ArevaEPRDCPEm Resource

From: BRYAN Martin (EXTERNAL AREVA) [Martin.Bryan.ext@areva.com]
Sent: Wednesday, September 29, 2010 10:05 AM
To: Tesfaye, Getachew
Cc: DELANO Karen (AREVA); ROMINE Judy (AREVA); BENNETT Kathy (AREVA); PANNELL George (AREVA); HALLINGER Pat (EXTERNAL AREVA); HOKE Robert (AREVA); RYAN Tom (AREVA); Ford, Tanya
Subject: DRAFT Response to U.S. EPR Design Certification Application RAI No. 419, FSAR Ch. 18, question 18-172;
Attachments: 118-9042375-004P (DRAFT).pdf; 20100928155440.pdf

Getachew,

Attached please find the revised DRAFT U.S. EPR Human System Interface Design Implementation Plan 118-9042375-004. The current final due date is October 1, 2010. Because this document contains proprietary material, an affidavit for withholding from public disclosure is attached. Please let me know if this response can be finalized.

Thanks,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
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From: BRYAN Martin (EXT)
Sent: Tuesday, July 20, 2010 5:47 PM
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Subject: Response to U.S. EPR Design Certification Application RAI No. 419, FSAR Ch. 18

Getachew,

The proprietary and non-proprietary versions of RAI 419 are submitted via AREVA NP Inc. letter, "Response to U.S. EPR Design Certification Application RAI No. 419" NRC10:066, dated July 19, 2010. An affidavit to support withholding of information from public disclosure, per 10CFR2.390(b), is provided as an enclosure to that letter.

The following table indicates the respective pages in the response document that contain AREVA NP's responses to the subject questions.

Question #	Start Page	End Page
RAI 419 — 18-171	2	3
RAI 419 — 18-172	4	5

A complete answer is not provided for one of the questions. The schedule for technically correct and complete response to this question is provided below.

Question #	Response Date
RAI 419 — 18-172	October 1, 2010

Sincerely,

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Cc: Bongarra, James; Walker, Jacqwan; Marble, Julie; Junge, Michael; Eudy, Michael; Steckel, James; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 419 (4727,4780),FSAR Ch. 18

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on June 14, 2010, and discussed with your staff on June 17, 2010. Drat RAI Question 18-173 was deleted as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,

Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
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Hearing Identifier: AREVA_EPR_DC_RAIs
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PROPRIETARY

AREVA NP Inc.,

an AREVA and Siemens company

U.S. EPR™ Implementation Plan

Document No.: 118 - 9042375 - 004

U.S. EPR Human System Interface Design Implementation Plan

Safety Related? ☐ YES ☒ NO

Does this document contain assumptions requiring verification? ☐ YES ☒ NO

Does this document contain Customer Required Format? ☐ YES ☒ NO

Signature Block

Name and Title/Discipline	Signature	P/LP, R/LR, A/A-CRF, A/A-CRI	Date	Pages/Sections Prepared/Reviewed/ Approved or Comments
Robert Hoke / Human Factors Engineer		P		ALL
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Desmond Raymond / Human Factors Engineering Manager		A		ALL

Note: P/LP designates Preparer (P), Lead Preparer (LP)
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A/A-CRF designates Approver (A), Approver of Customer Requested Format (A-CRF)
A/A-CRI designates Approver (A), Approver - Confirming Reviewer Independence (A-CRI)

Record of Revision

Revision No.	Pages/Sections/ Paragraphs Changed	Brief Description / Change Authorization
000	ALL	Initial Release
001	ALL	Formatted document into new template. Complete re-write to reflect RAI responses
002	References	Deleted document numbers for internal references. Added trademark to EPR
003	ALL	Revisions due to RAI batch 350
004	Section 5.2	Added laydown space consideration for LCS HSI design
004	Section 6.1	Revision due to RAI 419 Question 18-172
004	Section 7.4, & 7.5	Clarification of Trade-off study criteria

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1.0 INTRODUCTION

1.1 Purpose

The Human System Interface (HSI) design for the U.S. EPR^{TM} plant is based upon operating experience and outputs from the human factors engineering (HFE) program analysis. The HSI consists of conventional instrumentation and control (CNV I&C) as well as digital displays and controls. The purpose of this HSI design implementation plan is to describe the methodology used to design the HSI as well as the operation and control centers that are within the scope of the U.S EPR™ HFE program. The HSI consists of the Process Information and Control System (PICS), the Safety Information and Control System (SICS). The operation and control centers within the scope of the HFE program are the main control room (MCR), remote shutdown station (RSS), technical support center (TSC), and Instrumentation and Control Service Center (I&CSC). Design of HSIs associated with non-I&C systems, such as risk-important local control stations (LCS) or fire panels in the MCR, is the responsibility of the system engineer. The design of the LCS follows the LCS specific style guide which includes HFE guidance established by the HFE and control room design team (CRDT). Design of the Emergency Operations Facility (EOF) is the responsibility of the COL applicant; however the HFE and CRDT participate in that design.

Included in the HSI design are aspects such as the layout of the operation and control centers, human system interactions (e.g. trackball, pushbuttons, and alarms), and display design. The HSI design takes into account plant-level (specifically, critical safety functions) and system-level functional requirements and incorporates the control room hardware/software and operating crew as an integrated system. This single system concept integrates the operator with the machine to create a team type human system environment.

By implementing this plan, reasonable assurance is provided that applicable regulatory documents and codes, HFE standards, and HFE guidelines are followed during the U.S. EPR^{TM} detailed design process.

The HSI is designed with the following considerations:

- The HSI design supports the personnel in their role of monitoring and controlling the plant. In addition, the roles of personnel are optimized.

- For risk-important human actions (HAs), the design minimizes the probability of human errors and maximizes the probability that human errors are detected prior to a negative safety impact. The effects of any human errors are mitigated if they occur.

- The HSI design takes into account the use of HSIs over the duration of a shift, during shift turnover, and during periods of short term relief where decrements in performance may occur.

- The HSI is designed for all modes of operation; normal, abnormal, and emergency, during refueling, start-up, and low power operation.

The HSI is designed to meet the following basic requirements:

- Operator tasks are executable (sufficient time allotted, applicable controls and information available).

- The operator is able to check the result of an action against the objective of the action (operator feedback).
- The allocated tolerance ranges (safety limits, time limits, precision) are clearly defined.
- Actions that fail or are erroneous are recoverable.
- The operator is able to evaluate the system or plant response to a control action. Multiple contexts (i.e., physical, functional) for monitoring the process are preferred.
- Feedback is provided demonstrating that the desired action is accomplished and that the desired task/function is fulfilled.
- The operator is able to evaluate the safety state of the plant processes from the available displays and indications.

1.2 Scope

The scope of the HSI design includes the following:

- Basic concepts and detailed design for the displays, controls, and alarms for all HSI control stations (including conventional I&C).
- Design of LCSs associated with risk-important monitoring, operation, and maintenance.
- Coding and labeling conventions for control room and plant components displays.
- Creation and maintenance/revision of the U.S. ERP™ style guide.
- Design of the screen-based HSI including the actual display layout, the standard dialogues for accessing information and controls, and navigation.
- Layout of operator work stations and work space.
- Environmental considerations such as ambient conditions, lighting, and acoustics.
- Evaluation of HSI design.

1.3 Applicability

This implementation plan applies to the U.S. EPR™ design activities.

1.4 Owner

Program Manager, HFE and Control Room Design

1.5 Definition of Terms

Emulation	A simulation, often the result of a software translation program, which correctly represents the behavior and functionality of a process or I&C system or subsystem according to the application-specific configuration.
Flamanville 3 (FA-3)	EPR™ nuclear reactor; currently being built in France.
Full Scope Simulator	A simulator that includes the operator interfaces in a replica of the control room, including the operating consoles and HSI, connected to a simulation of the DCS and the plant dynamic model. Used to conduct detailed validation of HSI design where full functionality and a full operational context are needed.
Functional Requirements Analysis (FRA)	The FRA is the identification of functions that are performed to satisfy plant safety objectives to prevent or mitigate the consequences of postulated accidents that could damage the plant or cause undue risk to the health and safety of the public.
Function Allocation (FA)	The FA is the analysis of these required plant control actions and the subsequent assignment to manual control, automatic control with passive, self-controlling mechanisms, or combinations of manual and automatic control (e.g., shared control and automatic systems with manual backup).
Human System Interface (HSI)	The HSI is a system of devices, which includes hardware and software, used by personnel to control, monitor and interact with the plant including the alarms, displays, controls, and decision support aids.
Human Reliability Analysis (HRA)	The HRA is a structured approach used to identify potential human failure events and to systematically estimate the probability of those errors using data, models, or expert judgment.
Mockup	A static representation of a human-system interface.
Olkiluoto 3 (OL-3)	EPR™ nuclear reactor; currently being built in Finland.
Operating Experience Review (OER)	The HFE OER is a systematic review, analysis, and evaluation of operational experience that applies to the development of the human-system interface design.

Part-task Simulator	One or more represented workstations connected to the plant dynamic model. Used to optimize new task performance and procedure development and obtain user feedback on detailed HSI design concepts where functionality is required but where a full operational context is not needed.
Plant Model	The plant model integrates the integrated system process, system logic, and HSI models of each system to provide the complete dynamic plant behavior. It provides high-fidelity simulation of normal operation and emergency conditions, including design basis accidents.
Prototype	Initial form of the HSI, used to obtain user feedback on early detailed HSI design concepts where limited functionality is required.
Probabilistic Risk Assessment (PRA)	The PRA is a systematic evaluation which demonstrates that the design poses acceptably low risk of core damage accidents and consequences.
Process Information and Control System (PICS)	The PICS is the non-safety related I&C system that provides the human-system interface (HSI) to control and monitor the plant during all modes of operation.
Safety Information and Control System (SICS)	The SICS is the safety related I&C system that provides the HSI to control and monitor the plant for a limited amount of time to keep it in a safe and steady power condition or to shutdown the plant in the event the PICS is not available.
Simulation	The implementation of a process, I&C system, or I&C subsystem by developing a model that runs within the simulator development environment and replicates the behavior of the system
Task Analysis (TA)	The TA is the identification of requirements (i.e., specifying the requirements for the displays, data processing, controls, and job support aids) for accomplishing specific tasks that are a group of related activities having a common objective or goal.

1.6 Acronyms

CNV I&C	Conventional Instrumentation and Control
COL	Combined Operating License
CRDT	Control Room Design Team
DCS	Distributed Control System
EOP	Emergency Operating Procedure
EPG	Emergency Procedure Guideline
FA	Function Allocation
FA-3	Flamanville-3 Nuclear Power Plant
FRA	Functional Requirements Analysis
FSAR	Final Safety Analysis Report
HA	Human Action
HFE	Human Factors Engineering
HSI	Human System Interface
HRA	Human Reliability Analysis
I&C	Instrumentation and Control
I&CSC	I&C Service Center
ITAAC	Inspections, Tests, Analysis, and Acceptance Criteria
LCS	Local Control Stations
LOOP	Loss Of Off-site Power
MCR	Main Control Room
MI	Minimum Inventory
NRC	Nuclear Regulatory Commission
NUREG	Publications Prepared by the NRC staff
OER	Operational Experience Review
OL-3	Olkiluoto-3 Nuclear Power Plant
PAM	Post Accident Monitoring
PICS	Process Information and Control System
P&ID	Piping and Instrumentation Diagram
POP	Plant Overview Panel
PPE	Personal Protective Equipment
PRA	Probabilistic Risk Assessment
PWR	Pressurized Water Reactor

QDS	Qualified Display System
RMT	Requirements Management Tool
RSS	Remote Shutdown Station
SDD	System Description Document
SDRD	System Design Requirements Document
SICS	Safety Information and Control System
SPDS	Safety Parameter Display System
SSE	Safe-Shutdown Earthquake
TA	Task Analysis
TSC	Technical Support Center
V&V	Verification and Validation

2.0 HSI DESIGN INPUTS

The HSI begins with inputs from the HFE analysis (such as OER, FRA, FA, and TA) and the plant design documentation (such as SDDs, P&IDS). This section describes the HFE program inputs, regulatory requirements, and industry guidance that are input into the HSI design methodology.

2.1 Analysis of Personnel Task Requirements

Several analyses are performed in the early stages of the design process to identify HSI design requirements. These requirements are documented in the references listed for each of the inputs discussed in the subsections below.

2.1.1 Operation Experience Review

An operating experience review performed in accordance with Reference [7] is used to identify any HFE related safety issues as well as any positive HFE-related experiences with HSIs and control rooms. The goal of the OER is to compare the analysis of current work practices, operational problems and issues in current designs, and industry experience with candidate technological approaches to system and HSI technology and specific supplier solutions.

The OER also includes a survey of advanced HFE technology, from nuclear and non-nuclear industries, as a part of the OER process. This survey of HFE-related technology is not restricted to HSI hardware/software and includes HSI evaluation tools. The survey results are used as an input into the HSI design process, such as HSI evaluations where new technologies are compared to current HSI designs during trade-off studies and performance-based evaluations.

By using the results of the OER during the HSI design, HSI options identified as undesirable are avoided. The OER results are also used to identify HSI options that have been proven acceptable in other designs.

2.1.2 Functional Requirement Analysis

Functional requirements analysis (FRA) is the identification of functions performed to satisfy plant safety objectives to prevent or mitigate the consequences of postulated accidents that could damage the plant or cause undue risk to the health and safety of the public.

The FRA inputs lead to the definition of concept of operations with respect to the role of personnel. The inputs define potential changes to functions and allocations, but are evaluated against the established automation criteria.

More specifically, the FRA determines the performance requirements and constraints of the HSI design and establishes the functions that are necessary to meet these requirements. The FRA is documented in the requirements management tool (RMT), which provides the data structure used to assess the impact of design changes, including the impact changes may have on the HSI.

The results of FRA are used as an input to functional allocation.

Details of the FRA process are given in Reference [8].

2.1.3 Functional Allocation

The functional allocation (FA) allocates the functions resulting from the FRA into human action, automation, or a combination of both human action and automation. The FA is an iterative process that is performed interactively as the design becomes more detailed. The FA for each system is documented in that system's SDD. HSI design engineers extract FA information from the SDD.

The FA allocates functions to increase plant safety and efficiency by considering human capabilities and limitations in the design, thus, human error is contained. The initial function allocation is based on the vision to design a state-of-the-art HSI using current human factors principles, which reduce operator errors and promote accurate evaluation and control.

The allocation of functions uses areas of human strengths and avoids allocating functions to personnel which challenge human limitations. The allocation of functions to personnel, systems, or personnel-system combinations reflects sensitivity, precision, time, and safety requirements, required reliability of system performance, and the number and level of skills of personnel required to operate and maintain the system. The outputs of FRA and FA are used as inputs to TA, where HSI task support requirements are identified. This includes insight into the information that is displayed and how that information is presented. This information is used in the HSI, procedure, and training design verify that adequate task support is available to the operators.

Details of the FA process are given in Reference [8].

2.1.4 Task Analysis

Functions allocated to human actions (HAs) are grouped into tasks of related activities with a common goal. A task analysis is performed to identify the requirements for accomplishing these tasks (i.e., specifying the requirements for the displays, data processing, controls, and job support aids needed to accomplish tasks).

TA outputs are inputs to HSI design. When the tasks are selected, high-level descriptions of the tasks based on basic information are developed. For example, the purpose, relationship to other tasks, and timing are considered.

Using the high-level descriptions, more detailed descriptions of a task are developed to decompose the task into detailed steps. As these details emerge, task support requirements (i.e., the process data and controls required) are identified.

The task support interface requirements from TA define the inventory and characterization of the HSI elements such as alarms, displays, and controls necessary for operators to perform specific tasks. This includes grouping interface items on individual displays and the required display navigation, or the location of conventional interface items on panels. Examples of information requirements identified through TA and used during HSI design include parameter values (units, precision), display format, trends, parameter limits, and system or equipment state. Task support requirements determine what is displayed, how it is displayed, how information is grouped, and the sequence of information presentation.

The TA also identifies the support requirements of the tasks associated with individual functions. The TA provides one of the bases for making design decisions such as:

- Determining before hardware fabrication whether system performance requirements are met by combinations of anticipated equipment, software, and personnel
- Verifying that human performance requirements do not exceed human capabilities
- Use as basic information for developing manning, skill, training, and communications requirements of the system
- Forming the basis for specifying the requirements for the displays, data processing, and controls needed to carry out the tasks).

Details of the TA process are given in Reference [9].

2.1.5 Staffing and Qualifications Analysis

Staffing and qualification analysis considers the allocation of assigned operational activities, the impact of those activities on crew member roles and responsibilities, and the impact of changes to operational requirements for the operating crew as a whole.

The results of the evaluation of staffing, qualifications, and integrated work design impacts the HSI design in terms of:

- How operational activities are allocated to crew members, including assignments that make operational activities more efficient or reduce workload.
- How teamwork is supported.
- Personnel qualifications.
- Required staffing levels.

As the design evolves, the staffing and qualification analyses are re-iterated. The design of the HSI is then modified as necessary based upon any findings to maintain the safety of the plant. Relevant staffing number assumptions and operator roles/responsibilities details are given in Reference [12].

During the HSI design phase, HSIs are associated with each of the tasks resulting from the TA. Evaluations are performed to assess the HSI design, procedures, and to verify operator workload is at acceptable levels. Inputs to these analyses include the number and skill set of crew members in the staffing and qualification assumptions and the results of the FA.

The assumptions for the staffing and qualification levels of the control room personnel are used as the HSI design basis is evaluated and are adjusted based on the outputs of TA. The results of staffing and qualifications analysis provide input into control room and workstation layout that is assessed during the HSI task support evaluations.

Control room design considers the initial staffing assumptions. The control room is designed to facilitate communication among the operators, to provide sufficient monitoring capabilities for the control room staff, and to support control room tasks.

Details of the staffing and qualification analysis process are given in Reference [9].

2.1.6 Human Reliability Analysis

Human reliability analysis (HRA) is conducted to evaluate the potential for human error that may affect plant safety. The results provide a list of risk-important human actions and scenarios. The HSIs used to perform those risk-important HAs are specifically addressed providing a design that minimizes the probability of human error.

HRA results consider design modifications when risk-significant HAs, along with their performance shaping factors, are identified and are mitigated with HSI design modifications. HRA supports HSI design by providing feedback identifying where additional design effort has potential for minimizing personnel errors that have risk-significance and improving operator recovery from human errors and plant system failures.

Details of the HRA integration process are given in Reference [10].

2.2 System Requirements

The HSIs are designed to meet system requirements. I&C functional requirements are specified for each of the plant systems using Reference [5]. System limitations are identified in the SDDs for the plant systems. Additionally, computer hardware and software limitations provide HSI design constraints.

2.3 Regulatory Requirements and Guidance

Applicable U.S. regulatory requirements are listed below.

10 CFR 50.34(f)(2)(i)	Simulator
10 CFR 50.34(f)(2)(iii)	State-of-the-Art Human Factors Principles

10 CFR 50.34(f)(2)(iv)	Safety Parameter Display System
10 CFR 50.34(f)(2)(v)	Bypassed and Inoperable Status
10 CFR 50.34(f)(2)(vi)	High Point Venting
10 CFR 50.34(f)(2)(xi)	Relief and Safety Valve Indication
10 CFR 50.34(f)(2)(xii)	Auxiliary Feedwater Initiation
10 CFR 50.34(f)(2)(xvii)	Accident Monitoring Instrumentation
10 CFR 50.34(f)(2)(xviii)	Inadequate Core Cooling Instrumentation
10 CFR 50.34(f)(2)(xix)	Instruments for Monitoring Plant Conditions
10 CFR50 Appendix A GDC 19	General Design Criteria for Nuclear Power Plants
10 CFR 50.55a(a)(1)	Codes and Standards
10 CFR 50.34(f)(2)(iii)	Additional TMI-Related Requirements (on control room designs)
10 CFR 52.47(a)(8)	Content of Applications (for standard design certification dealing with compliance with TMI requirements)
Regulatory Guide 1.22	Periodic Testing of Protection System Actuation Functions
Regulatory Guide 1.47	Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems
Regulatory Guide 1.62	Manual Initiation of Protective Actions
Regulatory Guide 1.97	Criteria For Accident Monitoring Instrumentation For Nuclear Power Plants
Regulatory Guide 1.105	Setpoints for Safety-Related Instrumentation
NUREG-0696	Functional Criteria for Emergency Response Facility," Nuclear Regulatory Commission, 1981
NUREG-0654	Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," Nuclear Regulatory Commission, 1980

NUREG-0737	Clarification of TMI Action Plan Requirements," Nuclear Regulatory Commission, 1980
NUREG-0700	Human-System Interface Design Review Guidelines (NRC, 2002)
NUREG-0711	Human Factors Engineering Program Review Model, Rev. 2, U.S Nuclear Regulatory Commission (NRC), January 2004
NUREG-0800	Standard Review Plan, Chapter 18 Human Factors Engineering (NRC, 2004)
NUREG-0835	Human Factors Acceptance Criteria for the Safety Parameter Display System," October 1981.
NUREG-1342	A Status Report Regarding Industry Implementation of Safety Parameter Display Systems," April 1989.

2.4 Other Requirements

2.4.1 Customer HFE Requirements

Depending on plant specific operating procedures and plant location, the HSI is designed to incorporate customer specific requirements. For example, the HSI can be customized to meet utility requirements for a unique site specific function recovery procedure (e.g., Loading Offsite Power).

2.4.2 Industry HFE Codes and Standards

Applicable industry codes and standards are listed below.

ANSI/AIAA G-035-1992	Guide to Human Performance Measurements (American National Standards Institute, 1993).
ANSI HFS-100	American National Standard for Human Factors Engineering of Visual Display Terminal Workstations (American National Standards Institute, 1988).
EPRI NP-3659	Human Factors Guide for Nuclear Power Plant Control Room Development (Kinkade and Anderson, 1984).
EPRI TR-1008122	Human Factors Guidance for Control Room and Digital Human-System Interface Design and Modification (2004)
IEEE Std. 1023-2004	IEEE Guide to the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations (Institute of Electrical and Electronics Engineers, 2004).

IEEE Std. 1289	IEEE Guide to the Application of Human Factors Engineering in the Design of Computer-Based Monitoring and Control Displays for Nuclear Power Generating Stations (Institute of Electrical and Electronics Engineers, 2004).
NUREG/CR-6393	Integrated System Validation: Methodology and Review Criteria (O'Hara, Stubler, Higgins, Brown, 1997).
NUREG/CR-6637	Human-System Interface and Plant Modernization Process: Technical Basis and Human Factors Review Guidance (Stubler, O'Hara, Higgins, and Kramer, 2000).
NUREG/CR-6636	Maintainability of Digital Systems: Technical Basis and Human Factors Review Guidance," March 2000.
NUREG/CR-6635	Soft Controls: Technical Basis and Human Factors Review Guidance (W. Stubler, O'Hara, and Kramer, 2000).
NUREG/CR-6634	Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance (O'Hara, Higgins, Stubler, and Kramer, 2000).
NUREG/CR-6633	Advanced Information Systems: Technical Basis and Human Factors Review Guidance (O'Hara, Higgins, and Kramer, 2000).

3.0 CONCEPT OF OPERATIONS

A concept of operations is developed to identify the relationship between personnel and plant automation, provide a high-level description of how personnel work with the HSI resources, and address the coordination of crew member activities. The plant I&C platform, the HSI, and the control rooms are designed to consider the concept of operations.

The concept of operations is primarily concerned with the MCR operating team. The secondary concern includes system users considered in the design of other user interfaces. The concept of operations is provided in Reference [14].

4.0 FUNCTIONAL REQUIREMENTS SPECIFICATION

Functional requirements for the HSI are developed to address

- the concept of operations
- personnel functions and tasks that support their role in the plant as derived from function, task, and staffing/qualifications analyses
- personnel requirements for a safe, comfortable working environment

- minimizing human error and the impact of human error on the safety of the plant/public
- maximizing operational and situational awareness

The HSI specific functional requirements are documented in system design requirement documents (SDRD) and produced for each of the operation and control centers (i.e., MCR, TSC, RSS, I&CSC) and HSIs (i.e., PICS and SICS). Additional inputs to the development of the HSI SDRDs include the inputs described in Section 2.0. Each SDRD is developed using the procedure given in Reference [2]. These procedures maintain standard content and format. HSI requirements specific to each plant system are documented in their respective SDRDs and SDDs.

The functional requirements for the operation and control centers addresses aspects such as the monitoring and control responsibilities for each room, the number people expected to perform/monitor plant operations, and other aspects of the concept of operations for normal, abnormal, and emergency operation, refueling, low power operation, shift turnover, shift briefings, communication, emergency plan implementation, safety tagging, maintenance, tests, and surveillances. Additionally, requirements for personnel functions and tasks that support their role in the plant and habitability are specified.

The functional requirements for the HSI systems include the human interface requirements, the functions the HSI system performs, as well as the display, control, and alarm requirements. The display and control requirements include aspects such as the need for any calculated variables. These requirements ultimately become the display elements.

Functional requirements for the HSI are developed using

- the Plant Technical Requirements Document (PTRD) (Reference [6])
- the plant and I&C systems documentation (i.e., SDRD and system description document (SDD))
- the Concept of Operations (Reference [14])
- display and control requirements derived from the U.S. EPR™ HSI Design Work Plan (Reference [18])

The overall design control process is described in section 4.5 of the U.S. EPR HFE Program Management Plan (Reference, [11]). The HSI design element of the HFE program follows this overall process. Plant requirements (including high level HSI requirements) are documented in the PTRD. SDRDs are created for all plant systems, each operation and control center (i.e. MCR, TSC, RSS, I&CSC), and each HSI (PICS and SICS). These documents specify the design requirements for each of these systems/control rooms. SDDs are then created for each system, control room, and HSI based on their parent SDRD. The SDDs contain a more detailed system description based on the SDRD.

Each plant SDD contains a section with requirements specific to I&C. These I&C functional requirements (some of which are used as input to the HSI design) are developed and documented in each plant SDD using the "Development of I&C interface requirements" procedure (Reference, [5]).

Functional requirements are identified, analyzed, and documented as described in the U.S. EPR Functional Requirements Analysis and Functional Allocation Implementation Plan (Reference [8]) as well as detailed work plans for plant and system level functional requirements analysis. The HFE functional requirements are identified from the SDRDs and SDDs and are documented in the requirements management tool (RMT).

The functions are then divided into tasks which are analyzed and documented as described in the U.S. EPR Task Analysis Implementation Plan (Reference, [9]) as well as the detailed TA work plan. Staffing and qualification requirements are also addressed during task analysis. The outputs from TA are then used as an input to HSI design through the identification of displays, controls, and alarms needed for each task. Additional HFE documents such as the concept of operations and style guides (HSI and LCS) are used as input to the HSI design process.

The HSI Design Work Plan (Reference, [18]) provides the instructions required to gather the requirements from the inputs for HSI design including SDRDs, SDDs, and the outputs of task analysis. This work plan also provides the detailed steps for designing the HSI including displays, conventional panels, and workstations.

5.0 HSI CONCEPTUAL DESIGN

The U.S. EPR™ plant implements a modern I&C design based on operating experience gained internationally in new plant designs and retrofits in existing plants with digital I&C equipment. During the conceptual design phase, all the inputs may not be available. The HSI that is designed using preliminary inputs are verified once the final input information is available. Gaps discovered may prompt a design change. Concept documents for the HSI display design, computer based procedures, and alarm management are created to document the preliminary concepts based on customer requirements and vendor capabilities.

5.1 System Descriptions

Using the requirements from the SDRDs, HFE engineers develop conceptual designs for each of the operation and control centers (i.e., MCR, TSC, RSS, I&CSC) and HSIs (i.e., PICS and SICS). The design is documented using a system description document (SDD). The SDDs are iterative documents that are revised as more details of the design are determined. The SDD describes the system design in sufficient detail to permit verification that the design satisfies the design requirements. The SDD identifies interfaces with other systems so that the design input requirements for each system are understood. Cross-discipline independent reviews of SDDs for systems which interface with non-HSI, non-control room, or non-I&C systems are also required. Each SDD is developed using the procedures given in References [3] and [4]. These procedures maintain standard content and format.

5.1.1 Operation and Control Centers Systems

During the conceptual design phase, the basic layouts of the MCR, TSC, RSS, I&CSC are determined and documented in the respective systems SDD. The basic layout includes aspects such as

- Room location and control boundaries
- Space dimensions
- Entrance / Egress locations

For the MCR, details concerning placement of operator sit-down workstations, stand-up consoles, sit/stand workstations, and plant overview panels (POPs) are also defined. The layout of these components in the MCR is determined with guidance from NUREG-0700 (Reference [25]), such as visibility, reach and grasp requirements, and anthropometric dimensions for the intended user population as well as feedback from lessons learned or operating experience from the OER (see section 2.1.1).

Additionally, the layout is designed to accommodate operator roles and responsibilities provided in the Initial Staffing Assumptions and the Concept of Operations documents (References [12] and [14]). The operator roles and responsibilities influence communication requirements among the operating, maintenance, and other staff members (e.g., engineering, management, radiological and chemical control, I&C technicians) during all plant states.

5.1.2 HSI Systems

System descriptions for the HSIs (PICS and SICS) are developed based upon U.S. regulations and guidance, functional requirements, and operating experience. The SDDs for the HSI systems document the following elements.

5.1.2.1 Safety Parameter Display System

The required safety parameter display system (SPDS) parameters are available on the PICS and SICS. These parameters, as well as transmission criteria, are in accordance with NUREG-0696 (Reference [22]), NUREG-0654 (Reference [23]), and NUREG-0737 (Reference [24]). During the conceptual design phase, these parameters are defined and documented through the PICS and SICS SDDs.

5.1.2.2 Inventory of Alarms, Displays, and Controls

The process data inventory, setpoints, and equipment layout needed to operate the U.S. EPR™ plant is determined by the system engineers for each piping and instrumentation system. These are documented in various piping and instrumentation diagrams (P&IDs) or electrical one-line diagrams. The corresponding design documents capture the functions and functional requirements as well as the design basis for each function. These design documents are then used as input into the FRA and TA processes.

Through the FRA/FA and TA processes the required inventory of alarms, displays, and controls is identified and documented. Guidance on how to organize and present the required alarms, displays, and controls are provided by the HSI Style Guide (see Section 6.2 and Reference [15]). Hardware and software requirements to implement this inventory and the subsequent HSI designs are verified as described in Reference [13].

The MCR provides the capability for safe shutdown, even assuming a safe-shutdown earthquake (SSE), a loss of offsite power (LOOP), and the most limiting single failure. Localized emergencies which make the environment unsuitable for the operators and require evacuation of the MCR are not postulated concurrent with other design basis events. If evacuation of the MCR is required, the operators can establish and maintain a safe shutdown from outside the MCR through the use of the PICS in the RSS.

5.1.2.3 Minimum Inventory of Alarms, Displays, and Controls

A minimum inventory of alarms, displays, and controls necessary to perform crew tasks for the MCR and the RSS is defined for the U.S. EPR™ plant. The methodology for selecting this minimum inventory is provided in Section 6.1 of this implementation plan.

5.2 HFE Guidance for Local Control Station Design

A separate style guide is provided by the HFE and control room design team and is used in the design of HSI features for the plant and LCS. This style guide provides guidance on such issues as general plant layout design, equipment accessibility requirements, coding and labeling, and environmental issues such as lighting, acoustics, personnel protection equipment, and ambient conditions suitable for personnel. The style guide contains design guidelines applicable to engineering disciplines (e.g., structural engineers) that are required to follow the style guide for plant and equipment layout decisions.

Task support requirements for risk significant LCSs are included as a part of the analysis and results of task analysis. These requirements are used as input to the LCS HSI design process; including if lay down space is required as a part of the LCS design.

5.2.1 Plant Layout Design and Equipment Accessibility

System engineers specify space requirements for their equipment during the plant layout phase taking into account maintenance, testing, and component replacement. A style guide provides guidance for these space requirements. Location of interfaces also considers the general physical layout of the system. HSIs are placed in easy to access locations (e.g., manual valve operators are not located where access requires the use of a portable ladder or scaffold) and the associated parameter indicators are readily visible and easily read (for example, meters, gauges, and dials).

5.2.2 Coding, Language, and Information Presentation

Rules for coding, labeling, and presenting information on LCSs and on most equipment are specified in a style guide. The nomenclature and terminology used in operating procedures and design documentation (e.g., system manuals and plant drawings) are standardized and consistent with those used for operator interfaces.

Unique equipment identifiers are established in the equipment database early in the design phase, and those identifiers are maintained throughout the design, manufacture, construction, testing, procedure development, and operational staff training. In conformance with NUREG-0711 (Reference [26]) and consistent with NUREG-0700 (Reference [25]); the LCS Style Guide specifies requirements for the use of symbols, abbreviations, syntax, and color schemes.

5.2.3 Lighting of the Control Rooms and Workspaces

The lighting in the control rooms and workspaces, including LCSs, provides suitable working conditions for personnel by:

- Providing adequate lighting for performance of their tasks (e.g., good contrast for easy discrimination of required information, good minimum lighting level for the preservation of alertness).
- Avoiding glare and reflection.
- Adequate lighting during degraded conditions.

5.2.4 Acoustic Environment

The acoustic environment and the mean noise level in the MCR and RSS aids operator alertness so that the monitoring and controlling of processes and the associated mental activities are performed in comfort, distraction- and stress-free, and communication among the members of the operating staff is not disrupted. The acoustic environment support auditory feedback as a form of coding.

For LCS in areas of the plant that cannot provide a comfortable acoustic environment, the design of the HSI accommodates these conditions (e.g., appropriate communication devices are selected in areas where hearing protection is required).

5.2.5 Personnel Protection Equipment

The use of personnel protection equipment (PPE) such as hearing, eye, and head protection, anti-contamination clothing, and self-contained air breathing apparatus is not likely in the MCR. However it is placed in locations providing easy access within the control boundary. The storage of PPE is considered in the plant layout design and in locations where a LCS is placed. The HSI used in areas where personnel protection equipment is required is designed to support the tasks personnel perform while wearing PPE.

5.2.6 Ambient Conditions

During normal operation at basic atmospheric conditions, the temperature and humidity in the MCR and associated HSI rooms are controlled to normal comfort levels. During some design basis events, the temperature in the MCR may exceed comfort levels, but the control room air conditioning system maintains temperature and humidity within ranges defined in the MCR SDRD. For LCSs, the ambient environment may include temperature extremes, radioactive, and chemical hazards. The HSI for those LCSs are designed to accommodate these ambient conditions.

5.2.7 Extreme Workplace Conditions

Extreme workplace conditions are evaluated during the development of task requirements of the task analysis (TA). TA considers workplace factors, such as normal and extreme workplace conditions, that can be expected for the work environment. Examples of these factors include lighting/glare, temperature extremes, noise, humidity, radiation/contamination, unsafe floors (oily, wet, icy), pressure differentials between zones, confined spaces, and working at heights (fall potential).

Regulatory requirements related to extreme environmental conditions are considered during HSI design. These include emergency lighting, loss of ventilation, and the need for access to personal protective equipment (such as clothing and breathing apparatus). These requirements are documented in system design requirements documents using the standard design control process described in the U.S. EPR Human Factors Engineering (HFE) Program Management Plan (Reference, [11]). These requirements are incorporated into HSI design.

Environmental and lighting considerations for local control stations (LCSs) are addressed in U.S. EPR LCS Style Guide. These considerations include normal and emergency situations. Factors addressed by the U.S. EPR LCS Style Guide include the workstation envelope (e.g., access, reach, and so forth), radiation, heat, cold, noise, and lighting.

5.3 Develop Conceptual Alternative Designs

During the OER process, a survey of advanced, state-of-the-art technologies is performed. This survey is used to provide alternative designs that are proposed to meet the requirements defined in the SDRDs. These alternative designs may include aspects such as a different MCR layout or identifying multiple HSI solutions (trackball or touch display as an input device). Additionally, feedback given on the conceptual HSI design may result in varying styles of display or CNV I&C layout. Alternative designs are analyzed and evaluated to determine which style leads to a better, more efficient design. Details of the tests and evaluations are provided in Section 7.0.

6.0 HSI DETAILED DESIGN

The HSI detailed design process is an iterative process built upon the conceptual design phase. During the detailed design phase, system engineers, I&C engineers, mechanical engineers, electrical engineers, operations and HFE engineers interact to share information and details about the different systems and how the different systems interact. This interaction supports the HFE engineers in their efforts to provide HSI designs.

6.1 Minimum Inventory Development

The minimum inventory (MI) for the U.S. EPR MCR and RSS is developed as a part of the HSI design process. The MCR minimum inventory for the U.S. EPR™ design is the set of alarms, displays, and controls required for the operator to perform the manual actions that are credited in the emergency operating procedures (EOPs) and that are determined critical by PRA to bring the reactor to a safe shutdown condition and maintain it in the safe shutdown condition. This includes the plant process parameters (indications, controls, and alarms) that support the identified operator actions.

The minimum inventory is the set of HSI in the MCR as well as the HSI inventory in the RSS. The RSS minimum inventory is a smaller set of the parameters that are required to perform and confirm a reactor trip and then to maintain the reactor in a safe condition using the normal or preferred safety means.

The location of the minimum inventory is determined during the HSI design phase of detailed design. This determination is made based upon the HSI design (MCR or RSS) and the safety classification of the subject parameters. The minimum inventory is described as "readily accessible" on the HSIs in the subject control rooms (MCR or RSS). The accessibility of each MI parameter is determined during the MI identification process and evaluated during HSI evaluations.

The minimum inventory development process, is iterative similar to the other U.S. EPR™ HFE program elements. As design inputs are developed, the MI list is revised as the design evolves and the MI list is re-evaluated and adjusted as necessary until the design is finalized.

6.1.1 Applicable Minimum Inventory Guidance

The following is a list and description of applicable minimum inventory guidance that is used to develop and perform the minimum inventory methodology. The parent requirement for a review of minimum inventory comes from SECY 92-053. This requirement is elaborated upon in NUREG-0800, NUREG-0711, and ISG-05. In addition, the minimum inventory overlaps and includes post-accident monitoring (PAM) variables discussed in Regulatory Guide 1.97.

6.1.1.1 NUREG 0800, Rev. 1 Standard Review Plan (SRP)

Chapter 14 Section 14.3.9 of NUREG-0800 specifies that a minimum inventory of displays, controls, and alarms is included as a part of HFE Inspections, Tests, Analysis, and Acceptance Criteria (ITAAC). The methodology described in this plan is used to develop the minimum inventory to meet the ITAAC.

Also, a draft Branch Technical Position (BTP) 18-1 to NUREG-0800 was provided to the industry for public review. This document provides more specific guidance to minimum inventory and supersedes previous regulatory guidance. This document is used to develop the minimum inventory methodology to verify the required acceptance criteria are met.

6.1.1.2 NUREG 0711, Rev. 2 – Human Factors Engineering (HFE Program Review Model)

The development of minimum inventory is a part of the HSI design element of the HFE program described in NUREG-0711. Task analysis is the primary input into HSI design because it defines the task support requirements for the operators. These tasks include normal and emergency operations. The task analysis process is used for the development of minimum inventory. The parameters required to support the identified manual operator actions are determined.

6.1.1.3 NRC Digital I&C Interim Staff Guidance (ISG) – 05, Rev. 01

The HFE and I&C divisions of the NRC combined with the industry to form task working groups to develop guidance for issues that did not have clear regulatory paths with relation to a highly-integrated control room. MI was one of the issues that the NRC provided further guidance beyond what was provided in the SECY and NUREG documents. ISG-05 added many criteria that were not previously included as part of the MI in previous DC submittals.

Although this guidance is superseded by the draft BTP 18-1, this document used to verify that the U.S. EPR™ minimum inventory development methodology takes into account the required aspects of the process that are reviewed by the NRC, including the subsequent ITAAC.

6.1.1.4 NRC Regulatory Guide 1.97, Rev. 4 – Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants

This Regulatory Guide references IEEE 497, which focuses on post accident monitoring (PAM) variables. Due to the overlap of goals for PAM variables and EOP implementation, this guidance is used to verify the appropriate PAM variables are included as a part of the minimum inventory. The results of the PAM variable identification process are used as input to the minimum inventory identification process. More specifically, PAM variable types A, B, and C are considered for minimum inventory in accordance with NUREG-0800.

6.1.2 Personnel Qualification

The team members and their qualifications, as defined within the U.S. EPR HFE Program Management Plan (Reference, [11]), participating in the minimum inventory development include:

- Human Factors Engineering

- System Engineering
- I&C Engineering
- Plant Operations

Additional team members that provide input on an as needed basis are:

- Nuclear Engineering
- Architect Engineering
- Computer System Engineering
- Plant Procedure Development
- Personnel Training
- Systems Safety Engineering
- Maintainability and Inspectability Engineering
- Reliability and Availability Engineering

6.1.3 MI Selection Criteria

The manual actions in the EOPs and the risk significant HAs required to bring the reactor to a safe shutdown condition and maintain it in that condition are included in MCR MI HSIs that the operator uses to:

- Monitor the status of fission product barriers.
- Perform and confirm a reactor trip.
- Perform and confirm a controlled shutdown of the reactor using the normal or preferred safety means.
- Actuate safety-related systems that have the critical safety function of protecting the fission product barriers.
- Analyze failure conditions of the HSI while maintaining the current plant operating condition and power level until the HSI can be restored in accordance with applicable regulatory requirements.
- Maintain the plant in a safe condition (hot standby, hot shutdown, or cold shutdown depending on the event).

The RSS MI is required as a subset of the MCR MI. The RSS MI includes the HSI the operator needs to:

- Perform and confirm a reactor trip.
- Perform and confirm a controlled shutdown of the reactor using normal or preferred safety means.

- Maintain the plant in a safe condition (hot standby, hot shutdown or cold shutdown depending on the event).

6.1.4 MCR Methodology

The MCR minimum inventory is identified through an analysis of emergency procedure guidelines (EPGs), PRA/HRA, and post accident monitoring (PAM) variables. This analysis is followed by a task analysis on the identified tasks to determine the task support requirements for the operator to perform the actions. These additional parameters determined from the output of this analysis are added to the MI list. Once all MI parameters are identified, the accessibility of the parameters is then determined.

The MI inventory evaluation personnel identify and evaluate the MI tasks and their support parameters. The basis for each selection, the supporting parameters, and the accessibility determination is documented in an engineering record. This record is updated for each iteration of MI analysis as the design progresses.

The outputs of the MI methodology are input into the overall HSI design process such as control room layout, display/panel design, and HSI evaluations. Once the HSI design is complete, the MI is addressed during the verification and validation activities.

6.1.4.1 Identify MI Tasks

The U.S. EPR™ EPGs are analyzed to determine the manual actions that are performed to bring the reactor to a safe shutdown condition, and maintain it in that condition. The EPGs are an input to the MI identification process and are complete before this process is started.

As a part of the U.S. EPR™ probabilistic risk assessment (PRA), risk significant HAs are identified. The list of these actions is updated each time the PRA is revised. The U.S. EPR Implementation Plan for the Integration of HRA into the HFE Program (Reference, [10]) provides additional detail on how the PRA is used in the HFE program.

The methodology for determining the list of U.S. EPR™ accident monitoring variables is detailed in Reference [20]. The minimum inventory includes type A, B, and C of these variables.

6.1.4.1.1 EPG / EOP Analysis

- Evaluate each step of the U.S. EPR™ EPGs and identify the manual operator actions required for the safe shutdown of the reactor and to maintain it in a safe shutdown state from the criteria in section 6.1.3. This includes safety and non-safety success paths.

  Note: Once EOPs are developed as available, they are used in subsequent iterations of this step due to the additional detail contained in EOPs relative to EPGs.

- Review the U.S. EPR™ Engineered Safeguards Features and Reactor Trips defined in Tier 2 Chapter 7 of the final safety analysis report (FSAR) and identify any manual operator actions from the criteria in section 6.1.3.

- Record all identified MI related operator actions.

6.1.4.1.2 PRA / HRA Analysis

- From the U.S. EPR PRA Risk-Significant Human Actions (Reference, [21]) identify the risk significant HAs performed by the operators to bring the reactor to a safe shutdown condition and to maintain it in that state from the criteria in section 6.1.3.
- Review the operator manual actions listed in Tier 2 Chapter 15 Section 15.0.0.3.7 of the U.S. EPR™ FSAR, for which no automatic control is provided, and identify the actions that are included in MI from the criteria in section 6.1.3
- Record all identified MI related operator actions. If any actions are duplicated from previous analysis, they only need to be identified once.

6.1.4.1.3 Accident Monitoring Variables Analysis

- From the U.S. EPR Accident Monitoring Variables (Reference, [20]) document, identify the accident monitoring variables that support the criteria in section 6.1.3.
- Record all identified MI related operator actions. If any actions are duplicated from previous analysis, they only need to be identified once.

Note: The final set of PAM variables that are verified by combined operating license (COL) applicant (as described in the FSAR) during detailed design are used during subsequent iterations of MI identification.

6.1.4.2 Support Parameters

- Using the task analysis process described Reference [9] determine the plant process parameters, controls, and alarms that are required to carry out each of tasks identified for the minimum inventory.
- Record the indications, controls, alarms, and any other task support requirements determined to support the identified operator minimum inventory tasks.

6.1.4.3 Accessibility

The accessibility of each MI parameter is categorized and recorded using the criteria in this section. Accessibility is a design criterion and not a selection criterion and applies to all MI identified, however accessibility does not have an affect on what is included in the MI list.

Accessibility refers to how easily and quickly an operator can access and utilize an HSI resource. There are intermediate levels of accessibility that can be provided, such as displays or controls that are selectable after multiple actions, a single action, or require no actions whatsoever. The accessibility requirements determined from the MI methodology are input into the HSI and control room designs.

6.1.4.3.1 Spatially Dedicated Continuously Visible

Spatially dedicated continuously visible (SDCV) is defined as an MI parameter that is located in the same physical location on a panel or display and requires no actions (i.e. mouse clicks) to view the subject parameter. Credited manual actions, monitoring of safety functions, and backup of automatic success paths are considered for SDCV accessibility.

6.1.4.3.2 One-Step Accessible

One-step accessible is defined as being able to navigate to the MI parameter in one discrete action (such as a mouse click). Risk-significant actions from the PRA that are not time critical, long term actions in the EPGs, SDCV parameters that have multiple channels, and supporting parameters for SDCV parameters are considered for one-step accessibility. Example: A SDCV alarm is displayed that shows a main steam relief isolation valve did not close as expected. A one-step accessible action (clicking on the SDCV alarm) provides the supporting parameters on the main steam relief isolation valve display.

6.1.4.3.3 Selectable

Selectable is defined as requiring multiple actions to reach the MI parameter. MI parameters that are not time critical, are not directly related to safety systems, or do not fit into the SDCV or one-step categories are considered for selectable accessibility. Example: During recovery from a loss of offsite power (LOOP) event there are many non-safety electrical systems that require manual alignment by operations that are not required to be SDCV or one step accessible.

6.1.4.4 HSI Design

The minimum inventory is an input into the HSI detailed design process. Aspects such as accessibility in the control room and display design utilize the minimum inventory list. MI results are evaluated during trade-off studies and performance-based tests. The availability and reliability of the platforms on which the MI is implemented is addressed during HSI design.

Outputs from HSI design, including the MI, are also fed back into the overall HFE process. Iterations of task analysis evaluate the current minimum inventory at that stage of the design. Task analysis results then feed back into the HSI design phase where modifications are made to the design as necessary.

6.1.4.5 Verification and Validation

Verification and validation (V&V) of the minimum inventory list is completed during the V&V phase as described in the U.S. EPR Verification and Validation Implementation Plan (Reference, [13]). This facilitates the closure of inspections, tests, analysis, and acceptance criteria (ITAAC) in Tier 1 of the FSAR related to minimum inventory.

6.1.5 RSS Methodology

The RSS contains the equipment necessary to bring the plant to a safe shutdown state during an event requiring evacuation of the MCR, in addition to:

- A simultaneous single failure of a system, structure, or component (SSC) required to bring the plant to safe shutdown (not required to accommodate a single failure in addition to equipment damage caused by a fire).
- A sustained loss of either onsite or offsite AC power.

6.1.6 RSS MI Identification

- Using the MCR MI list, determine the required operator actions that fit the RSS MI criteria from section 6.1.3 and document as the RSS MI list.
- Review supporting parameters and accessibility requirements as they apply to the RSS and make any adjustments required.

6.2 HSI Style Guide

The HSI style guide (Reference [15]) covers many of the HSI design topics discussed in NUREG-0700 (Reference [25]). Guidelines that are not derived from the generic HFE guideline are properly justified using a basis of recent literature, analysis of current industry practices and operational experience, trade off studies and analyses, and the result of design engineering experiments and evaluations.

The style guide is written so it is readily understood by designers and addresses the overall design process. It supports the interpretation and comprehension of design guidance by supplementing text with graphical examples, figures, and tables. Throughout the design of the HSI features, layout, and environment, the style guide is used to support the interpretation and comprehension of design guidance and also helps to maintain consistency in the design across the HSIs.

The style guide specifies rules for the arrangement of information on displays and conventional control boards and for coding and labeling of information of different types of HSIs. The style guide promotes consistency between nomenclature and terminology used in operating procedures and those used on operator interfaces. Use of the style guide creates consistency between HSIs and plant documentation.

The HSI design supports operators in their primary role of monitoring and controlling the plant while minimizing physical and mental demands associated with use of HSIs. Principles discussed in NUREG-0700 (Reference [25]) that affect the design of the HSI are incorporated into the Style Guide (see Section 6.2). These principles include:

- Basic display design.
- Principles to increase usability.
- Display formats and elements.
- Use of the alarm system.
- Use of the operating procedure system.
- User interface interaction and management:
  - Display management.
  - Display hierarchy.
  - Navigating among displays.

- Workstation configuration:
    - Anthropometric data for equipment dimensions.
- Workplace environment:
    - Temperature and humidity.
    - Ventilation.
    - Illumination.
    - Sound levels.

The HSI design takes into account the use of HSIs over the duration of a shift where decrements in human performance due to fatigue may occur. Physical layout of the control room and workstations considers the distances operators are required to move to initiate manual actions. Excessive amounts of movement, including arm and hand movement, for long durations can impact the performance of the operator.

6.2.1 HSI Style Guide Development

[

1. Obtain regulatory and industry guidance.
2. Obtain any applicable operating experience from the OER (see section 2.1.1)
3. Create HSI style guide specific to the U.S. EPR™ design based on the guidance and state-of-the-art human factors principles. Justification is provided for any aspects of the style guide that deviate from the guidance.

]

6.3 Display Navigation and Hierarchy

Monitoring and control of the U.S. EPR^{TM} during plant operations is done using a digital "soft" control operator interface technology from a number of sit-down workstations. Through this digital interface, the control and monitoring capabilities needed to operate the plant is done from displays that have individual control and display capabilities. In order for the operator to effectively monitor and control the plant, a navigation method used to call up and assign individual displays to a given monitor is defined. In order to navigate to displays effectively, the displays are put into an organization, called the display hierarchy. The display hierarchy provides a means of identifying each individual display and supports the display navigation process. As a subset of the Style Guide, display navigation and hierarchy guidelines are created to provide the strategy for display navigation and hierarchy.

6.3.1 Display Navigation and Hierarchy Development

[

1. Obtain regulatory and industry guidance.
2. Obtain an applicable operating experience from the OER (see section 2.1.1)

]

3. Create the display navigation and hierarchy guidance specific to the U.S. EPR™ design based on the guidance and state-of-the-art human factors principles. Justification is provided for any aspects of the navigation and hierarchy that deviate from the requirements.

6.4 Symbol Library

As a subset of the Style Guide, a separate document U.S. EPR™ Symbol Library (Reference [17]) is developed to provide the basic symbols used to create the conceptual displays. By providing a standard library, consistency amongst displays is maintained. The symbols created for the displays are similar to, but not necessarily the same as those used on the P&IDs for coherence and to eliminate operator confusion.

6.4.1 Symbol Library Development

1. Obtain list of symbols used on the U.S. EPR™ P&IDs, electrical schematics, civil/architectural symbols (doors, hatches), and environmental symbols (radiation monitoring, chemistry)
2. Create U.S. symbol library based upon U.S. EPR™ symbols
3. Compare symbols to U.S. standard symbols (such as ISA or IEEE)
4. Perform GAP analysis between symbol library and U.S. standard symbols
5. Verify symbols that are different do not cause operator confusion or error

6.5 Alarm System Design

During the detailed design phase, details concerning alarms and management of those alarms are determined. Priorities and corresponding color definitions are defined as well as the specific displays for alarms.

The alarms alert and inform the operators when actionable events occur. Alarms require actions to correct, mitigate, compensate for a failure, or make repairs. The operators are not burdened by multiple alarm signals that demand simultaneous actions; however, task analysis establishes the priorities for responding to alarms to maintain a high level of safety. The following principles are applied when designing the logic of alarms and overall alarm processing:

- Alarm signals lead the operator to the true cause of the reported event (i.e., alarm hierarchy minimizes distractions).
- Alarms are integrated with the HSI to assist the operator with situational awareness, alarm response, and any associated troubleshooting.
- Alarm signals include logic so that only operationally relevant conditions are alarmed (e.g., the alarm logic for low discharge pressure downstream of a pump signals an alarm only if the pump is running).
- The overall plant state is considered for the generation of alarms, or at least to inhibit alarms that are not relevant for the actual plant state.

- Pre-alarms are provided before automatic actuation only when an operator has sufficient time to identify and perform mitigating actions to preclude the need for automatic actions.

6.5.1 Alarm System Design Development

[
1. Obtain regulatory and industry guidance on alarm system design
2. Create an alarm management concept document detailing how the alarm system functions
]

6.6 HSI Display Design

To determine what information is displayed to the operators, the HFE engineer coordinates with I&C engineers and plant system engineers to determine the detailed tasks and activities that the operator is expected to perform when using the display. For example, the tasks and activities related to steam generator level control:

- The operator is able to determine if feedwater inflow is greater than, equal to, or less than steam flow and if water level in the steam generators is rising, remaining constant, or falling.
- The operator is able to compare the current level in one steam generator with the levels in the all others.
- The operator is able to determine if the steam generator level in all steam generators is within the ‘normal’ operating range.
- The operator is able to determine if additional feedwater flow to any of the steam generators is currently required.
- The operator is able to locate the appropriate feedwater controls.

Such statements are the ‘functional’ requirements for the display. These are used to inform the display designer as to the content of the display, and during validation of the display to determine if the final display design provides the required operator support.

Additionally, the outputs of task analysis, the operating procedures, the system descriptions, the I&C functional requirements specification for the system, and the P&IDs of the system provide details such as:

- the components required to be displayed and controlled
- the indications required for the components

The U.S. EPR™ HSI Design Work Plan (Reference [18]) provides guidance to the HFE engineers for interfacing with the plant system engineer and the I&C engineer to determine the display and control requirements for the particular plant system. This work plan is used during the interface meetings for each of the plant systems to verify completeness and consistency.

6.6.1 PICS Display Design

The PICS is primary system used to monitor and control the plant. Displays for the PICS are designed to provide operators the information and control capability required to safely monitor and control the plant during all modes of operation, including accidents. Functional and task requirements determine the elements that are provided to the operator while guidance from the Display Navigation and Hierarchy document (Reference [16]) and the Style Guide (Reference [15]) provides display format and layout.

At this stage in the HSI design, procedures for U.S. EPR™ design are not yet developed. Due to this, operation procedures from generic pressurized water reactors (PWR) or predecessors may be used to verify the conceptual displays. Verification using operational procedures ensures that operators are able to safely perform normal, abnormal, and emergency operations using the displays. HFE engineers evaluate the displays and provide guidance for any modifications that are needed.

Revisions to any of the guidance documentation, such as the Display Navigation and Hierarchy document or Style Guide, are based on the feedback given on the conceptual displays.

The displays are categorized into three types; operations/function based, P&ID system based, and information listing, as described in the Style Guide (Reference [15]). Evaluation of displays by the CRDT is performed iteratively throughout the design process. Once all displays are developed for all the systems, evaluation of the displays as a collective group is performed.

6.6.1.1 PICS Display Design Development

1. Develop PICS displays using the HSI Design Work Plan (Reference [18])
2. Evaluate PICS displays using results from the HRA and TA, guidance from the style guide, and generic PWR procedures (note: Since the displays available are limited to only the systems that have been developed prior to this point, full procedure compliance may not be achieved).
    a. Do the alarms and indications aid in the recognition of:
        i. the status of critical safety functions,
        ii. the plant configuration,
        iii. the status of plant and system functions
        iv. the cause of the error and direct the operator to the right display and/or procedure?
    b. Do the sequence and type of display support situational awareness?
    c. How many displays does the operator have to access to complete the task?
    d. How long does it take the operator to complete the task relative to time allotted or regulatory requirements?
    e. Are there aspects of the displays that could lead the operator make a human error?

3. For aspects of the task that are not able to be performed or are cumbersome:
   a. Modify PICS displays to add or rearrange display/control indicators
   b. Create new PICS displays to include information needed to complete the task
   c. If necessary, propose to create new functions, allocations, tasks, or group commands to facilitate task completion

6.6.2 SICS Display Design

In addition to the PICS displays, the U.S. EPR™ design includes a backup of safety-related displays on the SICS. These displays are implemented using the QDS. Displays for the SICS are developed as similar to the PICS displays as possible. Differences in these displays are due to the different requirements governing the SICS displays as well as the limitations of the QDS, which are minimized to the greatest extent practical.

6.6.2.1 SICS Display Design Development Procedure

1. Obtain PICS displays for system
2. Develop SICS display for system
   a. Identify which components from PICS display are required to be on SICS display from
      i. I&C Functional Requirements Specification
      ii. U.S. EPR™ HSI Design Work Plan (Reference [18])
   b. Identify any QDS limitations that do not allow components to be displayed
   c. Using PICS displays as a template, layout SICS display with identified components from previous step. Match layout and flow to the PICS display

6.7 Conventional I&C Design

The U.S. EPR™ includes conventional I&C (CNV I&C) in addition to the digital displays for monitoring and control. CNV I&C include items such as push buttons, switches, digital and analog meters, and illuminated indicators. These items are used for certain safety related functions that are required to shutdown the plant in the event of a PICS failure. The layout of the CNV I&C on the SICS panels is determined by the HFE team to be efficient and support safe operability.

6.7.1 Conventional I&C Design Development

1. Determine the requirements for conventional controls as detailed in the U.S. EPR HSI Design Work Plan:
   a. PRA and HRA

b. Protection System SDD (trip and ESFAS functions)

c. Fixed-position, continuously-visible alarms

d. Time critical safety functions determined by plant-level FRA

e. OER (see section 2.1.1)

f. EPGs

2. Verify with system engineers list of CNV I&C is complete

3. Layout CNV I&C

4. Verify operators are able to execute safety function related tasks using CNV I&C

a. Are the appropriate alarms and indications present?

b. Are the appropriate control items present?

c. How long does it take the operator to complete the task relative to allotted time or regulatory requirements?

d. Are there aspects of the layout that could lead the operator to make a human error?

5. Revise list of required CNV I&C or layout of CNV I&C as needed

6.8 HSI Modifications

As described in Section 8.0, HSI modifications are consistent with the U.S. EPR™ design strategies for gathering and processing information and executing actions identified in the TA. Standardization and consistency reduces the need for retraining associated with a lack of proficiency because of modifications. Modifications to the U.S. EPR™ standard design HSIs are done in accordance with the U.S. EPR™ design control process (Reference [1]). A check list of HSI technical considerations are included in the design change work package for consistency with the U.S. EPR™ HSI standard design.

As the HSI design progresses, software prototypes of the displays are developed. These prototypes show how the displays are linked and interact with each other. HFE engineers test navigation techniques, hierarchical placement, and the ability of operators to follow operating procedures.

7.0 HSI EVALUATIONS

Evaluations are conducted throughout the HSI design process at various stages of development so that the HSI designs are optimized prior to performing the HFE V&V (Reference [13]). Activities such as concept evaluations, mock-up activities, trade-off evaluations, and performance-based evaluations are used at various stages of the design. These evaluations are performed using prototypes, mockups, simulators, and user feedback. To verify that the evaluations challenge the design and provide accurate results, procedures to govern the evaluation development and execution are prepared in advance. These procedures provide detailed and consistent instructions to each of the participants. This verifies that the participants in the evaluations have clear understanding of what the task is and increases the quality of results.

Additionally, the procedures provide a clear definition of what is being measured or evaluated. This verifies that the results are not misinterpreted. Clear instructions as to how to measure or evaluate the HSI, when to assist participants, and what to provide in the results documentation also maintain consistency and accuracy among results.

7.1 Prototypes

Prototypes of the HSI design that represent the actual HSI are developed and modified throughout the early detailed HSI design phase. User feedback on the prototypes allows cost effective, rapid evolutions of the HSI. As the design progresses, the prototypes evolve into more advanced dynamic representations, called simulators.

The initial paper prototypes consist of drawings showing the placement of HSIs, such as buttons or gauges. From these paper prototypes, HFE engineers are able to compare alternate designs as well as make any modifications. Prototype displays are developed for use in the mockups (see Section 7.2). These prototype displays are printed on paper (or similar media) that are easily moved from one area to the other in the mockup depending on user feedback.

7.2 Mockups

Mockups of the HSI and the MCR are constructed throughout the HSI design phase to assist HFE engineers in evaluating the design.

7.2.1 Virtual Mockup

A virtual mockup uses computer aided drawing software to construct a virtual control room containing the layout of the workstations, controls, and displays. This mockup allows the user to see the operator's 360° view from each workstation. It is used early in the HSI design to provide a cost-effective method to:

- Compare alternative control room layouts
- Obtain personnel feedback on the design
- Examine physical movement and access issues, e.g., in a maintenance context
- Evaluate PICS workstation dimensions and clearance (reach distance, see-over height, display height and orientation, mouse / keyboard location)
- Evaluate viewing distance and angles from each PICS workstation to POP
- Evaluate SICS panel dimensions (reach distance, height, benchboard slope, QDS distance and angle)

7.2.2 Workstation Mockup

A workstation mockup consists of a full-scale representation of an operator workstation. A workstation mockup is constructed for an operator workstation in the MCR as well as an operator workstation in the RSS. Additionally, a mockup of a workstation for any risk-important LCS may be constructed. For the workstation mockup of an MCR operator workstation, a partial POP is included positioned in the same location as in the MCR.

The workstation mockup allows evaluation of the following types of anthropometric features

- height of workstation
- sight lines, viewing angles (both horizontally and vertically), and viewing distance to workstation monitors
- sight lines above workstation monitors to partial POP
- adequate space for keyboard / mouse and monitors
- label and lettering visibility
- hand operated control location and accessibility (CNV I&C)
- reaches and body angles
- clearances and accessibility

7.2.3 Full-Scale Mockup

As the HSI design progresses, a full-scale mockup of the MCR and the RSS is constructed. This mockup includes all operator workstations as well as the full POP (for the MCR mockup). Construction of the mockup utilizes materials such as foam boards, plywood type panels, and paper representation of controls and displays. As the plant models and simulator design progresses, the full-scale mockup is integrated with the plant models and simulations to provide more dynamic capabilities.

A full-scale mockup provides three-dimensional relationships that are difficult to represent in a two-dimensional drawing. This allows evaluation, at a minimum, of the following

- traffic patterns, accessibility, and mobility in the control room
- viewing distances from supervisor to operator displays and controls
- supervisor and operator viewing distances to POPs
- peer-to-peer and operator to supervisor or maintainer communication
- size and distance between workstations and panels

7.3 Simulation

The HSI design is implemented using system and plant simulation and evaluation prior to performing HFE V&V (Reference [13]). Simulation early in the HSI design phase enables the HSI design to be optimized within cost, schedule, and resource constraints. The development of the simulator is an evolutionary process. The first stage of simulation development is the development of process models, I&C logic models, and HSI models for each plant system. During the next phase, each of the different models for each plant system (process, logic, and HSI) are integrated into a single model, the integrated system model. The third phase integrates the separate integrated system models into a single plant level model. The plant model is used to evaluate plant level functional requirements, tasks, and system interfaces.

7.3.1 System Process Model

Simulation of each mechanical system's thermodynamics and hydraulics captures the system design calculations (process flow, heat load, pipe sizing, pressure drop, equipment sizing, etc.) and configurations (P&ID and 3D model). As the detailed design of the system progresses, the process model is evaluated through integration with the logic model (discussed in Section 7.3.2).

Simulation of each electrical system captures the design calculations (electrical load calculations, circuit breaker protection logic, electrical load lists) and configurations (1-line drawings, 3D model, circuit diagrams). As the detailed design of the electrical system progresses, the electrical model is evaluated through integration with the related system process model, system logic model, and HSI model.

At the conclusion of the system's detailed design, the fidelity of the resulting electrical model meets ANSI/ANS-3.5-2009 (Reference [27]) requirements.

7.3.2 System Logic Model

Simulation of each of the mechanical and electrical systems' I&C logic captures the instrument and control elements represented on the system's P&IDs, setpoint calculations, system logic diagrams, and all embedded logic blocks. As the detailed design of the system progresses, the logic model is evaluated through integration with the system process model.

Simulation of I&C systems (e.g., protection system) captures the instruments (input signals), signal processing elements, system logic diagrams, and all embedded logic blocks. As the detailed design of the I&C system progresses, the logic model is evaluated through integration with the related system process models and/or a plant model (discussed in Section 7.3.55). At the conclusion of the system's detailed design, the fidelity of the resulting system logic model meets ANSI/ANS-3.5-2009 (Reference [27]) requirements.

7.3.3 HSI System Model

Simulation of the HSI systems (PICS and SICS) captures the displays and CNV I&C which reflect the inventory of indications and controls defined by the FRA and TA. As the HSI detailed design progresses, the HSI model captures the display navigation, alarm presentation, and any function and task specific displays. The HSI model is evaluated through integration with the work station mock-ups, related system process models, system logic models, the plant model (discussed in Section 7.3.55), part-task simulator (discussed in Section 7.3.66), and full-scope simulator (discussed in Section 7.3.77). At the conclusion of the HSI detailed design, the fidelity of the resulting system HSI model meets ANSI/ANS-3.5-2009 (Reference [27]) requirements.

7.3.4 Integrated System Model

The integrated system model integrates the system process, system logic, and HSI system models into a single system model for each plant system. During the detailed design, the integrated system model is used to evaluate design trade-offs within and among the different design disciplines (systems engineering, I&C engineering, and HFE). The integrated system model may be incorporated with work station mock-ups. At the conclusion of detailed design, the fidelity of the resulting integrated system models meets ANSI/ANS-3.5-2009 (Reference [27]) requirements.

7.3.5 Plant Model

The plant model integrates the different integrated system models to provide the complete dynamic plant behavior. During detailed design, the plant model is used to evaluate design trade-offs within and among the different design disciplines, among the different systems, and between plant and system functions/goals.

Simulation of the plant dynamic behavior includes the following plant conditions

- Plant heat-up, reactor criticality, and low power operation (below 20% reactor total power), and integrated system operations
- Normal power changes (between 20% and 100% reactor total power) and integrated system operations
- Steady-state operation, maintenance, and surveillances
- Plant cool-down, mid-loop operation, and refueling
- Off-normal operations (i.e., reactor trips, turbine trips, load rejections)
- Accidents (Chapter 15 events)
- Equipment / component malfunctions and failures (required to demonstrate the inherent plant responses and automatic plant control functions)

Characteristics of equipment and components of the systems such as motors, pumps, valves, regulators, etc. are included to reproduce correct steady state and transient performance of the systems. The simulation generates the transient responses caused by changes in various pressures and flows, moderator and fuel temperatures, core reactivity effects, fission product inventory, and any other contributing phenomenon.

At the conclusion of detailed design, the fidelity of the resulting integrated plant model meets ANSI/ANS-3.5-2009 (Reference [27]) requirements.

7.3.6 Part-task Simulator

[The part-task simulator consists of a workstation connected to one or more of the integrated system models or the plant model. This type of simulator may model one or more of the following:

- Non-safety control room hardware (PICS)
- Safety control room hardware (SICS)
- Remote shutdown hardware (RSS)
- Risk-important LCS
- Plant overview panel (POP)

The part-task simulator provides the ability to evaluate the monitoring and control displays. These displays are dynamically linked and provide navigation capabilities and alarm behavior. Users are able to implement operating procedure outlines to evaluate and optimize TA and integration with the HSI (i.e., navigation features, display hierarchy, alarm system behavior).

In addition to providing feedback for optimization, this simulator is also used to evaluate portions of the HSI design. This includes aspects such as evaluating situational awareness (limited scope), workload level, completeness of the PICS displays, and generic operating procedures. Additionally, modifications based upon user feedback or other design required changes can quickly and easily be implemented for evaluation.]

7.3.7 Full Scope Simulator

[The purpose of the full-scope simulator is to provide a platform for the evaluation of integrated plant systems and risk important HSI. It meets the requirements of 10 CFR 50.34(f)(2)(i) to provide a simulator that correctly models the control room, including the capability to simulate small-break LOCAs. This simulator includes the operator interface (operating consoles and HSI) in a replica of the control room and is connected to an emulation of the PICS and SICS hardware and the plant model. The simulator software is designed to properly emulate the plant and system response to a change in one or more plant or system variables.

Because the full scope simulator incorporates all operationally significant systems (including emulations of PICS and SICS and computerized procedures) and a replica of the control room, it allows an evaluation of the plant systems and the HSI as a single, integrated system. This includes

- The control room layout
- SICS panel design
- Procedure displays
- Computerized displays
- Crew coordination, communication, teamwork, and other concept of operations (i.e., transition from the PICS to SICS)]

- Situational awareness

The full-scope simulator is designed with the following objectives:

- Interface completeness – The simulator represents the integrated system. This includes HSIs and procedures not specifically required in the test scenarios.
- Interface physical fidelity – A high degree of physical fidelity in the HSIs and procedures is represented, which include alarms, displays, controls, job aids, procedures, communications, interface management tools, layout, and spatial relationships.
- Interface functional fidelity – A high degree of functional fidelity is represented. HSIs are functionally available. Highly functional fidelity includes HSI component modes of operation (i.e. the changes in functionality that can be invoked on the basis of personnel selection and/or plant states).
- Environmental fidelity - A high degree of environmental fidelity is represented. The lighting, noise, temperature, and humidity characteristics are reasonably reflected. Full environmental assessment is completed during HFE design implementation and start-up activities.
- Data completeness fidelity – Information and data provided to personnel completely represents the plant system monitored and controlled from that facility.
- Data content fidelity – A high degree of fidelity is represented. The information and control presented is based on an underlying thermodynamic model that accurately reflects the U.S. EPR™ plant .
- Data dynamic fidelity – A high degree of data dynamic fidelity is represented. The process model is capable of providing input to the HSI allowing information flow and control response to occur accurately and timely (e.g., information is provided to personnel with the same delay that occurs in the plant).

At the conclusion of detailed design, the fidelity of the resulting full-scope simulator meets ANSI/ANS-3.5-2009 (Reference [27]) requirements.

The process for development of the full-scope simulator is provided in Appendix B.

7.4 Trade-off Evaluations

In order to verify that the best design is chosen from the alternative designs, trade-off evaluations are performed. HSI features that are the subject of such evaluations are determined through OER results, a survey of advanced HSI technologies, or when there are multiple designs that meet the HSI design requirements. These evaluations compare alternative display layouts, alternative HSI input devices, and other HSI aspects (e.g., text size, font styles, color coding). Positive and negative features of each alternative design are noted in order to document an accurate determination of the 'best' design. Factors considered in trade-off evaluations include:

- Personnel task requirements – workload analysis
- Human performance capabilities and limitations (i.e., speed, accuracy, workload)

- HSI system performance requirements
- Inspection and testing requirements
- Maintenance requirements
- Use of proven technology and operating experience of predecessor designs
- Design, capital, and maintenance cost
- Time to implement
- HSI usability (correctly, efficiently, and confidently)
- Physical characteristics

The results of trade-off studies are recorded to document the advantages and disadvantages of available options. The basis for the selection of the optimized design is provided. Results of the evaluations are used to determine HSI selection decisions. For example, the choice of a trackball or a touch screen is determined for certain applications based on evaluation results. The HSI design process is iterative, and if a design change is required due to the results of a trade-off evaluation, then the output is reintroduced into the HSI detailed design phase as shown in Appendix A.

7.5 Performance-Based Evaluations

In addition to trade-off studies, performance-based evaluations are performed as a part of HSI evaluation. Performance-based evaluations measure personnel and HSI performance during pre-defined scenarios. These scenarios, the test participants, and the testbeds used are designed based on the objective of the test and the maturity of the HSI design being tested. Section 4.12.6 of the U.S. EPR Human Factors Verification and Validation Implementation Plan (Reference, [13]) details evaluation methods and procedures also used for HSI design evaluations.

HSI features subjective of such evaluations are determined based on OER results, a survey of advanced HSI technologies, risk significant human actions (HAs) from HRA, or when there are multiple designs that meet the HSI design requirements. HSI design inputs from other HFE program elements are addressed in Section 2.1.1.

Performance of the user and the HSI interactions are measured. These measurements are defined, such as the time requirements for trackball and touch screen operations. For any manipulated characteristics (such as font size or color coding), each distinct test condition is documented and systematically varied for the test. The selection of the performance measurements are based on test objectives, the parameters measured, and the criteria they are measured against.

Performance measures may include the following:

- Time to complete task (relative to time allotted)
- Task complexity

- Error occurrence
- Operator workload
- User opinion

An example of a performance-based test is an analysis of the time required to operate a trackball or a touch screen during a specific task.

To verify the accuracy of the performance-based evaluations, the tests are designed to minimize bias, confounding, and error variance (noise).

When personnel are selected to participate in evaluation activities (for example, task analysis, subjective reporting, questionnaire completion, HSI usability, or verification and validation (V&V)), bias is controlled. Bias is an influence that disturbs population selection randomness and hinders accurate and impartial measurement. The assignment of participants to evaluation groups is randomized to eliminate the possibility that a group has a common characteristic, which could lead to bias.

A goal of performance-based tests is to exclude confounding variables so that cause and effect can be established. Confounding means an observed effect could result from multiple causes. The effects of confounding are controlled by changing certain conditions (experimental variables). This is done by keeping controllable variables not being studied constant (such as time of day or ambient noise level), including a control group in the evaluation (a group that is not subjected to the studied variable), and through the random assignment of participants to groups. The use of matched pairs and/or exposing the participants to experimental conditions is considered.

Error variance (noise) is variability among results that cannot be attributed to the effects of the independent variable and may obscure the independent variable. Error variance may be the result of individual differences such as age, skill level, or motivation. Attempts to keep potential nuisance variables (such as time of day, and day of the week) constant throughout the evaluation to minimize the effects are made. Evaluations are designed to permit the identification of nuisance variables so that their effect (error variance) is minimal.

Once performance-based evaluations are complete, the HSI design process is used to analyze the results and to make design modifications if problems are identified in the test results. The results of performance-based tests are used as input to trade-off studies.

Evaluation Process:

1. Identify the need for HSI evaluation based on results of OER or multiple designs that meet design requirements.
2. Select personnel to conduct activity.
3. Develop evaluation procedure.
4. Select users to participate (i.e., subjects, observers, evaluators).
5. Develop scenarios based on type of evaluation.

[

6. Train subjects.
7. Train managers and data collectors.
8. Define performance measurements and/or acceptance criteria.
9. Execute evaluation plan.
10. Analyze results.
11. Recommend any possible design modifications.
12. Document results in a summary report.

]

8.0 THE OVERALL U.S. EPR™ DESIGN CONTROL PROCESS

The HSI design products are required to meet the AREVA NP design control process and requirements. The design control process facilitates the translation of high level requirements into lower level requirements, design inputs into design outputs, and high level design features into lower level subsystem and component design features. The HSI design meets the U.S. EPR™ design control process (Reference [1]). The HSI design process is an iterative process which is generated from design inputs and results in outputs. The HSI design output documents are independently verified by fully qualified engineers. A part task simulator is used to validate the displays for functionality utilizing the plant operating procedures. Validation is performed per the HFE V&V Implementation Plan (Reference, [13]) employing a full-scope simulator.

9.0 HSI DESIGN DOCUMENTATION

The HSI design documentation is developed during the design process and includes:

- The detailed HSI description including its form, function and performance requirements and characteristics,
- The basis for the HSI requirements and design characteristics,
- The records of the basis of the design changes, and
- The outcomes of tests and evaluations.

The SDRD and SDD for each HSI system (e.g. PICS, SICS, MCR, etc) document the HSI design. Each SDD includes the detailed HSI description, including its form, function, and performance characteristics and the bases for the HSI requirements and design characteristics with respect to operating experience and literature analyses, engineering evaluations, experiments, and benchmark evaluations. Separate test or evaluation reports document the outcomes of tests and evaluations performed in support of the HSI design.

10.0 REFERENCES

1. AREVA NP Procedure, "Design Control Process"
2. AREVA NP Procedure, "Development of System Design Requirements Documents"
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4. AREVA NP Procedure, "I&C Engineering Design Control Process"
5. AREVA NP Procedure, "Development of I&C Interface Requirements"
6. AREVA NP Document, "Plant Technical Requirements for EPR Design Certification"
7. AREVA NP Document, "U.S. EPR Human Factors Operating Experience Review (OER) Implementation Plan"
8. AREVA NP Document, "U.S. EPR Functional Requirements Analysis and Function Allocation Implementation Plan"
9. AREVA NP Document, "U.S. EPR Task Analysis (TA) Implementation Plan"
10. AREVA NP Document, "U.S. EPR Implementation Plan for the Integration of Human Reliability Analysis (HRA) into the Human Factors Engineering (HFE) Program"
11. AREVA NP Document, "U.S. EPR HFE Program Management Plan"
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14. AREVA NP Document, "Concept of Operations: Design of the U.S. EPR Control Rooms"
15. AREVA NP Document, "U.S. EPR Human System Interface Design Style Guide"
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17. AREVA NP Document, "U.S. EPR Display Symbol Library"
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20. AREVA NP Document, "U.S. EPR Accident Monitoring Variables"
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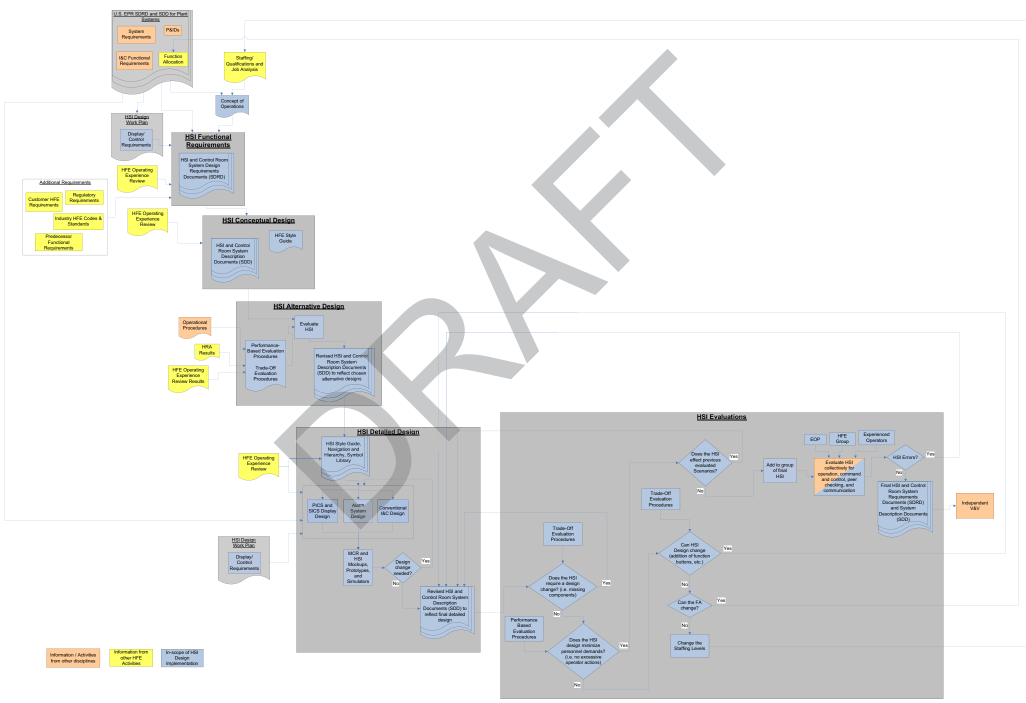
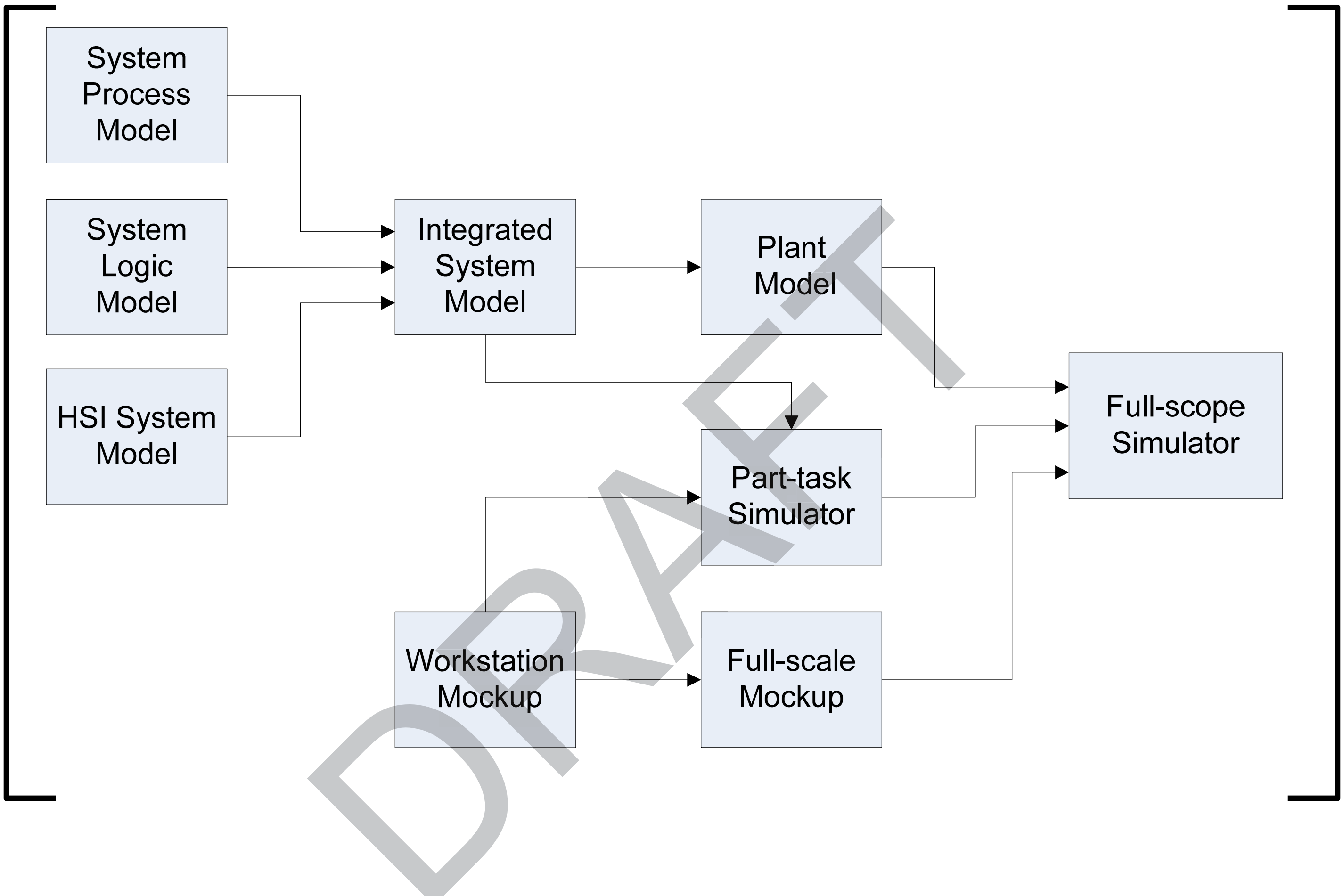
27. ANSI/ANS-3.5-2009, "Nuclear Power Plant Simulators for Use in Operator Training and Examination."

APPENDIX A: HSI DESIGN PROCESS



APPENDIX B: SIMULATOR DEVELOPMENT PROCESS



AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is George L. Pannell. I am Manager, Product Licensing, Corporate Regulatory Affairs for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in the enclosed "U.S. EPR Human System Interface Design Implementation Plan 118-9042375-004" and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information".

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraph 6(b,d) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 20th

day of September, 2010.

Sherry L. McFaden
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 10/31/2010
Reg. # 7079129

SHERRY L. MCFADEN
Notary Public
Commonwealth of Virginia
7079129
My Commission Expires Oct 31, 2010