

Enclosure 6

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ESBWR Human Factors Engineering

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**ESBWR HFE Design Implementation Plan
Revision 2**



**GE Energy
Nuclear**

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LICENSING TOPICAL REPORT

ESBWR HFE DESIGN IMPLEMENTATION PLAN

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1 OVERVIEW

The Design Implementation Plan, NEDO-33278, addresses the final “as-built” implementation of the Human Factors Engineering (HFE) guidance into ESBWR standard plant design. The ESBWR overall HFE design process is depicted in Figure 1. The standard design includes standardized Human System Interfaces (HSIs), procedures, and training. The ESBWR Combined Operating License Owners Group (COLOG) is responsible for establishing and maintaining the standard plant design and good human factors practice.

Figure 2 depicts the design implementation process described in this plan. The COLOG is responsible for design implementation of new plants constructed using the ESBWR standard plant design. The implementing organizations execute their responsibilities under the plans described in the ESBWR Man-Machine Interface Systems and Human Factors Engineering Implementation Plan (MMIS and HFE Implementation Plan), NEDO-33217. The design implementation, startup, and operational duties of the COL applicants include aspects of these plans, which are transferred to the COL applicant under their license obligations to ensure the integrity of the HFE infrastructure is maintained throughout the life cycle of the plant.

The HFE aspects of the ESBWR standard plant including design of the HSIs, standard plant procedures, and standard plant training documentation, are verified and validated using the Full Scope Simulator (FSS) during the HFE Verification and Validation (HF V&V) process. The Design Implementation as described in this plan is performed to assure that the “as-built” HFE design conforms to the design that was used in the ESBWR standard plant V&V efforts.

1.1 Purpose

The purpose of this document is to:

1. Confirm that the final HSIs, procedures, and training (as-built) HFE design conforms to the ESBWR standard plant design resulting from the HFE design process and V&V activities. Any identified human engineering discrepancies (HEDs) are assessed and properly addressed.
2. Verify aspects of the design that may not have been evaluated previously in the V&V process. This includes any hardware/software, new or modified displays that were absent from the simulator-based integrated V&V process, and any physical or environment (e.g., noise, lighting, etc.) differences between those present at the V&V process and the “as-built” Main Control Room (MCR).
3. Verify resolution of remaining HEDs and open items from the Human Factors Engineering Issue Tracking System (HFEITS).
4. Transfer design implementation responsibility to the COLOG.
5. Transfer responsibility for HFEITS to COLOG.

1.2 Scope

The “as-built” confirmations, verifications, and validations described in this plan apply to the initial COL plants associated with the ESBWR design effort. The COLOG is responsible for:

- Regulatory obligations of design implementation

- Application of the “as-built” confirmation to all stations, panels, components, and elements managed under the ESBWR HFE program.

The ESBWR standard plant design against which the “as-built” comparison is made is derived from the revised HSI design and the standard plant procedures and training documents. These include the corrections and improvements from the V&V process. The ESBWR standard plant design remains the intellectual property of General Electric.

1.3 Definitions and Acronyms

1.3.1 Definitions

Construction documents - the fabrication and installation documentation for the full scope of the HSI requirements.

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

Human Engineering Discrepancies – design features that are incompatible with human capabilities.

Human System Interfaces - A human-system interface (HSI) is that part of the system through which personnel interact to perform their functions and tasks. In this document, "system" refers to a nuclear power plant. Major HSIs include alarms, information displays, and controls. Procedures are also HSIs, but are developed and treated in a separate activity plan, and are treated separately in this plan. Operator controls and information displays, however, for the purposes of displaying on-line procedures are HSIs in the context of this activity.

Procurement documents - the GE/COL and contractor ordering documents and specifications and their associated human factors guidance for the complement of the HSI requirements.

Standard plant procedures (as-built) - the latest revisions to the procedures (at the time of design verification) developed within the scope of NEDO-33274, ESBWR Procedures Development Implementation Plan.

Standard plant procedures (V&V) - the procedures developed within the scope of NEDO-33274, ESBWR Procedures Development Implementation Plan, and used in the HF Verification and Validation activity.

Standard plant training (as-built) - the latest revisions of the training documentation and aids (at the time of design implementation) developed within the scope of NEDO-33275, ESBWR Training Program Development Plan.

Standard plant training (V&V) - the training documentation and aids developed within the scope of NEDO-33275, ESBWR Training Program Development Plan, and used in the HF Verification and Validation activity.

1.3.2 Acronyms

COL combined operating license
 COLOG COL owners group

FSS	full scope simulator
GEEN	General Electric Energy Nuclear
HED	human engineering discrepancies
HF	human factors
HFE	human factors engineering
HFEITS	human factors engineering issue tracking system
HSI	human-system interface
HVAC	heating, ventilation, and air conditioning
MCR	main control room
P&ID	pipng and instrument diagram
RE	responsible engineer
TL	task leader
V&V	verification and validation

2 REFERENCES

Supporting documents provide the input requirements to this plan. Supplemental documents are used in conjunction with this plan.

2.1 Supporting Documents

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

1. NP-2010 COL Demonstration Project Quality Assurance Plan (NEDO-33181, Rev 2)
2. ESBWR Design Control Document Chapter 18 (26A6642BX, Rev 3)
3. ESBWR Man-Machine Interface Systems and Human Factors Engineering Implementation Plan (NEDO-33217, Rev 2)

2.2 Supplemental Documents

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

1. ESBWR Human-System Interface (HSI) Design Implementation Plan (NEDO-33268, Rev 2)
2. ESBWR HFE Verification and Validation Implementation Plan (NEDO-33276, Rev 1)
3. ESBWR HFE Procedures Development Implementation Plan (NEDO-33274, Rev 2)
4. ESBWR Training Program Development Implementation Plan (NEDO-33275, Rev 1)

2.3 Regulatory Guidelines

1. NRC (2004a). Human Factors Engineering Program Review Model (NUREG-0711, Rev 2). Washington, DC: U.S. Nuclear Regulatory Commission.
2. NRC (2004b). Standard Review Plan, Chapter 18 – Human Factors Engineering (NUREG-0800, Rev 1). Washington, DC: U. S. Nuclear Regulatory Commission.
3. NRC (2002). Human System Interface Design Review Guidelines (NUREG-0700, Rev 2). Washington, DC: U.S. Nuclear Regulatory Commission.

3 METHODS

3.1 HSI Verification (As-Built)

3.1.1 Background

The Human-System Interfaces and their design characteristics (HSIs) are established in the HSI Design activity. The HSI adheres to applicable guidance. The HSIs are subsequently evaluated and confirmed in the HFE Verification and Validation. Following the HF V&V, the standard plant HSI Report is revised and becomes the basis for the requirements and acceptance criteria for the fabrication/procurement of the equipment for the “as-built” installation. The process and the rationale for the HSI design are documented and managed under General Electric Energy Nuclear (GEEN) Quality Assurance (QA) and ESBWR specific design program plans.

3.1.2 Goals

The goal of the “as-built” confirmation for the HSIs is to audit the procurement, start-up, and testing process to confirm (1) the GE/COL applicant’s procurement and construction specifications include the verified and validated HSIs and (2) that these designs are implemented.

3.1.3 Requirements

The final (as-built) HSIs and their design characteristics are compared with the complement of HSIs in the detailed standard plant design to verify that they conform to the design that resulted from the HFE design process and V&V activities (NRC, 2004a, Section 12.4.6 (2)).

3.1.4 General Approach

To complete the approach, the following shall be confirmed:

1. The GE/COL applicant’s applicable procurement and construction documents contain the elements of the HSI Report.
2. The applicable procurement and construction documents reflect the current and correct revision of the HSI Report.
3. A review of the engineering/vendor change documentation verifies that the HSI design characteristics remain intact.
4. An HED is written, if needed, to resolve the following issues:
 - a. If the procurement/construction documents or engineering change causes a variance from the HSI Report.
 - b. If there is not sufficient documentation to confirm that the procurement, start-up, and testing process has resulted in the HSIs as contained in the HSI Report.

3.2 Procedures and Training Confirmation (As-Built)

3.2.1 Background

The standard plant procedures and training documentation are established in development activities using applicable guidance documents. The HF V&V validates the adequacy of the proposed HSIs and the standard plant procedures and training to support personnel performance.

Some changes to the standard plant procedures and training may result from the HF V&V. If the nature of the changes is minor (e.g., confined to nomenclature and equipment numbering distinctions), the previous HFE validation remains applicable. If changes affect the sequence or content of procedures and training, these may impact the confidence of the validation results, and HEDs are written to resolve differences.

3.2.2 Goals

The goal of the “as-built” confirmation for the procedures and training is to conduct an audit of the standard plant procedures and training, compare the “as-built” documents to the corresponding documents used in the HF V&V, and assess any differences.

3.2.3 Requirements

The final (as-built) procedures and training are compared with the standard plant procedures and documentation to verify that they conform to the design that resulted from the HFE design process and V&V activities (NRC, 2004a, Section 12.4.6 (2)).

3.2.4 General Approach

The procedures and training confirmation consists of:

1. Auditing the standard plant procedures and training. The audit results are compared to the corresponding standard plant procedures and training documents used for the HF V&V.
2. Writing an HED to resolve any deviations or changes.

3.3 Final HFE Design Verification Not Performed in the Simulated HF V&V Activity

3.3.1 Background

Some HFE design aspects may not be able to be addressed in the simulated HF V&V. These would include:

1. Designs and features that are modifications to the standard design
2. HFE aspects that are not feasible to perform in the simulated environment.

The items represented in category 1 above are documented in HEDs, due to the fact that they deviate from the standard plant design. These items will be addressed individually (See Section 4.4) according to the context and criteria established in the HED. Items in category 2 are itemized in the recommendations from the HF V&V Results Summary Report. Below are some examples of items in category 2 that may need to be reviewed in the actual MCR environment:

- Communication equipment interfaces (phones, radios, intercoms, etc.)

- Lighting (normal and emergency)
- Habitability systems (HVAC, noise mitigation features, etc.)
- Use of plant-specific training manuals and procedures
- Data and video interfaces with the TSC and equipment to duplicate or link the EOF to the plant process database
- Procedure/P&ID drawing laydown area

3.3.2 Goals

The goal of this activity is to verify aspects of the design not previously verified in the HF V&V.

3.3.3 Requirements

Aspects of the design that are not addressed in the V&V Implementation Plan NEDO-33276 are evaluated during design implementation using appropriate V&V methodologies (NRC, 2004a, Section 12.4.6 (1)).

3.3.4 General Approach

Following the recommendations from the HF V&V Results Summary Report, the list of items to be verified is developed and confirmed. The applicable evaluation criteria are established from the Human Factors Style Guide, other guidance documents established or adopted during the design process, or applicable sections from NUREG-0700 (NRC, 2002). The team conducts the verification of the list.

3.4 Resolution of Remaining HEDs and Open issues and transfer of HFEITS

3.4.1 Background

The HF V&V of the standard plant design addresses the bulk of the HEDs and issues from the HFE design and development. Following acceptance of the standard plant design, the responsibility for HFEITS is transferred to the COLOG. After design implementation, issues and HEDs continue to be entered into the HFEITS under the responsibility of the COLOG.

3.4.2 Goals

The goal of this activity is to evaluate the remaining HEDs and open issues in HFEITS from the ESBWR standard plant design for impact to the safe operation of the plant (See Appendix A of NEDO-33217).

3.4.3 Requirements

Remaining HEDs and open issues in HFEITS are verified as adequately addressed (NRC, 2004a, Section 12.4.6 (3)).

3.4.4 General Approach

The design implementation resolves the HEDs and issues from the MMIS and HFE Implementation Process by closing remaining items, and transferring responsibility to maintain the HFEITS (or equivalent) to the COLOG.

4 IMPLEMENTATION

4.1 Verification of Final As-Built HSI Requirements

The documentation review audits the procurement and construction documents to determine that the HSI requirements derived from the HFE design process and V&V activities are specified and verified within the normal plant equipment acquisition process.

4.1.1 Inputs

1. HSI Requirements (See Definitions)
2. Procurement Documents (See Definitions)
3. Construction Documents (See Definitions)

4.1.2 Process

4.1.2.1 Acceptance Criteria

The documentation review is considered sufficient if the Task Leader (TL) determines that the process is complete in complying with the following acceptance criteria:

1. HSI requirements listed in the revised HSI Report are invoked within the applicable procurement and construction documentation. The revision of the HSI Report is verified to be current to the list confirmed/amended in the HF V&V activity.
2. Differences/modifications to the HSI Report are identified in the form of HEDs and entered in the HFEITS database.
3. Manufacturing detailed specifications, plans, and drawings called out in the procurement and construction documents reviewed make direct reference to the HSI requirements contained in the HSI Report.
4. Manufacturing and/or procurement quality procedures are invoked that are in compliance with NEDO-33181.
5. Engineering change documentation from the applicable quality systems is reviewed and any changes affecting the HSI design requirements contained in the HSI Report are identified in the form of HEDs and entered in the HFEITS database.
6. Task reports and summary report documentation are completed.

4.1.2.2 Resources

1. Data resources
 - HFE standard plant database files
 - HFEITS
 - Plant procurement, construction, and contract documentation
2. Staffing resources
 - Design implementation task leader (TL)

- HFE responsible engineer (RE)

4.1.2.3 Actions/Tasks

1. Establish detailed plan and schedule and brief team. (TL)
2. Gain access to plant bid specification and contract documentation. (RE)
3. Conduct review of plant bid specification and contract documentation. (RE)
4. Document results on plan forms, prepare HEDs as needed, and deliver outputs to Task Leader. (RE)
5. Review output documentation for compliance to acceptance criteria. (TL)
6. Prepare task Results Summary Report. (RE)
7. Summarize findings for incorporation into Design Implementation Results Summary Report. (TL)

4.1.3 Outputs

1. Confirmation signature of the TL documenting compliance to acceptance criteria.
2. HEDs for deviations from ESBWR standard plant HSIs.
3. Summary of findings for incorporation into Results Summary Report.

4.2 Confirmation of Standard Plant Procedures and Training

An audit of the standard plant procedures and training is conducted. The auditor compares the “as-built” documents with the corresponding standard plant documents used in the HF V&V to identify adapted (changed or revised) sections (if any) and assesses the nature of the modifications. If modifications other than equipment nomenclature are observed, HEDs are written to assess and address the deviation.

4.2.1 Inputs

1. Standard plant procedures (as-built) (See Definitions)
2. Standard plant training (as-built) (See Definitions)
3. Standard plant procedures (V&V) (See Definitions)
4. Standard plant training (V&V) (See Definitions)

4.2.2 Process

The Design Implementation Task Leader (TL) conducts a pre-job briefing with assigned staff, directs the performance of the activity, and verifies that results comply with the acceptance criteria. One or more members from the HFE team are assigned HF Responsible Engineers (RE) to conduct the audit, complete documentation, and submit task reports.

4.2.2.1 Acceptance Criteria

The confirmation of standard plant procedures and training is considered sufficient if the Design Implementation Task Leader (TL) determines that the following criteria have been completed:

1. An audit of the standard plant procedures and training is completed identifying adapted sections (if any) from the standard plant documentation validated in the HF V&V activity.
2. Differences/modifications found in the audit, that go beyond the category of equipment nomenclature, are identified in the form of HEDs and entered in the HFEITS database.
3. Task reports and summary report documentation are completed.

4.2.2.2 Resources

1. Data resources
 - HFE standard plant database files
 - HFEITS
2. Staffing resources
 - Design implementation task leader (TL)
 - HFE responsible engineer (RE)
 - One to two HFE team members

4.2.2.3 Actions/Tasks

1. Establish detailed plan and schedule and brief team. The plan should include the audit strategy (methods to identify procedure and training modifications), and forms to document audit results. (TL)
2. Conduct audit of the standard plant procedures and training documents. Identify adapted sections (if any) using the audit strategy. If adapted sections are observed, assess if the changes are other than equipment nomenclature. Prepare HEDs as needed and document the results of the audit on the task forms. (RE)
3. Compile results, update HFEITS and other documentation, and prepare task reports. (RE)
4. Review output documentation for compliance to acceptance criteria. (TL)
5. Summarize findings for incorporation into Design Implementation Results Summary Report. (TL)

4.2.3 Outputs

1. Confirmation signature of the TL documenting compliance to acceptance criteria.
2. HEDs listed in HFEITS for deviations from ESBWR standard plant procedures and training.
3. Summary of results including data collection forms for incorporation into Results Summary Report.

4.3 Verification of HFE Design Not Performed in the Simulated HF V&V Activity

The purpose of this effort is to verify HFE design aspects not closed in the HF V&V activity. Recommendations from the HF V&V Results Summary Report contain the listing of items to address. Additional items may be added to the list to address related HEDs or HFE issues

contained in HFEITS. In this effort, the list of items for verification is compiled, verification criteria and means are established, and the verifications are performed and documented.

4.3.1 Inputs

1. Recommendations from the HF V&V.
2. HEDs and issues from HFEITS that may be addressed in the as-built design verification.
3. Sources for verification criteria including the ESBWR HF Style Guide.

4.3.2 Process

The Design Implementation Task Leader (TL) conducts a pre-job briefing with assigned staff, directs the performance of the activity, and verifies that results comply with the acceptance criteria. One or more members from the HFE team are assigned HF Responsible Engineers (RE) to compile the list of verification items, research and prepare verification criteria and forms, conduct the verifications, complete documentation, and submit task reports.

4.3.2.1 Acceptance Criteria

The Final HFE Design Verification is sufficient when the Task Leader (TL) determines that the following criteria have been completed:

1. It is confirmed that all items from the HF V&V recommendations list are in the verification list.
2. HEDs and issues in HFEITS are reviewed and related issues considered for addition to the verification list.
3. A review of verification criteria is completed concluding that criteria are appropriate and complete.
4. All verifications are addressed and verification forms completed in accordance with review criteria, task plans, and task briefing.
5. HEDs are written for items that deviate from their established verification criteria.
6. Task reports and summary report documentation are prepared.

4.3.2.2 Resources

1. Data resources
 - HFE standard plant database files
 - HFEITS
 - COL control room and/or full-scope simulator
2. Staffing resources
 - Design implementation task leader (TL)
 - HFE responsible engineer (RE)

- One to two HFE team members

4.3.2.3 Actions/Tasks

1. Establish detailed plan and schedule and brief team. The plan should include verification strategy and sources of verification criteria (e.g., Human Factors Style Guide) for items on the list and sample forms to collect and document verification results. (TL)
2. Complete the list of verification items, establish criteria, and prepare verification forms. (RE)
3. Review the verification criteria to be complete and appropriate to address the sources and context of the issues. Direct modifications/additions to verification criteria. (TL)
4. Update verification criteria and conduct the Final HFE Design Verifications. Identify discrepancies (if any) to established criteria in the form of HEDs documented in HFEITS. Document the results of the verifications on the task forms. (RE)
5. Compile results, update HFEITS and other documentation, and prepare task reports. (RE)
6. Review output documentation for compliance to acceptance criteria. (TL)
7. Summarize findings for incorporation into Design Implementation Results Summary Report. (TL)

4.3.3 Outputs

1. Documented compliance to acceptance criteria.
2. HEDs listed in HFEITS for items that deviate from established verification criteria.
3. Summary of results including data collection forms.

4.4 Resolution of HEDs and Open Issues in HFEITS

The resolution of HEDs and open issues is an ongoing activity throughout the design, construction, and testing phases of development. The goal of this activity is to bring closure to the resolution process at some time following the Design Implementation activity. Any long lead or ongoing resolutions to HEDs and open issues may be resolved by reference to the COL applicant's tracking programs that bring satisfactory resolution to the item.

4.4.1 Inputs

1. HEDs and open issues from HFEITS.
2. Task reports from other Design Implementation activities.

4.4.2 Process

HEDs and open issues are reviewed and verified to be satisfactorily resolved.

4.4.2.1 Acceptance Criteria

HEDs and open issues are resolved when the Task Leader (TL) determines that the following criteria have been met:

1. HEDs are written and documented in the HFEITS are satisfactorily resolved.

2. Open issues are written and documented in the HFEITS satisfactorily resolved.
3. Other Design Implementation activities are successfully completed.
4. Long-term, outstanding issue(s) not addressed are turned over to the COL applicant for action, tracking, and final disposition.

4.4.2.2 Resources

1. Data resources
 - HFE standard plant database files
 - HFEITS
2. Staffing resources
 - Design implementation task leader (TL)
 - HFE responsible engineer (RE)

4.4.2.3 Actions/Tasks

1. Initiate review of status of HEDs and open issues following completion of design implementation activities. (TL)
2. Conduct review of status of HEDs and open issues in HFEITS. (RE)
3. Prepare task report providing review results stating that all HEDs and open issues in HFEITS are resolved or are being tracked to completion. (RE)
4. Review output documentation for compliance to acceptance criteria. (TL)
5. Summarize findings for incorporation into design implementation Results Summary Report. (TL)

4.4.3 Outputs

1. Documented compliance to acceptance criteria.
2. Summary of results for incorporation into Results Summary Report.

5 RESULTS

The results of the Design Implementation activities are documented in the Design Implementation Results Summary Report. The report provides an introduction, background, and summary of results and outputs of the activities performed.

The report encompasses:

1. Design Implementation team members and backgrounds.
2. Final “as-built” HSI verification.
3. Confirmation of Procedures and Training design implementation.
4. Verification of HFE design not performed in the HF V&V.
5. Resolution to HEDs and open issues in HFEITS.
6. Turn over to COL applicant for tracking of the remaining long-term open HED/HFEITS issues.

Figure 1. HFE Implementation Process

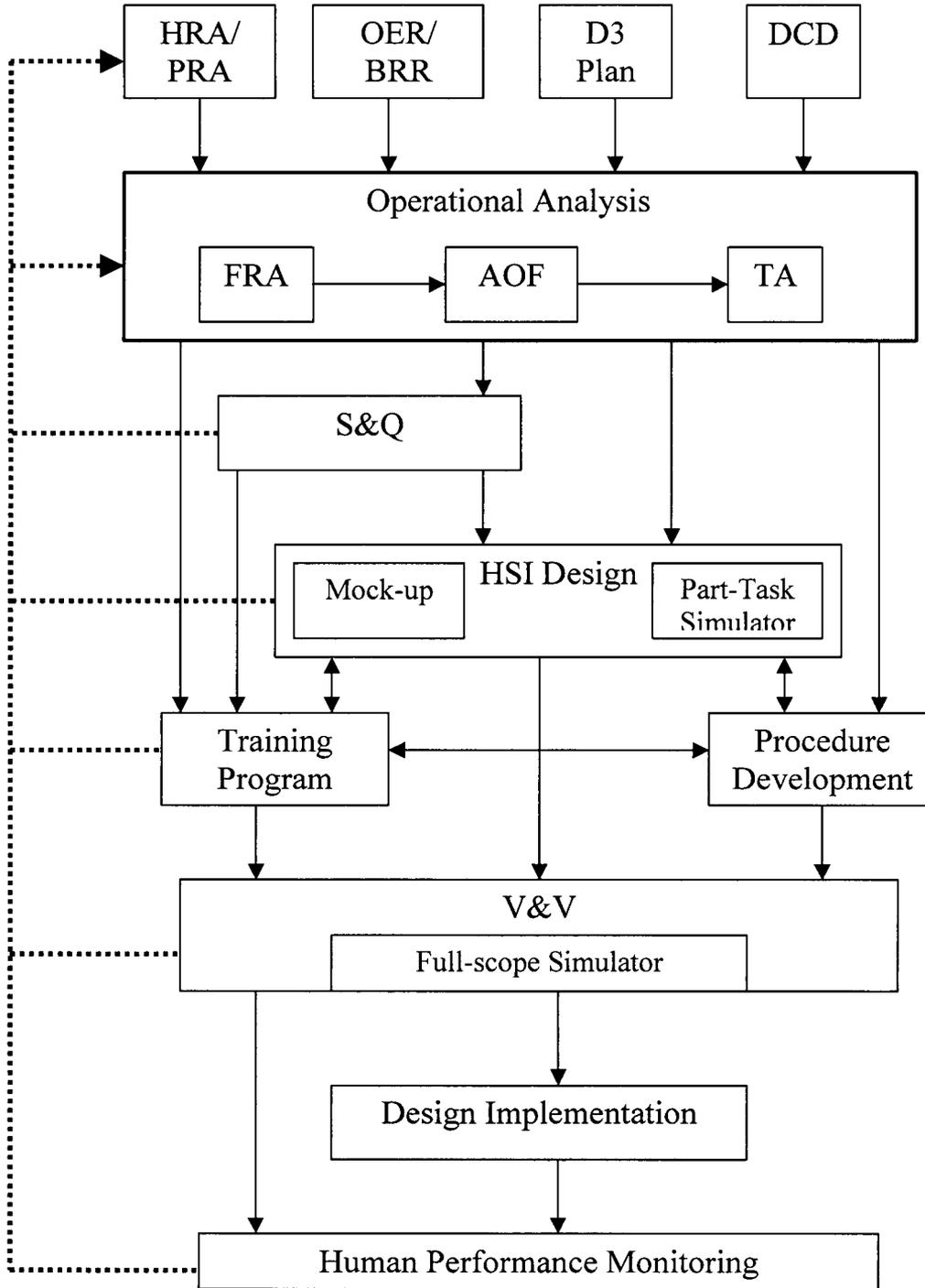


Figure 2. Design Implementation Plan

