US-APWR

Human Reliability Analysis Implementation Plan

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Revision History

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Abstract

This document presents the human reliability analysis (HRA) implementation plan (IP) for the U.S. Advanced Pressurized Water Reactor (US-APWR) human factors engineering (HFE) program. The HRA IP complies with NUREG-0711, Revision 2, "Human Factors Engineering Program Review Model," issued February 2004 (Reference 8-1).

Risk-important human actions (RIHAs) are identified in the HRA portion of the probabilistic risk assessment (PRA). This IP provides an overview of the PRA process that identifies RIHAs and references the sections of the PRA that describe that process in detail.

Deterministically important human actions (DIHAs) are extracted from the transient and accident analysis (TAA) and diversity and defense-in-depth coping analysis (D3CA). For the purposes of the US-APWR HFE program, RIHAs and DIHAs are collectively referred to as important human actions (IHAs). This IP describes the methodology used for that extraction.

IHAs are also considered during HFE analysis and design of human-system interfaces (HSIs) in order to minimize the likelihood of operator error and provide for error detection and recovery capability. Therefore, this IP describes how IHAs are addressed in subsequent HFE program elements:

- Functional Requirements Analysis and Function Allocation (FRA/FA)
- Task Analysis (TA)
- Staffing and Qualifications (S&Q)
- HSI Design (HD)
- Human Factors Verification and Validation (V&V)
- Design Implementation (DI)

This IP also describes how IHAs are addressed during human performance monitoring (HPM), procedure development, and training program development, although these activities are outside the scope of the US-APWR HFE program.

This IP also describes the requirements for documenting the results of the HRA in a results summary report (ReSR). The ReSR serves to demonstrate that the HRA was conducted in accordance with this IP, which is a requirement for inspections, tests, analyses, and acceptance criteria (ITAAC) closure.

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ACRONYMS

COL	Combined License
D3CA	diversity and defense-in-depth coping analysis
DCD	design control document
DI	design implementation
DIHA	deterministically important human action
FA	function allocation
FRA	functional requirements analysis
HA	human action
HD	human-system interface design
HED	human engineering discrepancy
HEP	human error probability
HFE	human factors engineering
HRA	human reliability analysis
HPM	human performance monitoring
HSI	human-system interface
HSIS	human-system interface system
I&C	instrumentation and control
IHA	important human action
IP	implementation plan
ISV	integrated system validation
ITAAC	inspections, tests, analyses, and acceptance criteria
MCR	main control room
MHI	Mitsubishi Heavy Industries
NRC	U.S. Nuclear Regulatory Commission
OCS	operational conditions sampling
OER	operating experience review
PMP	program management plan
PRA	probabilistic risk assessment
ReSR	results summary report
RIHA	risk-important human action
S&Q	staffing and qualifications
SDCV	spatially dedicated continuously visible
SME	subject matter expert
TA	task analysis
TAA	transient and accident analysis
US, U.S.	United States
US-APWR	US Advanced Pressurized Water Reactor
V&V	verification and validation

1.0 PURPOSE

This document provides the human reliability analysis (HRA) implementation plan (IP) for the US Advanced Pressurized Water Reactor (US-APWR). This IP conforms to the HRA guidance of NUREG-0711, Revision 2, “Human Factors Engineering Program Review Model,” issued February 2004 (Reference 8-1).

The objective of the HRA program element is to provide an overview the process for identifying risk-important human actions (RIHAs) contained in the probabilistic risk assessment (PRA), design control document (DCD) Chapter 19 (Reference 8-2), to describe the process for extraction of deterministically important human actions (DIHAs) from the transient and accident analysis (TAA) and diversity and defense-in-depth coping analysis (D3CA) while distinguishing DIHAs from other human actions (HAs) that are also described in these analyses, and to provide an overview the process for addressing important human actions (IHAs) in the US-APWR human−system interface (HSI) design through the analysis and design elements described in other US-APWR human factors engineering (HFE) IPs.

The HRA program element conforms to the guidance and satisfies the acceptance criteria of NUREG-0711 (Reference 8-1).

2.0 SCOPE

The scope of HRA is the identification and treatment of IHAs (which encompass RIHAs and DIHAs) in the overall HFE program. This document provides a reference to the methodology used in the US-APWR PRA to extract RIHAs. The PRA is described in Chapter 19 of the US-APWR design control document (DCD) (Reference 8-2). This HRA IP also describes the methodology for extracting DIHAs from the TAA and D3CA. The TAA is described in Chapter 15 of the US-APWR DCD. The D3CA is described in MUAP-07014 Revision 5, “Defense-in-Depth and Diversity Coping Analysis,” issued September 2011 (Reference 8-3) which is referenced from Chapter 7 of the US-APWR DCD. The RIHAs may overlap some of the DIHAs in the TAA and D3CA.

3.0 METHODOLOGY OVERVIEW

3.1 RIHA Identification

3.2 DIHA Identification

3.3 Addressing IHAs in Other HFE Program Elements

3.3.1 Addressing IHAs during OER

3.3.2 Addressing IHAs during FRA/FA

3.3.3 Addressing IHAs during TA

3.3.4 Addressing IHAs during S&Q

3.3.5 Addressing IHAs during HD

3.3.6 Addressing IHAs during Procedure Development

3.3.7 Addressing IHAs during Training Program Development

3.3.8 Addressing IHAs during V&V

3.3.9 Addressing IHAs during DI

3.3.10 Addressing IHAs during HPM

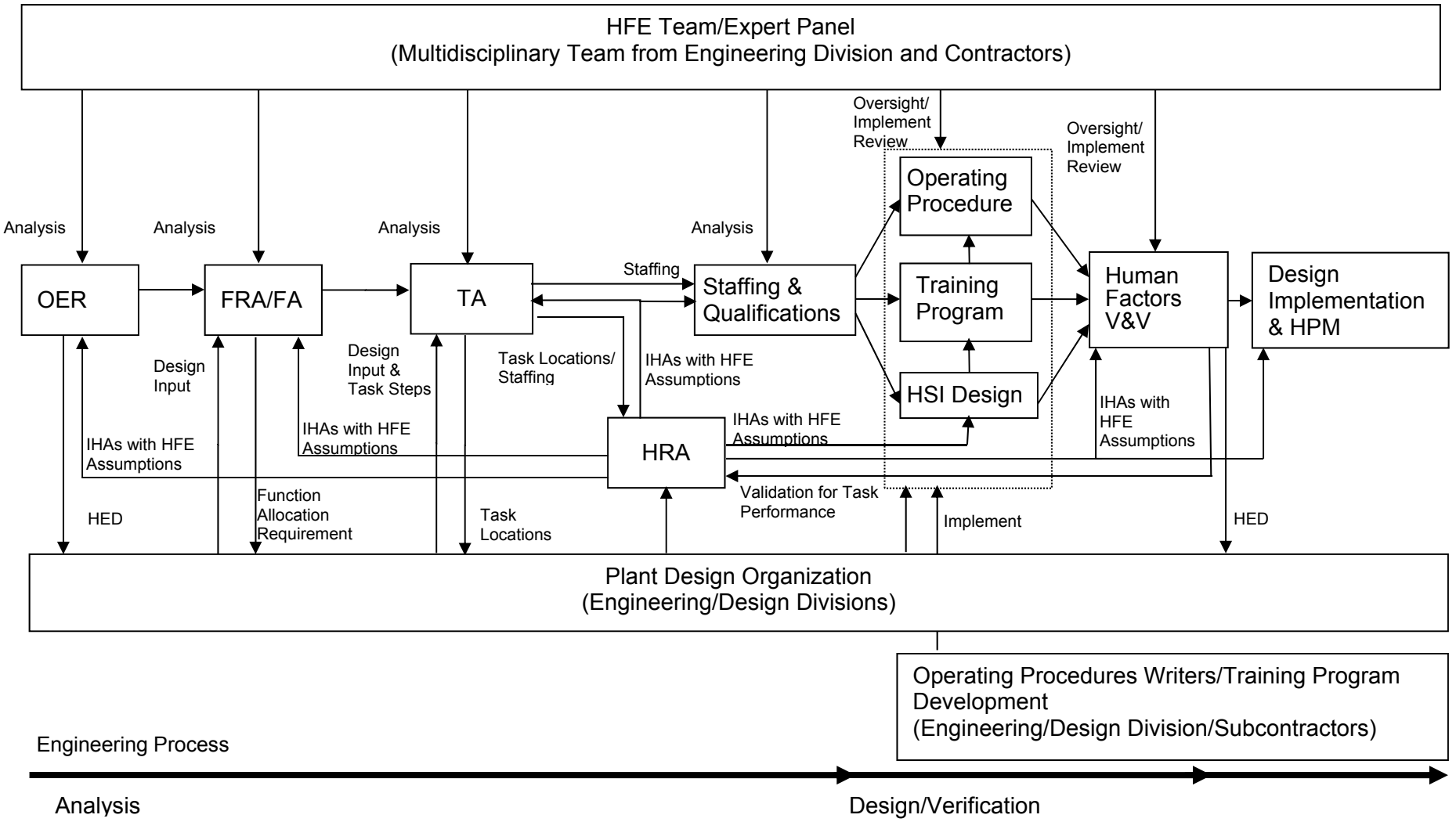

Figure 3-1 Role of HRA in HFE

4.0 METHODOLOGY

4.1 Identifying RIHAs

4.2 Identifying DIHAs

4.3 Documenting IHAs

Table 4-1 RIHA Source Document Data

Table 4-2 DIHA Source Document Data

4.4 Treatment of IHAs during FRA/FA

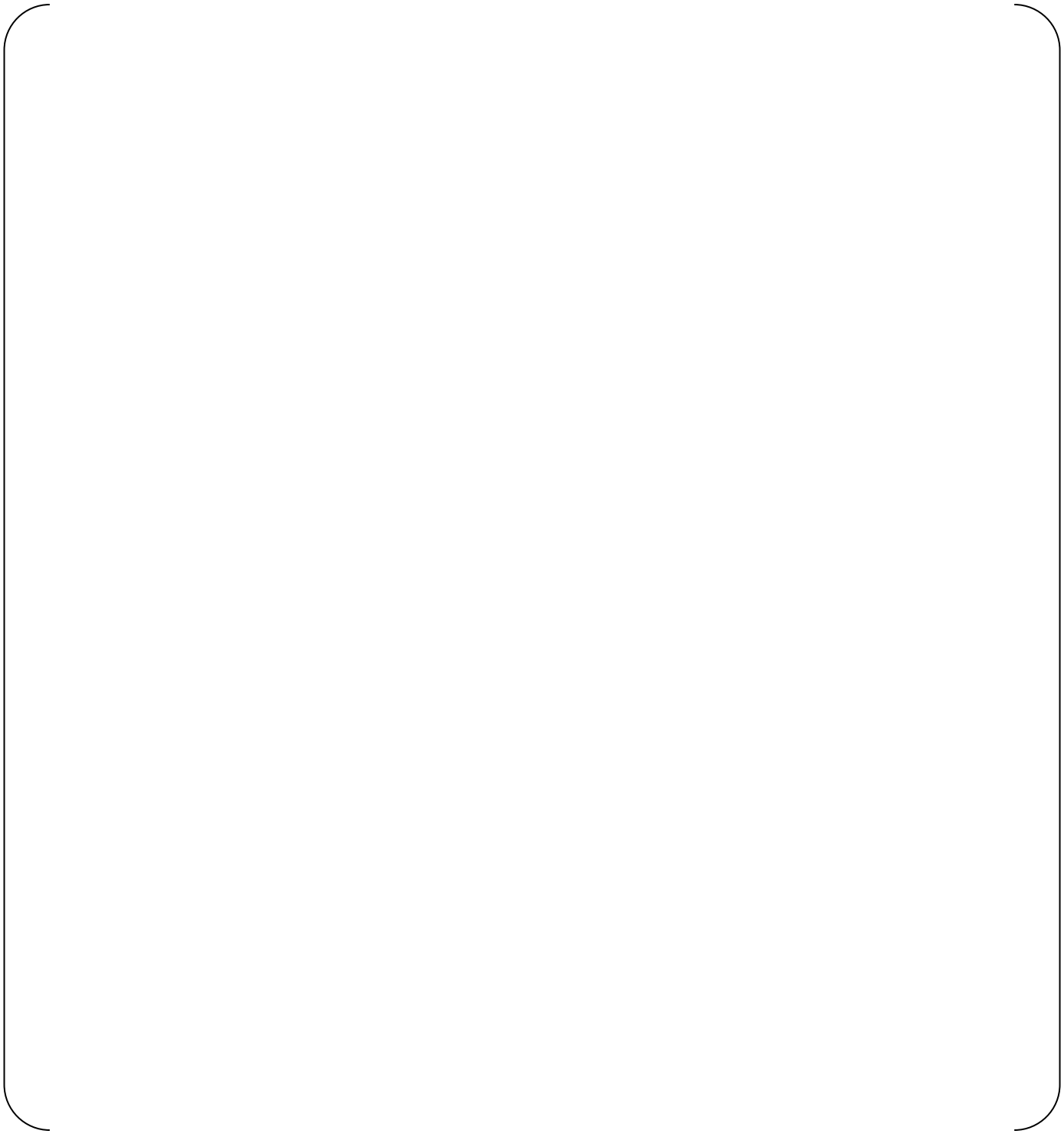

Figure 4-1 FRA/FA Process Overview

4.5 IHA Review

5.0 IMPLEMENTATION TEAM

The SMEs who conduct the HRA program elements are described in the applicable HFE program element IP (as described in Section 3 above). SMEs conducting HRA-specific activities are summarized in Table 5-1 below.

Table 5-1 HRA Implementation SME Summary

Implementation Activity	Section	Subject Matter Expert
Identification of RIHAs	Section 4.1 and 4.3	HSI/I&C engineering
Identification of DIHAs	Section 4.2 and 4.3	Plant operations
Review RIHA results	Section 4.4	HSI/I&C engineering
Review DIHAs results	Section 4.4	Plant operations

The SME qualifications are defined in MUAP−09019, Revision 3, “Human Factors Engineering Program Management Plan,” issued July 2013 (hereafter referred to as the “HFE PMP”) (Reference 8-8).

6.0 RESULTS SUMMARY REPORT CONTENT

The results of the HRA program element are compiled in an ReSR. The ReSR is used to demonstrate that the IHAs have been systematically identified in accordance with this IP. Demonstrating compliance to this IP, as documented through this ReSR, is a requirement of inspections, tests, analyses, and acceptance criteria (ITAAC) closure defined in the US-APWR DCD Tier 1.

The HRA ReSR includes the following:

- Implementation team member names and the SME position that they fulfill
- The HRA results overview, including the principal findings of the HFE program element
- The HRA execution results, including details demonstrating compliance to the methodology section of this IP, including the following:
  - Identified RIHAs, the source of those RIHAs in the PRA, and the assumed HFE characteristics
  - Identified DIHAs, the source of those DIHAs in the TAA or D3CA, the assumed HFE characteristics, and the basis for concluding any HAs identified in those analyses are not DIHAs
- A conclusion that the HRA program element has been conducted in accordance with the HRA IP, and that the IHAs have been adequately identified for use in other HFE program elements.

7.0 NUREG-0711 COMPLIANCE EVALUATION

This HRA IP is in full compliance with NUREG-0711 (Reference 8-1). Table 7-1 indicates where each NUREG-0711 criterion is met in this IP.

Table 7-1 Compliance with NUREG-0711

Review Criteria Stated in NUREG-0711 Rev. 2	HRA IP Section No. and paragraph
7.4 Review Criteria (1) Risk-important human actions should be identified from the PRA/HRA and used as input to the HFE design effort. • These actions should be developed from the Level 1 (core damage) PRA and Level 2 (release from containment) PRA including both internal and external events. They should be developed using selected (more than one) importance measures and HRA sensitivity analyses to provide reasonable assurance that an important action is not overlooked because of the selection of the measure or the use of a particular assumption in the analysis.	Section 3.1, References 8-4, 8-5
• When upgrading plant systems, HSIs, procedures, and training the scope of the analysis should address personnel actions resulting from the modification and its interactions with the rest of the plant. Consideration should be given to the following effects of these modifications on the existing HRA: - whether the original HRA assumptions are valid for the modified design - whether the human errors analyzed in the existing HRA are still relevant - whether the probability of errors by operators and maintenance personnel may change - whether errors may be introduced that are not modeled by the existing HRA and PRA - whether the consequences of errors, established in the existing HRA, may change	N/A, see the HFE PMP Section 6.1.11, Reference 8-4
(2) Risk-important HAs and their associated tasks and scenarios should be specifically addressed during function allocation analyses, task analyses, HSI design, procedure development, and training. This will help verify that these tasks are well supported by the design and within acceptable human performance capabilities (e.g. within time and workload requirements).	Sections 3.3.2 – 3.3.7, Section 4.4, References 8-7, 8-9, 8-10
(3) The use of PRA/HRA results by the HFE design team should be specifically addressed; that is, how are risk-important HAs addressed (through HSI design, procedural development, and training) under the HFE program to minimize the likelihood of operator error and provide for error detection and recovery capability.	Sections 3.3.5 – 3.3.7, Reference 8-3
(4) HRA assumptions such as decision-making and diagnosis strategies for dominant sequences should be validated by walkthrough analyses with personnel with operational experience using a plant-specific control room mockup or simulator. Reviews should be conducted before the final quantification stage of the PRA.	Section 3.3.8, References 8-11, 8-9

8.0 REFERENCES

8-1 Human Factors Engineering Program Review Model, NUREG-0711, Revision 2, U.S. Nuclear Regulatory Commission, February 2004.

8-2 Design Control Document for the US-APWR, Revision 3, MHI, March 2011.

8-3 Defense-in-Depth and Diversity Coping Analysis, MUAP-07014, Revision 5, MHI, September 2011.

8-4 Probabilistic Risk Assessment, MUAP-07030, Revision 3, MHI, June 2011.

8-5 Risk Significant Human Errors, N0-EB40026, Revision 0, MHI, December 2011.

8-6 Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, NUREG/CR-1278, A.D. Swain and H.E. Guttmann, U.S. Nuclear Regulatory Commission, August 1983.

8-7 Functional Requirements Analysis and Function Allocation Implementation Plan, MUAP-13007, Revision 0, MHI, July 2013.

8-8 Human Factors Engineering Program Management Plan, MUAP-09019, Revision 3, MHI, June 2013.

8-9 Task Analysis Implementation Plan, MUAP-13009, Revision 0, MHI, July 2013.

8-10 Human-System Interface Design Implementation Plan, MUAP-10009, Revision 3, MHI, June 2013.

8-11 Human Factors Verification and Validation Implementation Plan, MUAP-10012, Revision 3, MHI, July 2013.