

NuScale Power, LLC (NuScale) has developed a Human Factors Engineering (HFE) Program for the NuScale Power Plant utilizing proven HFE technology and incorporating accepted HFE principles, standards, and guidelines. The overall HFE Program incorporates twelve HFE elements under four general activities including planning and analysis, design, verification and validation, and implementation and operation. The planning and analysis activity includes an HFE Program management element for the management of the overall HFE Program to ensure that the HFE Program is properly developed, executed, overseen, and documented. This program management plan describes the HFE Program management element, and is consistent with the applicable guidelines of Section 2 of NUREG-0711, Revision 3 (Reference 8.1.1).

Executive Summary

The Human Factors Engineering (HFE) Program incorporates 12 HFE elements under four general activities in accordance with the guidance of NUREG-0711:

- planning and analysis
  - HFE Program management
  - operating experience review
  - functional requirements analysis and function allocation
  - task analysis
  - staffing and qualifications
  - treatment of important human actions

- design
  - human-system interface design
  - procedure development
  - training program development

- verification and validation
  - human factors verification and validation

- implementation and operation
  - design implementation
  - human performance monitoring

The HFE Program management element falls under the planning and analysis activity, and its purpose is to ensure that the HFE Program is properly developed, executed, overseen, and documented. This program management plan describes NuScale's overall plan to accomplish this goal. Consistent with the guidance of NUREG-0711, the topics of discussions in this program management plan include the HFE Program scope, team, processes and procedures, and tracking of HFE issues.

This program management plan also provides a summary of the remaining eleven HFE elements, and identifies the elements that are beyond the scope of the standard design. Specifically, activities associated with procedure development, training program development, and human performance monitoring elements are the responsibility of a licensee. Additional details on the implementation methodology and the results of analyses for the applicable HFE elements are contained in the associated implementation plans or the results summary reports.

1.0 Purpose

This NuScale Human Factors Engineering (HFE) Program management plan (PMP) describes how HFE is incorporated into the design of human-system interfaces (HSIs), procedures, and training. Human factors engineering is also applied to aspects of the overall plant design as described in Section 2.2.1. As part of the Operations organization, the HFE team ensures that the processes detailed in this plan are integrated into the analysis, development, design, and operation of the NuScale Power Plant.

The purpose of this Human Factors Engineering PMP is to describe the following:

- HFE Program goals and scope
- HFE team, qualifications, and organization
- HFE processes and procedures
- HFE Issues Tracking System (HFEITS)
- HFE technical program elements

The scope of this Human Factors Engineering PMP is consistent with the applicable guidance of Section 2 of NUREG-0711, Revision 3.

2.0 Human Factors Engineering Program Goals and Scope

2.1 Program Goals

The goal of this PMP is to describe how the overall NuScale HFE Program implementation is conducted to comply with regulatory requirements 10 CFR 50.34(f)(2)(iii) (Reference 8.2.1) and 10 CFR 52.47(a)(8) (Reference 8.2.2) regarding the use of state-of-the-art human factors principles.

The primary goal of the NuScale HFE Program is to provide a "human-centered" approach for plant operators and technicians to control plant processes and equipment safely and reliably so that the

- tasks can be accomplished by personnel within the required time frame and according to defined performance criteria (e.g., HSI navigation and system response time, human-human interaction).
- HSI, procedures, staffing and qualifications (S&Q), training, management, and organizational arrangements support optimum performance and situational awareness.
- design supports personnel in maintaining vigilance over plant operations and provides acceptable workload levels (i.e., minimize periods of under- and over-load).
- design of the HSI serves to minimize personnel errors and supports error detection and recovery capability.

As the program develops, the program goals are further defined and used as a basis for HFE tests and evaluations.

2.2 Program Scope

2.2.1 Assumptions and Constraints

The following assumptions and constraints shape the HFE Program:

Passive Features

The NuScale Power Plant is designed with passive features to make it inherently safe and to reduce the need for operator interaction.

- Reactor coolant flow is circulated without the use of reactor coolant pumps enabling passive cooling.
- Safety systems are designed with passive and fail-safe features.
- Decay heat is removed to the ultimate heat sink without the use of pumps or the need for electric power.
- No operator actions are necessary for a minimum of 72 hours following a design basis event.

Modular Design

The NuScale Power Plant is capable of operating up to six units. The NuScale Power Plant is considered a modular design because

- operation of the first module can begin before successive modules are installed.
- refueling of individual modules can occur with others online.
- systems (e.g., pool cooling water, instrument air, ventilation, radioactive waste, and component cooling water, fire protection, the alternating current electrical) are shared across up to six units.
- up to six units are controlled from a single main control room (MCR).

High Degree of Automation

The NuScale Power Plant is highly automated to reduce the need for operator actions and allow for monitoring multiple units simultaneously.

- Steady state routine operating tasks are automated to the extent that human interactions to start, stop, or suspend automated sequences do not distract the operator.
- The HSIs support operator monitoring and management of automated actions and sequences. Within limits, automated actions and sequences may be altered or suspended by the operator. Automated actions or sequences initiated in response to off-normal conditions or emergencies also make available to the operator information on why the actions were required and what actions have been or must be performed.
- Shutdown functions are automated to the extent that one operator at the controls can maneuver a unit from power operations to cold shutdown within a finite period of time. In off-normal conditions requiring unit shutdown, the operating crew may suspend nonessential activities, to provide appropriate resources to address the off-normal condition. Note: One operator at the controls is a design goal, rather than a constraint. The HFE analyses and HSI design activities determine if this is possible while still meeting the HFE Program goals.
- Most operability surveillance tests are sequences initiated by operators or executed (i.e.,configuration verified, test conditions verified, data collected, and results checked against acceptance criteria) by automation. Note: The design goal is to automate as much surveillance testing as is feasible considering technical specifications, regulation, and operator situational awareness.
- Computer-based procedures for normal, abnormal, and emergency operations and alarm response are text-based.

Main Control Room Operators

The staffing evaluations are based on activities performed by licensed control room operators. Staffing analysis for maintenance or refueling activities; activities completed by craft or technical personnel (e.g., mechanical, electrical, or

instrumentation and controls (I&C) maintenance; health physics; chemistry; engineering; or information technology); or activities associated with the Technical Support Center (TSC), Emergency Operations Facility (EOF), or other Emergency Response facilities are included only if they are determined to impact licensed operator workload. When licensed operator workload is impacted, then the area of concern is analyzed to quantify the impact to licensed operator workload or staffing, and develop HSI or staffing adjustments required to address the specific task and associated staffing requirements.

The numbers and qualifications of non-licensed operator personnel, including technicians and maintenance staff, are the responsibility of a licensee, and are not analyzed by the NuScale HFE Program.

Reference 8.2.9 provides more information on the methodology and results of staffing evaluations.

2.2.2 HFE Program Duration

The NuScale HFE Program is applicable from the start of conceptual design through turnover to the licensee. After plant turnover to the owner, an established Human Performance Monitoring Program maintains the HFE Program design data and appropriate processes.

2.2.3 Applicable Facilities

The scope of the NuScale HFE Program includes the alarms, controls, indications, and procedures applicable to the MCR and other operator enabled workstations connected to the module control system and plant control system. The HSIs at any other operator enabled workstation are an extension of the controls available in the MCR. Access may be limited based on location and operator login, or fully enabled in the event of MCR evacuation. The HSIs of the TSC, the EOF, and local control stations (LCS) are also included implicitly because their HSIs are derivatives of the main control room human-system interface. The EOF and the TSCwill comply with the guidance of NUREG-0696, Functional Criteria for Emergency Response Facilities. The HSI in the TSC and EOF are derivatives of the main control room human-system interface and comply with the HSI Style Guide; however, these HSIs are for information display only. No control functions are provided in any of the Emergency Response facilities. For these facilities, the program scope is limited to defining the plant data and their HSI’s impact on licensed operator workload.

2.2.4 Applicable Human-System Interfaces, Procedures, and Training

The HSI design process represents the translation of function, allocation, and task requirements into HSI characteristics and implementation strategies. The HSI design inputs include the following:

- operating experience review (OER)
- functional requirements analysis and function allocation (FRA/FA)

- task analysis (TA)
- S&Q
- treatment of important human actions (TIHA)
- concept of operations
- I&C systems design
- system requirements
- HSI Style Guide

The HFE Program supports procedure and training program development for normal operating, abnormal operating, emergency operating, alarm response, and accident management activities performed or supervised by licensed operators.

In addition, the program provides appropriate inputs to the training programs for the personnel identified in 10 CFR 50.120 (Reference 8.2.3), including

- I&C technicians.
- electrical and mechanical maintenance personnel.
- radiological protection personnel.
- chemistry technicians.
- engineering support personnel.
- other personnel who perform tasks directly related to plant safety, such as information technology technicians who troubleshoot and maintain support systems and their HSIs.

2.2.5 Applicable Personnel

The number and qualifications of operators including licensed control room operators as defined in 10 CFR 55 (Reference 8.2.4) and the control room supervisor and shift manager, are analyzed and defined by the NuScale HFE Program as described in Section 6.4.

2.2.6 Effects of Modifications on Personnel Performance

The HFE design process described in program elements up to and including design implementation (DI) evaluates the effect on personnel performance for modifications in the plant design performed before completion of startup testing that affect HSI design, procedures, or training. These evaluations occur directly or through the resolution of human engineering discrepancies (HEDs).

The licensee institutes a Human Performance Monitoring (HPM) Program to continuously evaluate impacts on human performance going forward. The HPM Program is described in Section 6.11.

Separate from HPM, licensees conduct plant modifications in accordance with regulatory requirements such as 10 CFR 50.59, Changes, Tests, and Experiments. These requirements invoke additional HFE analysis or testing as deemed necessary by the licensee's site-specific HFE team. The plant modification process is outside the scope of HPM.

2.3 Abbreviations and Definitions

Table 2-1 Abbreviations

Term	Definition
CFR	U.S. Code of Federal Regulations
DI	design implementation
DIHA	deterministically important human actions
EOF	Emergency Operations Facility
FRA/FA	functional requirements analysis and function allocation
HA	human action
HED	human engineering discrepancy
HFE	Human Factors Engineering
HFEITS	Human Factors Engineering Issues Tracking System
HPM	human performance monitoring
HRA	human reliability analysis
HSI	human-system interface
I&C	instrumentation and control
IP	implementation plan
ISV	integrated system validation
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
LCS	local control stations
MCR	main control room
NRC	U.S. Nuclear Regulatory Commission
OE	operating experience
OER	operating experience review
PMP	program management plan
PRA	Probabilistic Risk Assessment
QAPD	Quality Assurance Program Description
QMP	quality management plan
RIHA	risk-important human actions
RSR	results summary report
S&Q	staffing and qualifications
SME	subject matter expert
SRO	senior reactor operator
TA	task analysis
TIHA	treatment of important human actions
TSC	Technical Support Center
V&V	verification and validation

Table 2-2 Definitions

Term	Definition
Simulator Review Board	The Simulator Review Board reviews the results of simulator testing and compares them to analysis and engineering calculations to certify that the simulator reflects the plant design. This board consists of representatives from Safety Analysis, Probabilistic Risk Assessment (PRA), Engineering, and Operations. Their review is focused on realism to the operator and model validity.
Unit	A NuScale unit consists of the components necessary to generate electricity. This includes a primary side containing a reactor power module and its specific supporting systems, and a secondary side containing a turbine generator and its specific supporting systems.
Module	A NuScale module consists of the containment vessel, reactor pressure vessel, and all components internal and external to each vessel, up to the disconnect flanges.
HFE Design Team	The HFE Design Team reviews HEDs and determines the appropriate design changes to the HSI or plant design to resolve the HED. This group consists of members of the HFE team.

3.0 Human Factors Engineering Team, Qualifications, and Organization

3.1 Responsibility

Before HFE Program turnover, the NuScale HFE team is the primary organization that is responsible for the overall HFE Program. Specifically, the HFE team is responsible for

- developing HFE implementation plans (IP), procedures, and results summary reports (RSR), and ensuring HFE activities' compliance with the HFE plans and procedures.
- scheduling and overseeing HFE activities in HFE design, development, test, and evaluation as appropriate, and verifying that the team's recommendations are implemented.
- HFE reviews of documents produced by other engineering disciplines.
- initiating, evaluating, resolving or ensuring resolution of, and maintaining tracking records for HFE issues noted during design activities for all engineering disciplines (Section 5.0, Human Factors Engineering Issue Tracking System [HFEITS]).

3.2 Organizational Placement and Authority

The HFE team consists of two groups. The core group comprises those members who report to the HFE supervisor. The other group is not a specific organization. This group includes simulator engineers and various members of the Design Engineering organization such as System Engineering, Probabilistic Risk Assessment, Safety Analysis, and Mechanical Engineering. These members do not report to the HFE supervisor from a functional organizational perspective; rather, they are distributed throughout the design organization and represent expertise available to the core HFE team on an as-needed basis. Although these personnel do not report to the HFE supervisor, they are part of the HFE team, and take direction from the HFE supervisor while performing HFE activities. Accordingly, the HFE supervisor exercises sufficient authority and control over these personnel to reasonably ensure HFE tasks assigned to them are completed. The list and qualifications of the HFE team members are discussed in Section 3.3.

The HFE team members that report directly to the HFE supervisor are a diverse group that includes

- human factors engineers that have received formal HFE training.
- experienced operators that have held NRC-issued reactor operator and senior reactor operator licenses with varying backgrounds in areas such as training, engineering, maintenance, and licensing.

NuScale has integrated human factors engineers and operators into a group reporting to the HFE supervisor. This supervisor reports to a Plant Operations manager or director, who in turn reports to an Executive. The result is a diverse team with common interests that have significant authority to influence, establish design standards, and advise design engineers. This influence ensures the integration of systems into an operationally safe design.

The HFE supervisor has ultimate responsibility for scheduling and oversight of the various HFE activities and is the owner of the HFEITS database. The HFE supervisor or other members of the HFE team elevate issues within the management chain as necessary utilizing appropriate NuScale programs and tools.

The HFE Program is applicable from the start of conceptual design through completion of plant startup testing. Changes to the HFE organization and responsibilities may occur during construction and startup. A licensee is responsible for ensuring that transitions among responsible organizations are made as necessary and appropriate.

3.3 Composition

As discussed in Section 3.2, the HFE team includes personnel that report directly to the HFE supervisor, and various other personnel distributed throughout the organization who do not directly report to the HFE supervisor. The HFE team incorporates, at a minimum, the expertise described in the appendix of NUREG-0711, Revision 3 (Table 3-1). The experience and education levels of the members of the core HFE team meet many of the requirements listed in Table 3-1; however, both the core HFE team and the HFE team members distributed throughout the organization combined together meet the required experience and qualifications as listed in Table 3-1.

Alternative personal credentials may be accepted as the basis for satisfying these specific minimum qualifications for team membership. Acceptance of such credentials is evaluated on a case-by-case basis and approved, documented, and retained by the applicant in auditable files. The following factors are examples of alternative credentials that may be considered acceptable:

- Successful completion of technical portions of an engineering, technology, or related science baccalaureate program may be substituted for the bachelor's degree. Successful completion is be determined by a transcript or other certification by an accredited institution. For example, completion of 80 semester credit hours may be substituted for the baccalaureate requirement. The courses must be in technical subjects appropriate and relevant to the skill areas of the HFE Design Team for which the individual will be responsible.
- Related experience may be substituted for education at the rate of six semester credit hours for each year of experience, up to a maximum of 60 credit hours.
- Where course work is related to job assignments, post-secondary education may be substituted for experience at the rate of two years of education for one year of experience. Total credit for post-secondary education can not exceed two years of experience credit.

Table 3-1 Human Factors Engineering Team Member Qualifications

Technical Discipline	Minimum Qualifications
Technical Project Management	• Bachelor's degree • 5 years of experience in nuclear power plant design or operations • 3 years of management experience
Systems Engineering	• Bachelor of Science degree • 4 years of cumulative experience in at least three of the following areas of systems engineering: •design •development •integration •operation •test and evaluation
Nuclear Engineering	• Bachelor of Science degree • 4 years of nuclear design, development, test, or operations experience
HSI or I&C Engineering	• Bachelor of Science degree • 4 years of experience in design of hardware and software aspects of process control systems • Experience in at least one of the following areas of engineering: •design •power plant operations •test and evaluation • Familiarity with the theory and practice of software quality assurance and control
HFE	• Bachelor's degree in HFE, engineering psychology, or related science • 4 years of cumulative experience related to the human factors aspects of human-computer interfaces. Qualifying experience should include at least the following activities within the context of large-scale human-machine systems (e.g., process control): •design •development •test and evaluation • 4 years of cumulative experience related to the human factors aspects of workplace design. Qualifying experience should include at least two of the following activities: •design •development •test and evaluation
Plant Operations	• Has, or has held, an SRO license • 2 years of experience in relevant nuclear power plant operations
Computer System or Simulator Engineering	• Bachelor's degree in electrical engineering or computer science, or graduate degree in another engineering discipline (e.g., mechanical engineering or chemical engineering) • 4 years of experience in the design of digital computer systems and real-time systems applications • Familiarity with the theory and practice of software quality assurance and control
Plant Procedure Development	• Bachelor's degree • 4 years of experience in developing nuclear power plant operating procedures
Personnel Training	• Bachelor's degree • 4 years of experience in the development of personnel training programs for power plants • Experience in the application of systematic training development methods

Table 3-1 Human Factors Engineering Team Member Qualifications (Continued)

Technical Discipline	Minimum Qualifications
Safety Analysis	• Bachelor of Science degree • 4 years of experience in system safety engineering
Maintainability/ Inspectability Engineering	• Bachelor of Science degree • 4 years of cumulative experience in at least two of the following areas of power plant maintainability and inspectability engineering activity: •design •development •integration •test and evaluation • Experience in analyzing and resolving plant system and equipment-related maintenance problems
Probabilistic Risk Assessment	• Bachelor's degree • 4 years of cumulative experience in at least two of the following areas of power plant reliability engineering activity: •design •development •integration •test and evaluation • knowledge of computer-based, human-interface systems

3.4 Team Staffing

The HFE supervisor assigns members of the HFE team (including personnel from outside the Plant Operations organization) to HFE activities to ensure that the necessary expertise is applied in performing those activities. Members of the core HFE team are assigned as leads and owners of various HFE related areas. For example, each core HFE team member is assigned a group of systems and is the primary interface and representative with engineering for that system. Additionally, this person is responsible for completing the work in support of FRA/FA, TA, HSI, procedures, and training development for the systems assigned. This person also performs the system design document and functional specification reviews for the assigned group of systems. Members of the core HFE team are also assigned as functional leads for nonsystem areas such as PRA, emergency planning, and simulator design.

4.0 Human Factors Engineering Processes and Procedures

4.1 General Process Procedures

4.1.1 Human Factors Engineering Team Assignment

The HFE supervisor assigns personnel from throughout the organization so that the required expertise, knowledge, and experience are applied to each HFE activity. The IPs and RSRs describe the expertise utilized for each activity within the HFE Program element.

4.1.2 Internal Management of the HFE Team

The HFE supervisor assigns members of the HFE team (within the Plant Operations organization, Design Engineering, and other organizations) and supervises them during performance of HFE tasks.

4.1.3 Making Decisions on Management of the HFE Program

The HFE supervisor has ultimate responsibility for scheduling and oversight of the various HFE activities.

4.1.4 Making HFE Design Decisions

The HFE supervisor has primary authority to make management decisions for HFE activities. Where design decisions require input from multiple organizations, the HFE supervisor may elevate issues within the management chain utilizing NuScale tools and programs including HFEITS, the applicable NuScale internal procedures, design review boards (who perform design reviews as part of design), and the Corrective Action Program.

Any member of the HFE team may identify problems and propose solutions using the HFEITS tool. The HFE supervisor has authority to make decisions regarding resolution of HFEITS items (including HEDs).

4.1.5 Controlling Changes in Design of Equipment

The HFE supervisor is responsible for the design of and changes to MCR equipment. Design Engineering is responsible for the design of HSIs throughout the plant. Design changes to HSI and other equipment that have major input from HFE are governed through a design change process. As discussed in Section 3.4, the HFE team members perform reviews of the assigned system design documents and have the authority to approve the documents. They also participate in key meetings such as system design phase reviews. This involvement ensures that the HFE team members have the authority to influence and control design changes.

4.1.6 Review of Human Factors Engineering Products

The HFE supervisor has ultimate responsibility for scheduling and oversight of the various HFE activities including reviews of HFE team products. Where independent reviews (outside the overall HFE team) are necessary, the HFE supervisor retains approval authority for HFE team products.

4.2 Process Management Tools

Human Factors Engineering, like other NuScale engineering discipline activities, is conducted in accordance with the NuScale Quality Management Plan (QMP) and subordinate plans and procedures, including the design control process. The QMP establishes controls to ensure that provisions and commitments contained in NuScale Quality Assurance Program Description (QAPD) have been implemented appropriately.

The design process includes provisions to control design inputs, outputs, changes, interfaces, records, and organizational interfaces within NuScale and with suppliers. These provisions ensure that design inputs (e.g., design bases and the performance, regulatory, quality, and quality verification requirements) are correctly translated into design outputs (e.g., analyses, specifications, drawings, procedures, and instructions). This translation ensures that the final design output can be related to the design input in sufficient detail to permit verification. Design change processes and the division of responsibilities for design-related activities are detailed in NuScale and supplier procedures. The Design Control Program includes interface controls necessary to control the development, verification, approval, release, status, distribution, and revision of design inputs and outputs. Design changes and disposition of nonconforming documents are reviewed and approved by the NuScale design organization or by other organizations authorized by NuScale.

The HFE Program tools and techniques used to fulfill responsibilities are also available to support the HFE elements. Specific tools and techniques used for each HFE element are described in the respective IPs or RSRs. HFE Program tools and techniques used include

- design guidelines.
- design verification checklists.
- low fidelity aids such as mockups (computer aided drawings or physical representations of HSI).
- multi-unit control room simulator (capable of supporting single, shared, and multi-unit HSI, as well as training, procedure, and S&Q analysis).

4.3 Integration of Human Factors Engineering and Other Plant Design Activities

Appendix A describes the HFE team integration into the iterative design process through the design review process.

4.4 Human Factors Engineering Program Milestones

Table 4-1 shows the relationship of HFE Program element design activities to the activity milestones. The IP and RSR shown parenthetically in the activities column represent the type of submittal associated with a given activity or HFE element.

An HFE relative project schedule with milestones is integrated into the project design development schedule and is available for review.

Table 4-1 Human Factors Engineering Program and Design Activity Milestones

HFE and Design Activities		**Activity Milestones**	
Type of Activities	Activities	Standard Design Approval Application	Before Fuel Load
HFE Element Evaluation	Operating Experience Review (IP)	X	
	Operating Experience Review (RSR)		X
	Functional Requirements Analysis and Function Allocation (IP)	X	
	Functional Requirements Analysis and Function Allocation (RSR)		X
	Task Analysis (IP)	X	
	Task Analysis (RSR)		X
	Staffing & Qualifications (RSR) (Note 1)	X	
	Treatment of Important Human Actions (RSR) (Note 1)	X	
	Human-System interface Design (IP)	X	
	Human-System interface Design (RSR)		X
	Procedure Development		Note 2
	Training Program Development		Note 2
	Verification & Validation (IP)	X	
	Verification & Validation (RSR)		X
	Design Implementation (IP) (Note 3)	X	
	Human Performance Monitoring (Note 4)		X

NOTE 1: Each RSR issued without a corresponding IP includes a description of the methodology used for the HFE element.
NOTE 2: Training and Procedure Development are managed per Chapter 13.
NOTE 3: No RSR is required for this element because conformance of the as-built design to the verified and validated design is confirmed by an ITAAC.
NOTE 4: The Licensee will provide an IP for Human Performance Monitoring after the plant becomes operational.

4.5 Human Factors Engineering Documentation

The HFE documents that support design are quality records and retained in accordance with the NuScale QMP. The HFE documentation includes design verification checklists, HFEITS records, documentation identified in the HFE element technical reports (e.g., RSRs, guides, and training programs), and information stored in the HFE database.

Table 4-1 provides a tabulation of HFE milestones and corresponding activity timeline for the associated documentation.

4.6 Subcontractor HFE Efforts

If a subcontractor is involved in HFE activities, the HFE team verifies that the subcontractor is properly trained and complies with the NuScale QMP and subordinate plans and procedures. The QMP establishes controls to ensure that provisions and commitments contained in NuScale's QAPD have been implemented appropriately. The QAPD requires that NuScale subcontractors establish a qualification program that is applied to individuals performing quality inspections regardless of the functional group where they are assigned. The NuScale Quality Assurance organization verifies that the subcontractors conduct work in accordance with the NuScale QMP or the subcontractor's Quality Assurance Program as contracted.

5.0 Human Factors Engineering Issue Tracking System

5.1 Availability of Human Factors Engineering Issue Tracking System

The HFE issues are identified and tracked in the HFEITS database. An HFE issue is any issue that has not been resolved in the NuScale HFE Program process. Issues are those items that need to be addressed at some later date and thus need to be tracked to provide reasonable assurance that they are not overlooked.

The HFEITS database is available to any member of the HFE team and identification of issues is part of the NuScale safety-conscious work environment.

HFE issues may include

- recognized industry HFE issues.
- issues identified throughout the life cycle of the HFE project.
- human engineering discrepancies found during HFE design.
- deficiencies with operating procedures.
- discrepancies noted with the HSI.
- simulator modeling issues.
- simulator (control room) ergonomics.

The HFEITS database is maintained by NuScale, and updated as new issues are identified. Upon HFE Program turnover to a licensee, open items are communicated to the licensee for duplication in the licensee's tracking system. The HFEITS process is depicted in Figure 5-1.

5.2 Human Factors Engineering Issues Tracking Methodology

Because the HFE team is imbedded into the design engineering process, most potential HFE issues can be resolved immediately. This resolution is accomplished through direct feedback to design engineers, at engineering design phase review meetings, and during design document review and comment resolution. If the issue cannot be immediately resolved, it is entered into the HFEITS database and is assigned a unique tracking number. Supporting documentation in electronic format is attached to the database item.

The HFE issue is screened and evaluated to confirm potential degradation in human performance. Issues found that do not degrade human performance are either closed or transferred to more appropriate corrective action processes. Proposed corrective action to resolve the HFE issue is identified and assigned as necessary. Due dates for resolution of the overall evaluation or for each corrective action are established by the HFEITS administrator. Issue close-out and transfer with proper documentation is approved by both the HFEITS administrator and the HFE supervisor. The HFE supervisor may obtain support from the HFE team to resolve and approve the closure of items in the HFEITS database. At HFE Program milestones (completion of certain activities), the HFEITS database is reviewed for items to be resolved or closed.

5.3 Human Factors Engineering Issues Tracking Documentation

For each HFE issue, the following information is documented in the HFEITS database:

- issue date
- supporting information (e.g., attachments documenting the issue)
- assigned issue owner and evaluator
- whether or not the issue involves a human engineering discrepancy
  - Note: Management and closure of human engineering discrepancies are discussed in the HFE Program technical reports and RSRs (Section 6.0).
- proposed resolution
- HFE team acceptance or rejection and detailed justification
- implemented resolutions (e.g., changes to design)
  - Note: Descriptions of resolutions are sufficiently detailed to provide traceability and promote third party review.
- actions taken (e.g., programmatic or administrative changes determined appropriate to address larger issues)
- affected document(s)

5.4 Human Factors Engineering Issues Tracking Responsibilities

HFE team members are responsible for identifying, logging, evaluating, and tracking HFE issues to resolution.

5.4.1 Supervisor, Human Factors Engineering Team

The HFE supervisor has overall responsibility for administering and managing the HFE ITS team and review committee.

5.4.2 Human Factors Engineering Issue Tracking System Team Lead

The HFEITS team lead is responsible for requesting resolution and verification resources from the responsible manager, in order to resolve open HFEITS issues.

The HFEITS team lead is responsible for

- providing oversight of HFE issue tracking.
- coordinating appropriate resources across the company including operations subject matter experts (SMEs), software developer SMEs, and plant system SMEs to identify and implement resolution solution.
- approving resolution of HFE issues with support from HFE team as needed.
- coordinating the HFEITS review committee.
- coordinating with the software review board.

- adding and removing users authorized to modify the database.
- negotiating initial issue evaluator and owner assignments.
- negotiating initial resolution and corrective action due dates.
- tracking the issue resolution and corrective action due dates.
- approving issue evaluator and owner changes.
- approving due date changes.

5.4.3 Human Factors Engineering Issues Tracking System Administrator

The HFEITS administrator is assigned responsibility for managing the software component of the database. The administrator will not necessarily be a member of the HFE team (e.g., an information technology specialist). The HFEITS administrator's responsibilities include

- managing the integrity of the HFEITS database.
- maintaining hardware and software for optimum performance.
- managing database security.

5.4.4 HFE Team Member Issue Evaluator

An HFE team member issue evaluator's responsibilities include

- evaluating issues.
- identifying the extent and significance of issues.
- recommending selection of issue owners.
- recommending corrective actions.
- recommending resolution due dates.

5.4.5 Issue Owner

The issue owner's responsibilities include

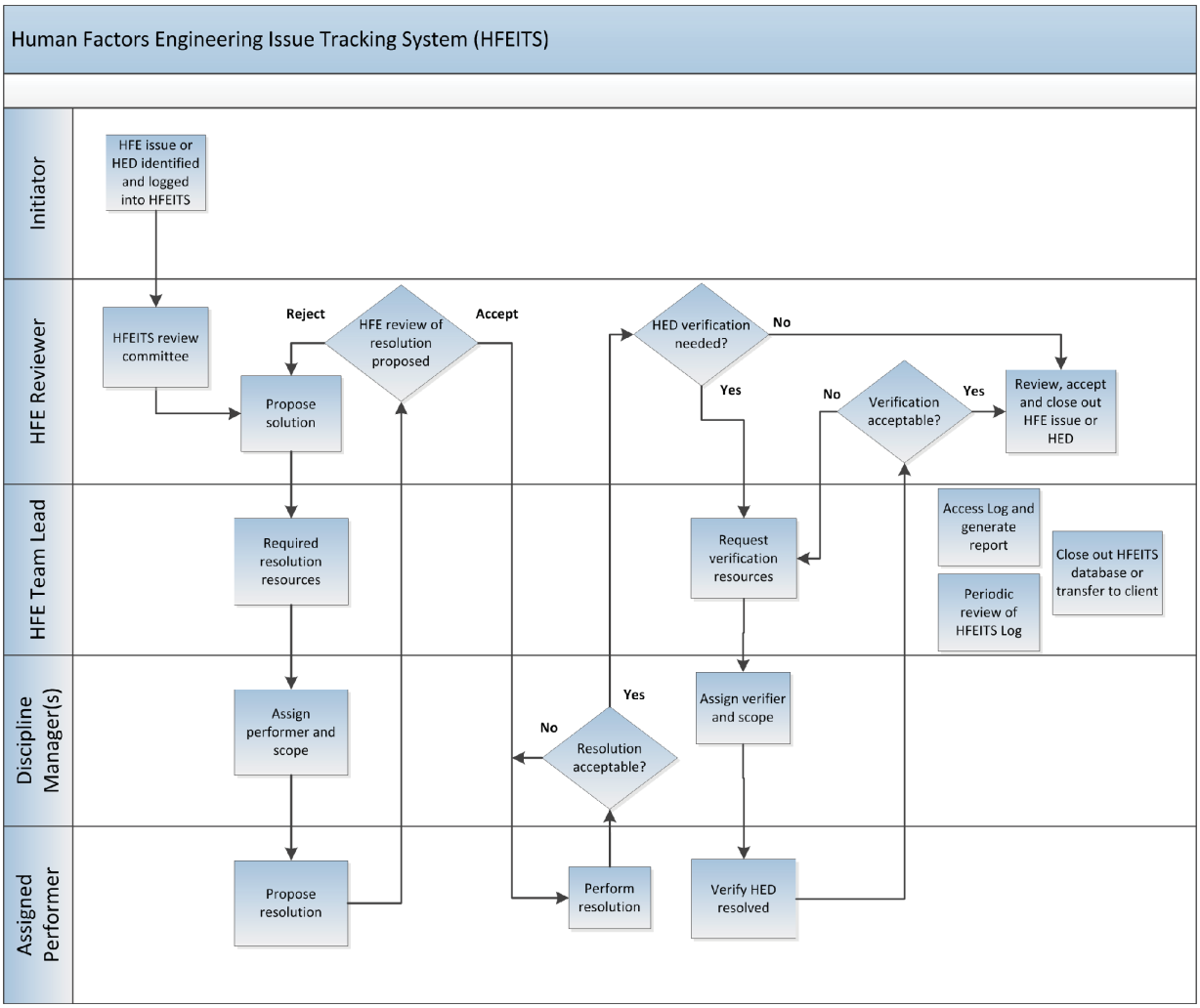
- resolving issues.
- updating HFEITS with proposed or completed actions.
- updating design documentation where appropriate.

5.4.6 HFEITS Review Committee

A HFEITS review committee reviews the HFE issues and HEDs submitted following an established internal NuScale procedure to evaluate designation, impact, priority, alignment with current development phases, and assignment to appropriate implementers. The HFE review committee is responsible for reviewing the full

documentation to verify the resolution is completed on HFEITS issues and HEDs before final closure.

Figure 5-1 Human Factors Engineering Issues System Process



5.4.7 Human Engineering Discrepancy Resolution

An HED is an issue discovered during the verification and validation phase of the HFE Program and may require engineering changes and verification. The HEDs are identified as personnel task requirements (as defined in the task analysis) that are not fully supported by the HSI, and the presence of HSI components that may not be needed to support personnel tasks. The HEDs are also identified if the design is

inconsistent (does not accommodate human capabilities and limitations) with HFE guidelines, such as NUREG-0700, or the NuScale HSI Style Guide.

The HEDs are identified, documented, and resolved throughout the verification and validation process.

The HED resolution process involves evaluation of the HEDs to determine if they require correction, development and evaluation of design solutions to address HEDs that must be corrected, and verification that the design solutions have been implemented. These topics are discussed in Reference 8.2.12.

The HEDs may not always be resolved; HEDs may be found acceptable after an evaluation in the context of the integrated design. The basis for a decision for accepting an HED without a change in the integrated design is documented. It may be based on accepted HFE practices, current published HFE literature, trade-off studies, tests, or engineering evaluations.

5.4.8 HED Process Flow

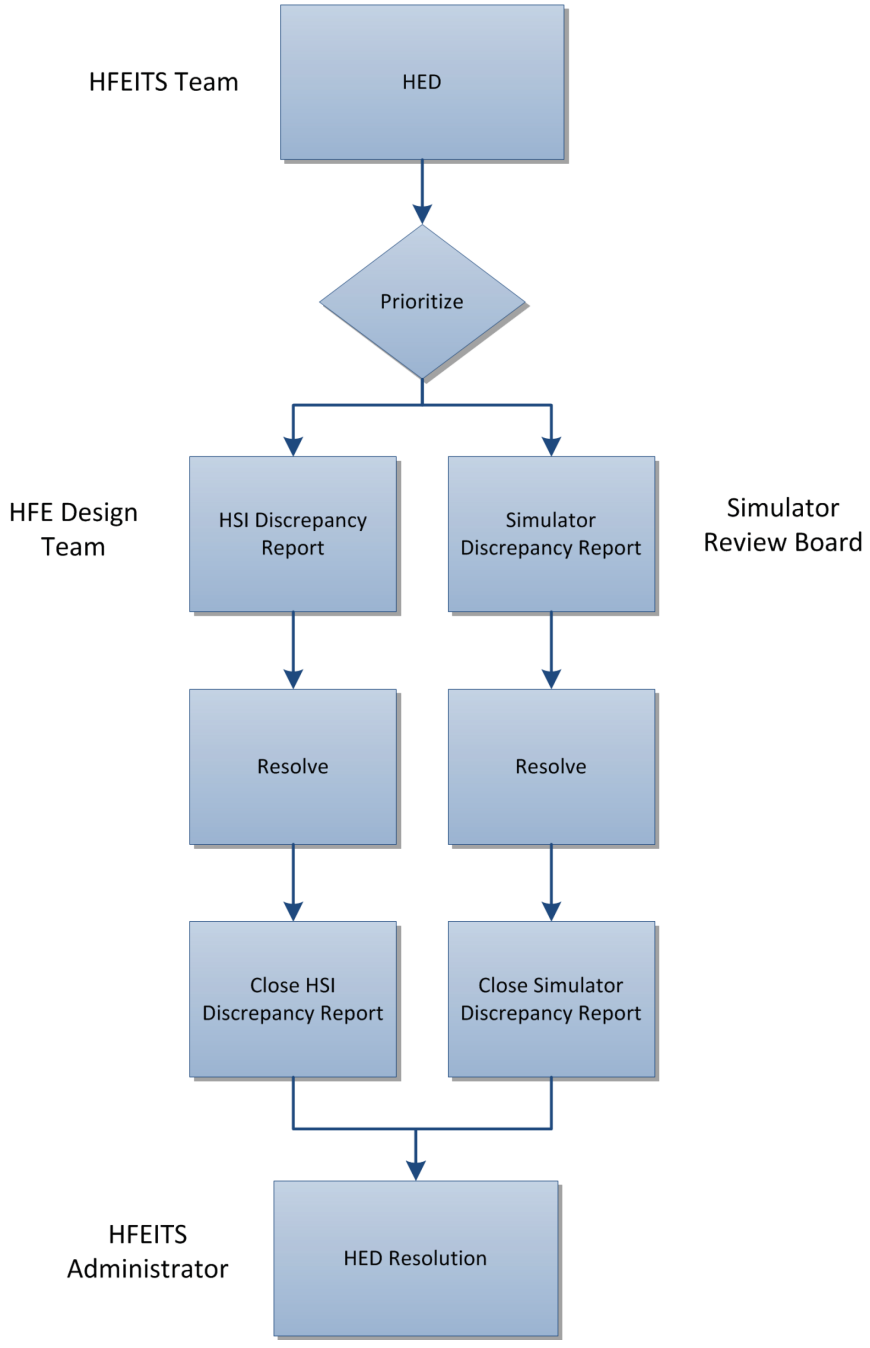
During verification and validation, HEDs are analyzed by the HFEITS team for priority selection and design category placement (e.g., HSI or simulator). Once the HED has been received, a discrepancy entry is created in the HFEITS database and the HED is prioritized as priority 1, priority 2, or priority 3 HEDs according to their importance as follows.

- Priority 1 HEDs have a potential direct or indirect impact on plant safety and are resolved before V&V is considered complete. The HEDs initiated as a result of a performance measure not being met (pass or fail performance measures) are priority 1 HEDs. Cross-cutting issues determined through HED analysis or performance measure analysis are priority 1 HEDs due to their global impact on the HSI design performance.
- Priority 2 HEDs have a direct or indirect impact on plant performance and operability and are resolved before the plant design is completed.
- Priority 3 HEDs are those that do not classify as priority 1 or priority 2. Priority 3 HEDs do not have to be resolved. If resolution of priority 3 HEDs is determined to be needed, they are resolved by NuScale or turned over to a licensee as appropriate.

The HED is then routed to the appropriate group for resolution. The HEDs related to the HSI are sent to the HFE Design Team, and HEDs related to simulator modeling are sent to the simulator review board. It is possible for HEDs to be routed to both groups.

The HED is then resolved, and the discrepancy entry closed. The HED resolution is reviewed for final closure in the HFEITS database by an HFE review committee. The HED resolution process is depicted in Figure 5-2.

Figure 5-2 Human Engineering Discrepancy Resolution Process



6.0 Human Factors Engineering Technical Program Elements

The NuScale HFE Program comprises the elements described below. The elements and associated activities are included in the integrated project development. Each element's IP or RSR provides

- description of the scope, inputs, analyses to be performed, outputs, and documentation.
- description of the applicable methodology.
- appropriate tools and facilities to be employed.
- description of the review and documentation requirements for subordinate documents that support HFE products.

The following sections provide a summary of each HFE element. A more detailed discussion is contained in the associated IPs or RSRs.

6.1 Operating Experience Review

The NuScale HFE Program includes an OER. As shown in Table 4-1, the OER activity documentation consists of an IP. The IP (Reference 8.2.6) describes the OER process and methodology. The findings from the OER must be incorporated in a future RSR. The RSR must document the specific types of OER conducted and the incorporation of applicable findings into the NuScale design.

The OER scope includes

- review of recognized industry HFE issues contained in NUREG/CR-6400 (Reference 8.2.5).
- review of recognized industry HFE issues identified since January 1996, one year before NUREG/CR-6400 was issued.
- review of operating experience related to the proposed NuScale design.
- identification of HFE issues obtained through interviews with plant personnel.
- identification of important human actions in the NuScale design.

The HFE team is responsible for conducting the OER. The qualifications of the HFE team members supporting OER are specified in the operating experience review implementation plan.

The OER methodology includes the following considerations:

- team and team lead responsibilities
- OER information review criteria
- OER database data entry
- OER item analysis approval

- results output to requisite NuScale engineering organizations
- OER database field descriptions
- OER plant personnel interview criteria
- coordination between the OER database and the HFE issues tracking database

If an OER issue is determined to be applicable to NuScale and HFE, but cannot be resolved at the current point in the design, it becomes an HFE issue. The HFE issues are tracked in the HFEITS database throughout the lifecycle of the HFE Program for the NuScale design project. The HFEITS database is described in Section 5.0.

6.2 Functional Requirements Analysis and Function Allocation

The NuScale HFE Program includes an FRA/FA. As shown in Table 4-1, the FRA/FA activity documentation consists of an IP. The IP (Reference 8.2.7) describes the FRA/FA process and methodology of the FRA/FA. The findings from the FRA/FA must be incorporated in a future RSR.

For each plant function, the HFE team documents

- purpose.
- predecessor functions of systems.
- relevant operating experience.
- differences from predecessor functions or systems.
- supporting sub-functions, processes, components, and systems.
- safety and risk significance.

To support the functional analysis, the HFE team then documents

- supported plant goal.
- conditions that indicate the need for the function.
- parameters that indicate the availability and operating status of each function, whether the function is achieving its purpose, and whether the operations of the function must be terminated.
- alternative success paths for the function.

Once the FRA is complete, the FA is conducted. A set of automation criteria is developed to allocate each function to manual, automatic, or shared execution. The HFE team allocates each function to optimize relevant automation criteria as follows:

- analyze predecessor function allocations and operating experience
- analyze upstream, downstream, and related functions in the overall plant design to assess indirect consequences

- evaluate relevant criteria impacting safety, reliability, situational awareness and cost effectiveness
- evaluate the aggregate impact to personnel considering the set of functions assigned to them
- allocate the function to a discrete allocation criteria to improve overall design consistency

Tools for the FRA/FA process include an FRA/FA database that produces a functional requirements hierarchy chart.

6.3 Task Analysis

The NuScale HFE Program includes a TA. As shown in Table 4-1, the TA activity documentation consists of an IP. The IP (Reference 8.2.8) describes the TA process and methodology. The findings from the TA must be incorporated in a future RSR.

Tasks are evaluated. From the wide range of plant operating conditions, tasks that meet the following criteria receive a more detailed task analysis:

- tasks that include important human actions as determined from safety analysis, PRA, and diversity and defense-in-depth coping analysis for I&C systems
- tasks that, if performed incorrectly, could impact nuclear safety or power generation
- tasks that are new or performed in a manner significantly different from similar tasks in the existing industry
- tasks related to monitoring automated systems
- tasks related to recognizing the failure or degradation of automated equipment and performance of associated tasks that implement backup responses
- administrative tasks and support aids such as reference materials, hard copy graphs, and calculators that place a large burden on the control room personnel
- maintenance or testing tasks that have augmented quality requirements
- tasks with potential effects on personnel safety (such as maintenance tasks performed in the containment)

After categorization, a task narrative is written to describe the objectives of a specific system's operator tasks and provide an overview of the activities personnel are expected to accomplish to complete the task. Narrative descriptions of operator activities contain requisite detail for a reviewer to correlate the described task objectives to the results of the completed TA. The narrative is brief for simple tasks but has greater detail from more complex tasks.

The detailed TA involves

- decomposition of task elements.
- preparation of the operational sequence diagram.

- determination of task attributes and completion of the task table.
- identification of knowledge and abilities.
- assignment of tasks to roles.
- analysis of the feasibility and reliability for important human actions.

A database is used to capture data from the TA process. The database contains the results from the TA and can be used to facilitate searches and reviews of previous analyses. The database also contains a list of the tasks reviewed, the task attributes, and the knowledge and abilities identified for each task.

6.4 Staffing and Qualifications

As discussed in Section 2.2.1, NuScale's HFE Program S&Q analysis addresses only the activities performed by licensed control room operators. The staffing and qualifications results summary report (Reference 8.2.11) describes the S&Q analysis process, the output documentation requirements, and the findings from the S&Q analysis.

As described in Section 2.2.1, the NuScale Power Plant uses passive safety systems and is highly automated to reduce the need for operator actions and allow for monitoring multiple units simultaneously. This level of automation impacts HSI design from the aspect of the number of physical interfaces, data processing, operating procedures, display screens, alarms, controls, and support aids needed for the accomplishment of tasks. The acceptability of staffing levels for the NuScale operating concept for identified modes and for the aggregate of tasks assigned to operating personnel is confirmed in the S&Q analysis.

The S&Q analysis also provides the staffing plan validation.

6.5 Treatment of Important Human Actions

The NuScale HFE Program includes provision for TIHA. The treatment of important human actions results summary report describes the process for determining and treatment of important human actions and includes the output documentation requirements. The treatment of important human actions results summary report (Reference 8.2.10) describes the findings from the analysis and resolutions.

The TIHA analysis identifies risk-important human actions (RIHA) from the PRA. The treatment of important human actions results summary report describes the PRA methodology, the method for determining human error probability, and the method used to determine the risk significance of those potential errors. Other PRA activities are outside the scope of the HFE Program.

The TIHA analysis also describes the methodology used to extract deterministically important human actions (DIHA) from the transient and accident analyses and the diversity and defense-in-depth coping analysis. The HFE personnel assess DIHAs to confirm with reasonable confidence that they can be carried out within the time available.

An additional detailed quantitative analysis of workload and time constraints is performed for both RIHAs and DIHAs in the TA, the S&Q, and in a performance-based test using the simulator, independent operating crews, and challenging scenarios. These important human actions are also included in ISV scenarios.

6.6 Human-System Interface Design

The NuScale HFE Program includes HSI design. An HSI design IP (Reference 8.2.11) describes the HSI methodology. The outputs of the HSI design element must be incorporated in a future RSR.

The HSI design element generates the main control room human-system interfaces, MCR derivative HSIs, and local control station human-system interfaces after translating HFE analysis outputs into the inventory of alarms, displays, controls, and operating procedures. A key output of the HSI design program element is a complete set of HSIs that are implemented in the control room simulator for subsequent V&V. The simulator includes the functions of the MCR and MCR derivative HSIs used in the waste management control room, module maintenance center, TSC, and EOF. The HSI design also generates the local control station human-system interface design and the requirements for their physical locations.

The OER identifies issues addressed by similar HSI designs. Assessments are made by the HFE team at the time the OER is conducted. The HSI design confirms that the OER issues remain addressed despite changes during plant design.

The TIHA element identifies assumptions regarding the characteristics of the HSI used for RIHAs and DIHAs. The HSI design element ensures these assumptions are implemented in the HSI (e.g., control accessibility from the MCR and spatially-dedicated continuously-visible HSI to reduce time required for human actions).

The HSI design uses the HSI inventory and characteristic outputs from TA to establish alarm priority and applicability logic, display and control designs, and procedure step acceptance criteria. The HSI design also uses these TA outputs to establish the grouping of HSI inventory for task-based display screens.

The S&Q analysis confirms the MCR operating staff numbers and qualifications for identified plant modes. The HSI design includes layout of the operator workstations and displays for the MCR. The HSIs at the waste management control room and module maintenance center are extensions of the HSI used in the MCR. Other local facilities are derivatives of the main control room human-system interfaces.

The HSI design uses plant operating procedures developed as part of the plant design (i.e., procedure development is integrated with HFE activities but not considered HFE Program scope) to generate computer-based procedures, which are necessary tools to support the ISV of the V&V program element. Other procedures (e.g., surveillance and test procedures) are also outside the scope of the HSI design element because they have their own development and V&V program.

The HFE issues generated during HSI design or from prior program elements are resolved during HSI design so that the final output is a complete HSI design suitable for V&V.

6.7 Procedure Development

Procedure development is the responsibility of the licensee. No IP or RSR for procedure development is submitted as part of the NuScale HFE Program. The Final Safety Analysis Report Chapter 13, Conduct of Operations, contains information related to procedure development.

6.8 Training Program Development

Operators who support the human factors V&V program element are trained in accordance with the NuScale Training Program.

Training program development is the responsibility of an applicant that references the NuScale Power Plant US460 standard design. No IP or RSR for training program development is submitted as part of the NuScale HFE Program. The Final Safety Analysis Report Chapter 13, Conduct of Operations, contains information related to Training Program development.

6.9 Human Factors Verification and Validation

The NuScale HFE Program includes human factors V&V. The verification and validation implementation plan (Reference 8.2.12) describes the human factors V&V process and includes the output documentation requirements. Following V&V activities, an RSR must be prepared to describe the outputs of human factors V&V.

Human factors V&V evaluations comprehensively determine that the HSIs, procedures, and training program conform to HFE design principles and that the HSIs enable plant personnel to successfully perform their tasks to achieve plant safety and other operational goals. Demonstrating conformance to the acceptance criteria defined in the human factors verification and validation implementation plan for the ISV is the final design acceptance milestone for the HSIs. Human factors V&V of the EOF is outside the scope of the human factors V&V program.

Verification and validation is conducted using a control room simulator that reflects the output of HSI design, procedures, and training program.

6.10 Design Implementation

The NuScale HFE Program includes design implementation. The design implementation implementation plan describes the DI process and includes the output documentation requirements. No RSR is required for this element because conformance of the as-built design to the verified and validated design is confirmed by ITAAC.

The DI demonstrates that the implemented design accurately reflects the verified and validated design. If the DI program element identifies differences (e.g., site-specific aspects that were not included in V&V or design changes that occur after V&V), those differences are evaluated to determine impacts to the analysis results from previous HFE Program elements, including V&V.

Priority 3 HEDs generated during V&V that are determined to require resolution, as well as HEDs generated after completion of V&V are resolved by NuScale or turned over to a licensee as appropriate.

6.11 Human Performance Monitoring

The HPM Program begins after DI is completed and continues for the life of the plant. The HPM Program is intended to detect degradation in operator performance compared to the performance observed during integrated system validation. Degradation may be due to many factors that occur during the life of the plant, including changes in personnel, changes in plant culture, changes in training methods, or changes in the HSI design itself. The HPM Program includes

- monitoring and investigating perceived or documented reduced human performance.
- analyzing causes of reduced human performance.
- developing corrective action plans for improvement.
- maintaining a culture of continuous monitoring of human performance through operating experience review.
- training and qualification.
- change management (modification process, configuration management).
- use of the plant simulator.
- independent reviews and audits.

The HPM Program is a catalyst for corrective actions during the life of the plant; the licensee manages its own Corrective Actions Program. The HPM Program is a responsibility of the licensee.

7.0 NUREG-0711 Conformance Evaluation

Table 7-1 provides a mapping of the sections in this PMP where each NUREG-0711, Revision 3 criterion is met.

Table 7-1 Conformance with NUREG-0711

Review Criteria	HFE PMP Section No. and paragraph
2.4.1 General HFE Program Goals and Scope (1) *HFE Program Goals* - The applicant should state the general objectives of the program in "human-centered" terms. As the HFE program develops, they should be further defined and used as a basis for HFE tests and evaluations. Additional Information- Generic "human-centered" HFE design goals include the following: • personnel tasks can be accomplished within time and performance criteria • the HSIs, procedures, staffing/qualifications, training, and management and organizational arrangements support personnel situation awareness • the design will support personnel in maintaining vigilance over plant operations and provide acceptable workload levels, i.e., minimize periods of under- and over-load • the HSIs will minimize personnel error and will support error detection and recovery capability	Section 2.1, All
(2) *Assumptions and Constraints* - The applicant should identify the design assumptions and constraints. Additional Information- An assumption or constraint is an aspect of the design, such as a specific staffing plan or a specific HSI technology that is an input to the HFE program rather than the result of HFE analyses and evaluations.	Section 2.2.1, All
(3) *HFE Program Duration* - The applicant's HFE program should be in effect at least from the start of the design cycle through completion of initial plant startup test program.	Section 2.2.2, All
(4) *Facilities* - The applicant's HFE program should cover the main control room (MCR), remote shutdown facility (RSF), technical support center (TSC), emergency operations facility (EOF), and local control stations (LCSs). The 12 HFE elements should be applied to each of them, unless otherwise noted for a specific HFE element. However, applicants may apply the elements of the HFE program in a graded fashion to facilities other than the MCR and RSF, providing justification in the HFE program plan.	Section 2.2.3, All
(5) *HSIs, Procedures and Training* - The applicant's HFE program should address the design of HSIs and identify inputs to the development of procedures and training for all operations, accident management, maintenance, test, inspections, and surveillance tasks that operational personnel will perform or supervise. In addition, the HFE design process should identify training program input for the following personnel identified in 10 CFR 50.120- instrument and control technician, electrical maintenance personnel, mechanical maintenance personnel, radiological protection technician, chemistry technician, and engineering support personnel. In addition, any other personnel who perform tasks directly related to plant safety should be included, such as information technology technicians who troubleshoot and maintain support systems and their HSIs.	Section 2.2.4, All

Table 7-1 Conformance with NUREG-0711 (Continued)

Review Criteria	HFE PMP Section No. and paragraph
(6) *Personnel* - The applicant's HFE program should consider operations staffing and qualifications, including licensed control-room operators as defined in 10 CFR Part 55, and the following categories of personnel- non-licensed operators, shift supervisor, and shift technical advisor.	Section 2.2.5, All
(7) *Additional Considerations for Reviewing the HFE Aspects of Plant Modifications* - In addition to any of the criteria above that relate to the modification being reviewed, the applicant should address the following considerations: • The goals of the applicant's HFE program should address the potential effects of a modification on the performance of personnel. The transition from the existing plant configuration to the modified one can pose different demands on human performance than either the initial or the final configurations. Therefore, the modification and its implementation should be planned to minimize the effects of the change on personnel performance. The HFE program for the modification should consider: - planning the installation to minimize disruptions to work - coordinating changes in training and procedures when implementing the modification - conducting training to maximize personnel's knowledge and skill with the new design before implementing it • The applicant's HFE program should involve plant personnel to ensure that the following are considered from a user's perspective in establishing the requirements for the modification, and evaluating the outputs of the design process: - user's understanding of how plant systems are structured and behave - task demands and constraints of the existing work environment and work processes	Section 2.2.6 All
2.4.2 HFE Team and Organization In this document, the term "HFE team" means the primary organization(s) responsible for the applicant's HFE program. However, we do not assume that HFE is the responsibility of a single organizational unit, or that there is an organizational unit called the "HFE team." *Responsibility* - The applicant's team should be responsible for: • developing all HFE plans and procedures • overseeing and reviewing all activities in HFE design, development, test, and evaluation, including the initiation, recommendation, and provision of solutions through designated channels for problems identified in implementing the HFE work • verifying that the team's recommendations are implemented • assuring that all HFE activities comply with the HFE plans and procedures • scheduling work and milestones	Section 3.1, All

Table 7-1 Conformance with NUREG-0711 (Continued)

Review Criteria	HFE PMP Section No. and paragraph
Organizational Placement and Authority - The applicant should describe the primary HFE organization(s) or function(s) within the engineering organization designing the plant or modification. The organization should be illustrated to show organizational and functional relationships, reporting relationships, and lines of communication. The applicant also should address the following: • When more than one organization is responsible for HFE, such as instrumentation and control (I&C) and operations, the lead organizational unit answerable for the HFE program plan should be identified. If organization changes are expected over time (e.g., from design through construction to startup) necessary transitions between responsible organizations should be described. • The team should have the authority and organizational placement to reasonably assure that all its areas of responsibility are completed, and to identify problems in establishing the overall plan or modifying its design. • The team should have the authority to control further processing, delivery, installation, or use of HFE products until the disposition of a nonconformance, deficiency, or unsatisfactory condition is resolved.	Section 3.2, All
Composition - The applicant's HFE team should include the expertise described in the appendix to this report.	Section 3.3, All
Team Staffing - The applicant should describe team staffing in terms of job descriptions and assignments of team personnel.	Section 3.4, All
2.4.3 HFE Process and Procedures (1) *General Process Procedures* - The applicant should identify the process through which the team will execute its responsibilities. It should include procedures for the following: • assigning HFE activities to individual team members • governing the internal management of the team • making decisions on managing the HFE program • making HFE design decisions • controlling changes in design of equipment • reviewing of HFE products	Section 4.1, All
(2) *Process Management Tools* - The applicant should identify the tools and techniques (e.g., review forms) the team uses to verify that they fulfilled their responsibilities.	Section 4.2, All
(3) *Integration of HFE and Other Plant or Modification Design Activities* - The applicant should describe the process for integrating the design activities (i.e., the inputs from other design work to the HFE program, and the outputs from the HFE program to other plant design activities). The applicant should also discuss the iterative aspects of the HFE design process.	Section 4.3, All
(4) *HFE Program Milestones* - The applicant should identify HFE milestones that show the relationship of the elements of the HFE program to the integrated plant design, development, and licensing schedule. A relative program schedule of HFE tasks should be available for the NRC staff's review showing relationships between the HFE elements and the activities, products, and reviews. Additional Information- A milestone might include, for example, the date when a simulator will be available for integrated system validation and operator training.	Section 4.4, All

Table 7-1 Conformance with NUREG-0711 (Continued)

Review Criteria	HFE PMP Section No. and paragraph
HFE Documentation - The applicant should identify the HFE documentation items, such as RSRs and their supporting materials, and briefly describe them, along with the procedures for their retention and for making them available to the NRC staff for review.	Section 4.5, All
Subcontractor HFE Efforts - The applicant should include HFE requirements in each subcontract contributing to the HFE program. The applicant should periodically verify the subcontractor's compliance with HFE requirements. The HFE plan should describe milestones and the methods used for this verification.	Section 4.6, All
2.4.4 Tracking HFE Issues (1) *Availability* - The applicant should have a tracking system to address human factors issues that are: • known to the industry (defined in the Operating Experience Review element, see Section 3) • identified throughout the life cycle of the HFE aspects of design, development, and evaluation deemed by the HFE program as human engineering discrepancies (HEDs) (see Section 11.4.4) Additional Information: Issues are those items that need to be addressed later, and hence must be tracked to assure that they are not overlooked. Establishing a new system to track HFE issues independent from the rest of the design effort is unnecessary; rather, an existing one can be adapted for this purpose (such as a plant's corrective-action program).	Section 5.1, All
(2) *Method* - The applicant's method should: • establish criteria for when issues are entered into the system • track issues until the potential for negative effects on human performance is reduced to an acceptable level.	Section 5.2, All
(3) *Documentation* - The applicant should document the actions taken to address each issue in the system; if no action is required, this should be justified. Additional Information- The description of the final resolution of the issue should be sufficiently detailed so that a third party can understand how it was resolved.	Section 5.3, All
(4) *Responsibility* - After identifying an issue, the applicant's tracking procedures should describe individual responsibilities for logging, tracking, and resolving it, along with the acceptance of the outcome.	Section 5.4, All
2.4.5 Technical Program (1) The applicant should describe the applicability and status of each of the following HFE elements-	Section 6.0, All
Operating Experience Review	Section 6.1
Functional Requirements Analysis and Function Allocation	Section 6.2
Task Analysis	Section 6.3
Staffing and Qualifications	Section 6.4
Treatment of Important Human Actions	Section 6.5
HSI Design	Section 6.6
Procedure Development (Described in SRP, Chapter 13 submittal)	Section 6.7
Training Program Development (Described in SRP, Chapter 13 submittal)	Section 6.8
Human Factors Verification and Validation	Section 6.9
Design Implementation	Section 6.10

Table 7-1 Conformance with NUREG-0711 (Continued)

Review Criteria	HFE PMP Section No. and paragraph
Human Performance Monitoring *Additional Information*: The applicant should identify each applicable element of the HFE program. If the applicant determines that an HFE element is not applicable to the HFE program, the applicant should give a rationale. For example, if an applicant's HFE program involves modifying a control room HSI wherein the level of automation is not affected, then the Functional Requirements Analysis and Function Allocation element might not be included. The applicant should describe the status of each element in the HFE plan (i.e., will the element be enacted in the future, is it currently being performed, or is it completed). The applicant should clearly identify the use of past analyses that the NRC has not reviewed (i.e., analyses originally undertaken for another design) and justify their use in the current application. The criteria for the technical review of each element in the HFE program are presented in Sections 3 to 13 of this document.	Section 6.11
(2) The applicant should identify the approximate schedule for completing any HFE activities that are unfinished at the time of the application. *Additional Information*: For example, if an applicant for design certification has not finished V&V, the applicant should give an approximate schedule for its completion.	Table 4-1
(3) The applicant's plan should identify and describe the standards and specifications that are sources of the HFE requirements.	Referenced Documents, Section 8.2
(4) The applicant's plan should specify HFE facilities, equipment, tools, and techniques (such as laboratories, simulators, rapid prototyping software) that the HFE program will employ.	Section 4.2, Associated IPs and RSRs

Table 7-1 Conformance with NUREG-0711 (Continued)

Review Criteria	HFE PMP Section No. and paragraph
(5) Additional Considerations for Reviewing the HFE Aspects of Plant Modifications - The applicant should provide assurance that a modification to the control room or a change to risk-important human actions does not compromise defense in depth in accordance with RG 1.174. The applicant should assure the following important aspects of defense in depth: • A reasonable balance is preserved among prevention of core damage, prevention of containment failure, and consequence mitigation. • There is no over-reliance on programmatic activities to compensate for weaknesses in plant design. This may be pertinent to changes in credited human actions (HAs). • System redundancy, independence, and diversity are preserved commensurate with the expected frequency, consequences of challenges to the system, and uncertainties (e.g., no risk outliers). • Defenses against potential common cause failures are preserved, and the potential for the introduction of new common cause failure mechanisms is assessed. Caution should be exercised in crediting new HAs to verify that the possibility of significant common cause errors is not created. • Independence of barriers is not degraded. • Defenses against human errors are preserved. For example, establish procedures for a second check or independent verification for risk-important HAs to determine that they have been performed correctly. The intent of the General Design Criteria (GDC) in Appendix A to 10 CFR Part 50 is maintained. GDC that may be relevant are: • 3 - Fire Protection • 13 - Instrumentation and Control • 17 - Electric Power Systems • 19 - Control Room • 34 - Residual Heat Removal • 35 - Emergency Core Cooling System • 38 - Containment Heat Removal • 44 - Cooling Water Safety margins often used in deterministic analyses to account for uncertainty and provide an added margin to provide adequate assurance that the various limits or criteria important to safety are not violated. Such safety margins are typically not related to HAs, but the reviewer should take note to see if there are any that may apply to the particular case under review. It is also possible to add a safety margin (if desired) to the HA by demonstrating that the action can be performed within some time interval (or margin) that is less than the time identified by the analysis. *Additional Information*: Defense in depth, described in RG 1.174, is one of the fundamental principles upon which a plant is designed and built. It uses multiple means to assure safety functions and to prevent the release of radioactive materials. Defense in depth is important in accounting for uncertainties in equipment and human performance, and for ensuring some protection remains, even in the face of significant breakdowns in particular areas, such as safety systems, training, and quality assurance. Whereas an applicant may change a specific defense in depth strategy, defense in depth must be maintained overall. These types of defense in depth evaluations may be done as part of the 10 CFR 50.59 evaluation for modifying the plant.	Not applicable for Standard Design Approval Application submittal HFE Program

8.0 References

8.1 Source Documents

8.1.1 U.S. Nuclear Regulatory Commission, "Human Factors Engineering Program Review Model," NUREG-0711, Rev. 3, November 2012.

8.2 Referenced Documents

8.2.1 U.S. Code of Federal Regulations, "Contents of Applications; Technical Information," Section 50.34(f)(2)(iii), Part 50, Chapter I, Title 10, "Energy," (10 CFR 50.34(f)(2)(iii)).

8.2.2 U.S. Code of Federal Regulations, "Contents of Applications; Technical Information," Section 52.47(a)(8), Part 52, Chapter I, Title 10, "Energy," (10 CFR 52.47(a)(8)).

8.2.3 U.S. Code of Federal Regulations, "Training and Qualifications of Nuclear Power Plant Personnel," Section 50.120, Part 50, Chapter 1, Title 10 "Energy," (10 CFR 50.120).

8.2.4 U.S. Code of Federal Regulations, "Operators' Licenses", Part 55, Chapter I, Title 10, "Energy," (10 CFR 55).

8.2.5 U.S. Nuclear Regulatory Commission, "Human Factors Engineering (HFE) Insights for Advanced Reactors Based Upon Operating Experience," NUREG/CR-6400, January 1997.

8.2.6 NuScale Power, LLC, Human Factors Engineering Operating Experience Review Implementation Plan, TR-130409, Rev. 0.

8.2.7 NuScale Power, LLC, Human Factors Engineering Functional Requirements Analysis and Function Allocation Implementation Plan, TR-124333, Rev. 0.

8.2.8 NuScale Power, LLC, Human Factors Engineering Task Analysis Implementation Plan, TR-130413, Rev. 0.

8.2.9 NuScale Power, LLC, Human Factors Engineering Staffing and Qualifications Results Summary Report, TR-130412, Rev. 0.

8.2.10 NuScale Power, LLC, Human Factors Engineering Treatment of Important Human Actions Results Summary Report, TR-130416, Rev. 0.

8.2.11 NuScale Power, LLC, Human-System Interface Design Implementation Plan, TR-130417, Rev. 0.

8.2.12 NuScale Power, LLC, Human Factors Verification and Validation Implementation Plan, TR-130415, Rev. 0.

Appendix A NuScale HFE Program Design Integration

As illustrated in Figure A-1, the HFE team is integrated into the iterative design process through the design review process.

Figure A-1, Point 1 illustrates the HFE Program integration at the start of the design process through the Human Factors Engineering Issue Tracking System (HFEITS). Unresolved HFE issues identified by the HFE Program and the HFE team are accumulated and tracked to resolution in the HFEITS database (Section 5.0 discusses more details on HFEITS). Early in the design planning process, applicable design inputs are identified. These inputs include requirements (e.g., Utility Requirements Document, Owners Requirements Document and codes and standards), proposed design solutions and unresolved issues (e.g., action tracking system and HFEITS). Starting with those initial design inputs, the design engineering team establishes design requirements, which evolve to detailed designs.

Figure A-1 NuScale and Human Factors Engineering Program Design Integration

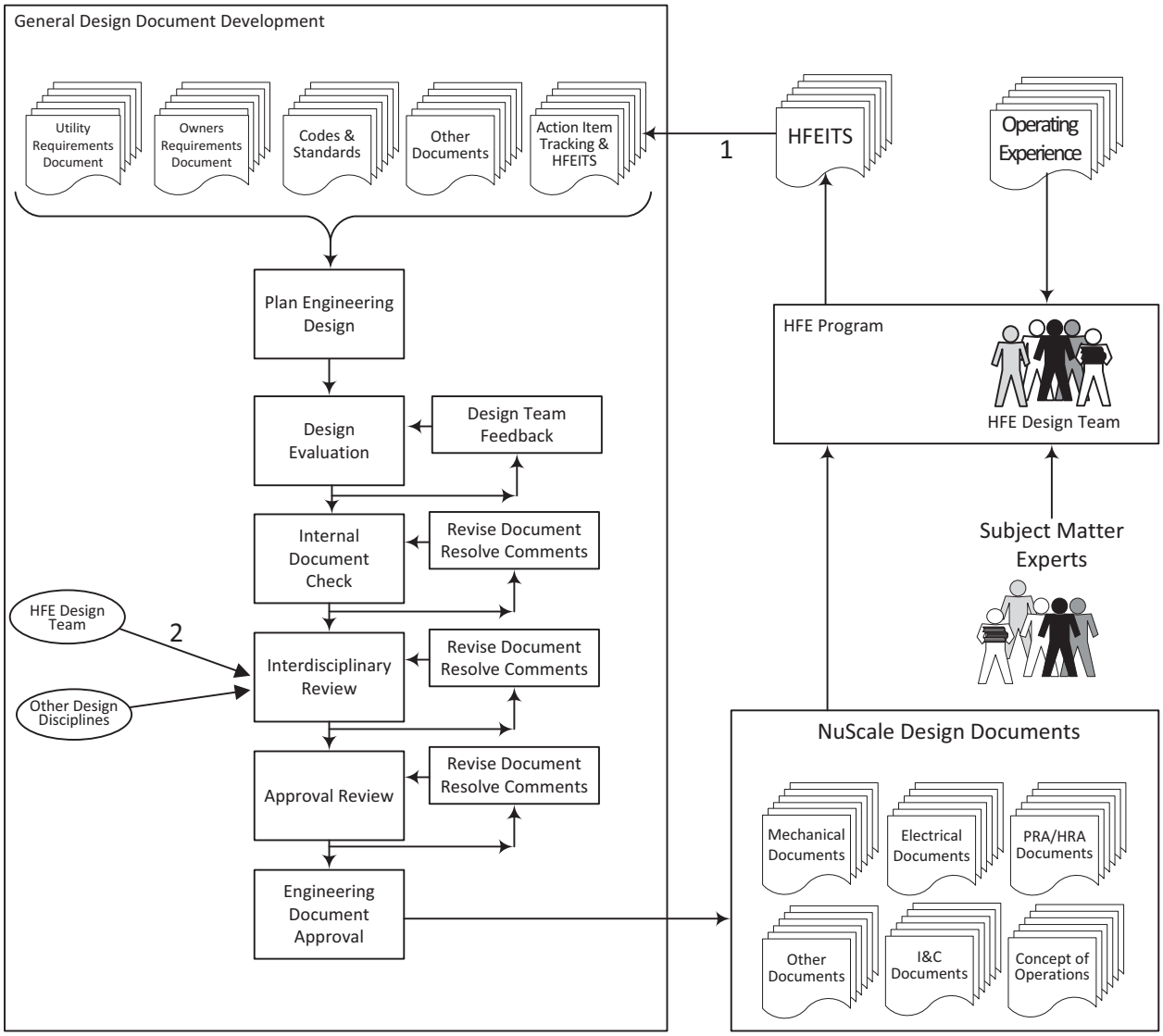


Figure A-1 Point 2 represents the HFE team's direct participation in the interdisciplinary review process. When a design document has gone through internal document check, the design discipline manager identifies appropriate disciplines to participate in an interdisciplinary review. In addition to the interdisciplinary review, an HFE team member is assigned to perform reviews of the system design documents. This review allows the HFE team to identify emerging human factors problems in the design and monitor effective resolution of human factors problems. For example, the HFE team participated in the NuScale reactor building interdisciplinary review. As a direct result of that HFE team review, the control room envelope was enlarged to ensure adequate space for required control room equipment and personnel.

As illustrated in Figure A-2, the HFE Program process has three primary inputs:

- the operating experience
- the subject matter experts
- the NuScale design documents

Figure A-2 Point 1 (consistent with Figure A-1 Point 1), illustrates the HFE Program's integration into the design process through HFEITS.

Figure A-1 Point 2 impacts the interdisciplinary review process and is not represented in Figure A-2.

Figure A-2 Human Factors Engineering Program Process

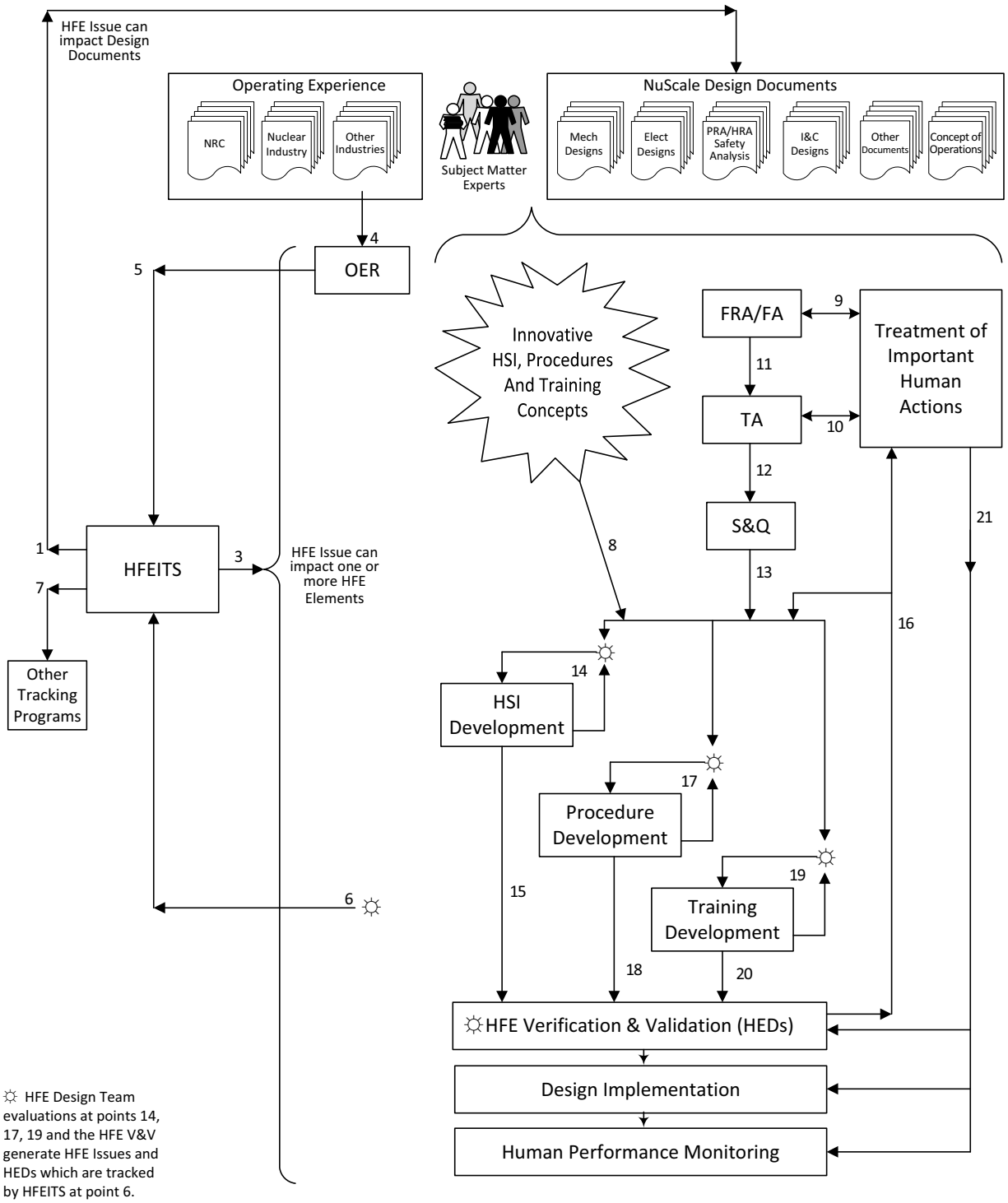


Figure A-2 Point 3 represents the resolution of HFE issues within the HFE Program. Issues within HFEITS may impact any of the HFE Program elements. For example, an HFE issue associated with a particular system may impact OER and require investigation to determine if relevant lessons had been applied to predecessor systems. Similarly, an HFE issue could impact a portion of an analyzed task (TA) conducted on an important human action. Because HFE issues may impact any or several of the HFE elements, Point 3 terminates at a bracket enveloping the HFE elements.

Figure A-2 Point 4 represents the OE input to the HFE Program via the OER element. The OE from the NRC, the nuclear industry, and other industries is reviewed to identify lessons learned from comparable operating concepts. The OE review results typically conclude that the particular operating experience falls into one of the following categories:

- OE is not applicable to the NuScale design
- OE is applicable and adequately addressed in the NuScale design
- OE may be applicable but further investigation is required (Point 5)

A prescreened OE item that has been included in the OER database and requiring further evaluation is determined to be not applicable is documented in the OER database along with the basis for that conclusion. An OE determined to be applicable and adequately addressed in the design is similarly documented in the OER database with the basis and reference to the implementing design document.

Figure A-2 Point 5 represents the OE that may be applicable but requires further investigation. These issues are presumed to be HFE issues and entered into HFEITS for resolution. In some cases, the HFE issue screening may determine that all or portions of these issues are not HFE issues. Reference 8.2.6 contains more details on the screening process.

Figure A-2 Point 6 represents the collective input of HFE issues into HFEITS, excluding those from OER. While many HFE issues originate in the OER process (Point 5) or from the HFE elements associated with analysis, implementation or operation, the bulk of HFE issues originate through the HFE team's evaluation of HSI development, procedure development, training development, and HFE verification and validation (HFE team evaluation points ☼). These evaluations generate the HFE team's feedback regarding the development products (HSIs, procedures, and training program). In most cases, the issues identified in the development evaluation are resolved as part of the iterative development process. However, problems that cannot or will not be resolved through product development become HFE issues. Additionally, HFE issues identified during the HFE verification and validation are generally designated as HEDs. Both HFE issues and HEDs are entered into HFEITS as illustrated by Point 6.

Figure A-2 Point 7 represents issues entered into the HFEITS that contain some action or issue resolution outside of the HFE Program. Such non-HFE issues requiring corrective action or follow-up are entered into an action tracking system.

Figure A-2 Point 8 represents an important facet of SMEs input to the HFE Program. These experts, along with the HFE team participants, generate innovative and creative ideas regarding HSIs, procedures, and training program development. The ideas are often derived from nontraditional activities and do not depend on other HFE elements. Individuals may begin contemplating the HSI before they join the team and may sustain this creativity for the duration of their participation in the program. Consequently, the HSIs, procedures, and training program development may begin and progress before the influence of other HFE elements shape the development.

Figure A-2 Point 9 represents direct input of TIHA to the FRA/FA. The TIHA represents the graded approach of focusing HFE efforts on specific human actions and types of human actions based on the importance of the action to the public's health and safety as identified through PRA, human reliability analysis (HRA), and transient and accident safety analysis design documents. The TIHA input focuses FRA/FA on the functions associated with important human actions and ensures that functional allocation reconciles with human actions assumed in the designed documents. As with Points 10 and 21, Point 9 also represents the iterative feedback from TIHA as a result of revisions to design documents (PRA/HRA) or the results of HFE verification and validation.

Figure A-2 Point 10 represents the direct input of TIHA to TA. Similar to the TIHA input to FRA/FA illustrated in Point 9, TIHA input focuses TA on those important human actions to ensure each receives comprehensive analysis and is both feasible and reliable. As with Points 9 and 21, Point 10 also represents the iterative feedback from TIHA as a result of revisions to design documents (PRA/HRA) or the results of HFE verification and validation.

Figure A-2 Point 11 represents the availability of FRA/FA results, which enable the start of TA. The FRA/FA is accomplished in two steps: functional requirements analysis, and function allocation (assignment of automation level). The primary inputs to the functional requirements analysis are the various design documents. Through analysis and SME interviews, the HFE team identifies those functions that must be carried out to satisfy the plant's operating and safety goals. Function allocation is the assignment of functions to manual control, automatic control, or a combination of both. An additional input to the FRA/FA element is illustrated by Point 9, TIHA. The HFE Program takes a graded approach in focusing efforts on human actions, placing the greatest emphasis on those human actions considered to be most important. Thus, Point 11 represents the functions allocated to humans, which is the primary input to TA.

Figure A-2 Point 12 represents the results of TA, which, along with influence of the concept of operations, are inputs to the S&Q analysis. Assumptions in the concept of operations follow the division of task responsibility traditionally found in commercial nuclear facilities. Those assumptions place control room management, supervision, and oversight responsibilities with senior reactor operators. Reactor operators are assumed to have responsibility for monitoring and control of safety related and augmented quality functions. Non-licensed operators, I&C technicians, electrical maintenance personnel, mechanical maintenance personnel, radiological protection technicians, chemistry technicians, and engineering support personnel provide operating support as requested and conduct nonimpacting inspections and surveys. The S&Q analysis evaluates the conformity and conflict between the TA results and the concept of operations to associate tasks with jobs. Minor conflicts are resolved through the iterative design process or changes to the concept of operations. In most cases, Points 12 and 13 differ little except that the TA must be iteratively focused to conform to traditional SRO, reactor operator and non-licensed operator roles and responsibilities and the concept of operations must be refined as task details are incorporated.

Figure A-2 Point 13 represents the working results of the HFE Program analysis elements that shape the development of HSI, procedures, and training. In concert with the innovative HSI, procedure and training concepts represented by Point 8, Point 13 drives development to meet functional, task, and qualification requirements.

Figure A-2 Point 14 represents the iterative design and development of HSI. The structured development methodology translates the innovative ideas, the concept of operations, HFE principles, functional requirements, task requirements, qualification requirements into HSI display characteristics, and control functions. The HFE team evaluation (signified by this symbol ☼) of the HSI is based on HFE principles, intuitive functionality, and NUREG-0700 using a variety of validation methods (e.g., table top analysis, walk through using event scenarios, and control room simulation) to refine and optimize the HSI. Early HSI development and HFE team evaluation is performed without use of accompanying operational procedures to drive the HSI towards intuitive displays and controls. As the iterative design process evolves towards a final design, the HSI development evaluation process increasingly emulates the formal verification and validation process.

Figure A-2 Point 15 represents the HSI design maturation from development to HFE verification and validation. In general terms, the iterative HSI development continues at Point 14 until the design evolution slows, indicating the design has matured and is ready for integrated validation in concert with available procedures and training. This V&V ensures the HSI, procedure, and training support the task defined in TA, the S&Q requirements, the concept of operations, and HFE principles.

Figure A-2 Point 16 represents the iterative feedback from the HFE verification and validation element to the treatment of important human actions and to the iterative development processes for HSI, procedures and training. That feedback comes from the verification of the HSI design and integrated system validation. The integrated system validation tests the design assumptions made in early PRA/HRA, FRA/FA and TA regarding the performance of important human actions and the capability of operators to properly execute those important human actions. The resultant feedback (signified by this symbol ☼) comes through direct communication across the HFE team as well as through HFE issues and HEDs, which are entered and tracked to resolution in HFEITS.

Figure A-2 Point 17 represents the iterative development of operating, alarm response, abnormal, and emergency response procedures. The structured development methodology translates the innovative ideas, the concept of operations, HFE principles, functional requirements, task requirements, and qualification requirements into required procedures and technical guidelines for emergency procedures. The HFE team evaluation (signified by this symbol ☼) of procedures is based on HFE principles, intuitive functionality, and NUREG-0700 (for computer-based procedures) using a variety of validation methods (e.g., tabletop analysis, walk-through using event scenarios, and control room simulation) to refine and optimize the procedures. As the iterative procedure development process evolves towards mature procedures, development evaluation increasingly emulates the formal verification and validation process.

Plant procedures may be developed outside of the HFE Program. For example, an applicant may elect to do so in order to develop operational elements using licensee personnel. When procedures are developed outside the HFE Program, relevant function, task, staffing and qualification, important human action, and HSI development information must be available to the procedure developer. Conversely, relevant procedures must be available to support the HFE verification and validation along with the attendant feedback mechanisms.

Figure A-2 Point 18 represents the procedure development maturation and transition to HFE verification and validation. In general terms, the iterative procedure development continues at Point 17 until the procedure is ready for integrated validation in concert with available HSI and training. This verification and validation ensures the HSI, procedure, and training supports the task defined by task analysis, staffing and qualifications requirements, concept of operations, and HFE principles.

Figure A-2 Point 19 represents the iterative development of training. The structured training development methodology translates the HFE principles, concept of operations, task requirements, qualification requirements, HSI development, and procedure development into appropriate Licensing and Non-Licensed Training Programs. These training programs identify methodologies (e.g., systematic approach to training) for development of learning objectives, conduct of training, training on the use of simulators, lectures, on-the-job training, training evaluation, and training duration. The HFE team evaluation (signified by this symbol ☼) of training development is based on HFE principles and industry guidelines for accredited training programs using a variety of validation methods (e.g., tabletop analysis or assist visits from operating plant training experts) to refine Training Program development. As the iterative training development process evolves towards maturity, development evaluation increasingly emulates the formal verification and validation process. In parallel with the training development but not shown in Figure A-2, the Training Program accreditation processes must iteratively influence Training Program development and content.

Plant Training Programs may be developed outside of the HFE Program. For example, an applicant may elect to develop operational elements using licensee personnel. When training programs are developed outside the HFE Program, relevant function, task, staffing and qualification, important human action, HSI development, and procedure development information must be available to the Training Program developer. Conversely, relevant Training Program job needs and learning objectives must be available to support the HFE verification and validation along with the attendant feedback mechanisms.

Figure A-2 Point 20 represents the maturation of the Licensed and Non-Licensed Training Program development, and transition to HFE verification and validation. In general terms, the iterative Training Program development continues at Point 19 until the Training Programs are ready for integrated validation in concert with available HSI and procedures. This verification and validation ensures the HSI, procedure, and training supports the task defined by task analysis, the staffing and qualifications requirements, the concept of operations and HFE principles. In parallel with HFE verification and validation not shown in Figure A-2, the Training Program accreditation processes must iteratively influence Training Program development and content.

Figure A-2 Point 21 (along with Points 9 and 10) represent the iterative feedback generated by the treatment of important human actions based on revisions to design documents (PRA/HRA) and the results of HFE verification and validation. Such feedback to the HFE verification and validation process ensures that new or changing important human actions are appropriately supported by the HSI, procedures and training. Similarly, such feedback to the design implementation and human performance monitoring elements ensures they appropriately prioritize important human actions.