AREVA NP Inc.,

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U.S. EPR™ PROJECT DESIGN GUIDELINE

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U.S. EPR Task Analysis Implementation Plan

Safety Related? ☐ YES ☒ NO

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

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Record of Revision

Revision No.	Pages/Sections/ Paragraphs Changed	Brief Description / Change Authorization
000	ALL	Initial Release
001	Section 1.1	RAI 336, 348, 369 Deleted incorrect notes in table
001	Section 1.5	Clarified objective to include all risk-significant HAs
001	Section 3.0	Added text to describe MTIS activities in relation to TA.
001	Section 4.4	Workload analysis section enhanced to describe a meaningful job
001	Section 4.4	Workload analysis section enhanced to form information exchange process with HRA.
001	Section 4.6	Added section on Staffing and qualification to match process requirements.
002	Section 2.1	Added References (RAI 426)
002	Section 3.0	Added MTIS information (RAI 408)
002	Section 3.1	Added information on problematic tasks (RAI 408)
002	Section 3.2	Added Section 3.2 Tools Instruments, and Methods (RAI 408)
002	Section 4.1	Added information on OCS (RAI 408) and emergency plan (RAI 426)
002	Section 4.2	Added reference to Appendices C and D
002	Section 4.2	Clarification of S&Q Analysis (RAI 426)
002	Appendices C and D	Added Appendices C and D (RAI 408)

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1.0 INTRODUCTION

Task Analysis (TA) is a method for describing what plant personnel must do to achieve the purposes or goal of their tasks. The description can be in terms of cognitive activities, actions, and supporting equipment. It is thus the identification of task requirements for accomplishing functions allocated to plant personnel. This includes the requirements for information, control, and task performance as well as the necessary HSI for the accomplishment of those tasks by personnel. For the U.S. EPR™ design, the functions to be analyzed are identified through the function requirements analysis (FRA) process and allocated to plant personnel, system, or a combination of plant personnel and system through the function allocation (FA) process [1]. A sampling process similar to the Operational Conditions Sampling (OCS) process described in the verification and validation implementation plan [2] is used to select functions to be subject to task analyses. As discussed in Reference [3], the assumptions on the staffing and qualification levels of the control room personnel used as the HSI design basis is validated and adjusted as necessary based upon the task analyses.

1.1 Applicability

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

1.2 Owner

Program Manager, human factors engineering (HFE) is responsible for providing this implementation plan.

1.3 Interfaces

Table 1-1: TA Interfaces with the Following Disciplines

Discipline	Role
Technical Project Management	Provides schedule and management of the HFE design and implementation process
Systems Engineering	Provides knowledge of the purpose, operating characteristics, and technical specifications of major plant systems, identifies system and component functions, provides input to task analysis, participate in the development of procedures and scenarios for task analysis
Nuclear Engineering	Provides knowledge of the processes involved in reactivity control and power generation, provides input to task analysis, participate in the development of procedures and scenarios for task analysis
I&C Engineering	Participates in the development, test, and evaluation of the HSIs
Architect Engineering	Provides knowledge of the configuration of plant components within the plant, provides input to task analysis, and the development of scenarios for task analysis
Human Factors Engineering	Provides expertise in TA methodologies, participate in the detailed analyses of tasks, including assessment of effects of human performance capabilities and limitations, identification of suitable HSI and associated characteristics to support tasks and participate in the resolution of identified human factors problems

Discipline	Role
Plant Operations	Provides knowledge of operational activities including task characteristics, HSI characteristics, environmental characteristics, and technical requirements related to operational activities, participates in the development of scenarios for task analyses and assists in performance of the analyses.
Computer System Engineering	Participates in the development of scenarios for task analyses involving failures of the HSI systems.
Plant Procedure Development	Participates in the identification and development of tasks to be analyzed. Develops procedures based on analyses of required operator tasks.
Personnel Training	Participates in the development of tasks for analysis.
Maintainability/Inspectability Engineering	Participates in the development of tasks for analysis.
Reliability/Availability Engineering	Identifies input into the design to provide reasonable assurance that it meets reliability and availability goals. Participates in the development of tasks for analysis. Participates in HRA analyses as required based on emerging details from TA.

Table 1-2: TA interfaces with the Other HFE Elements

HFE Element	Role
Operating Experience Review	Provides input to TA in the form of information about what type of tasks have had errors in the past, HA errors, problematic operations, and staffing shortfalls and details to be considered during actual analyses.
Functional Requirements Analysis/ Function Allocation	Provides input to TA in the form of the allocation of the plant functions to human, machine, or both and identifies the purposes and goals of analyzed tasks. Possible mismatches between functions allocated to personnel and their qualifications to be assessed during TA.
Human Reliability Analysis	Recommend tasks to analyze based on initial risk analyses, which include consideration of the effect of staffing levels and qualifications on plant safety and reliability. Utilizes the TA results to identify human actions (HAs) and sequences in which human errors may occur.
Human-System Interface Design	Provide assumed HSI details for initial TA. The TA assesses staffing demands resulting from the locations and use (especially concurrent use) of controls and displays and needs for coordinated actions between individuals. Utilizes the TA results to form the basis for the design of the HSI to ensure the design supports the primary operator tasks by defining what elements are provided (controls and displays) to the operator and how those elements are organized.

HFE Element	Role
Procedure Development	Utilizes the TA results to form the basis for procedures to guide the plant personnel in operating the HSI. As procedures are available, the TA assesses staffing and qualification demands resulting from requirements for concurrent use of multiple procedures and personnel skills, knowledge, abilities, and authority identified in procedures.
Training Program Development	Participate in the development of training scenarios to support TA. Utilizes the TA results to form the basis for refining the skills and training the plant personnel need to assure they have the knowledge, skills, and abilities to properly perform their roles and responsibilities. Communicates crew coordination concerns that are identified during the development of training to be considered in subsequent iterations of TA.
Human Factors Verification and Validation	Utilizes the TA results to define the task support verification criteria. The V&V process is used to validate the staffing and qualification assumptions and any subsequent modifications thereof.
Design Implementation	Obtain details of the plant construction and commissioning plan that identifies any interim MCR/HSI configurations and identify required operations that need to be performed under these conditions. Analyze potential tasks under these interim configurations to assure no safety concerns have been created.

1.4 Purpose

This implementation plan provides the objectives of the TA, the method to perform the TA, and a description of the final documentation of the TA.

1.5 Objectives and Scope

The objective of the U.S. EPR™ TA is to identify the specific tasks needed to accomplish selected functions that are allocated to personnel. The ultimate objective of these task analyses is to define the information, control, and support requirements for each analyzed task. From these requirements, the inventory and HSI characterization of alarms, displays, and controls necessary for operators to perform tasks is developed. The TA process also addresses any changes that are necessary to the initial staffing assumption [3]. This is accomplished during the workload analysis portion of TA. This is done in lieu of a separate implementation plan for staffing and qualifications since the results summary of TA includes all staffing and qualification levels needed to perform each task.

1.6 Definition of Terms

Term (Acronym)	Definition
Functional Requirements Analysis (FRA)	The examination of system goals to determine what functions are needed to achieve them..
Function Allocation (FA)	The process of assigning responsibility for function accomplishment to human or machine resources, or to a combination of human and machine resources.
Human System Interface (HSI)	That part of the system through which personnel interact to perform their functions and tasks. In this document, "system" refers to the U.S. EPR™ design. Major HSIs include alarms, information displays, controls, and procedures.
Human Reliability Analysis (HRA)	An integral activity of a complete Probabilistic Risk Assessment (PRA) to evaluate the potential for, and mechanisms of, human error that may affect plant safety.
interfaces , interface devices	The actual devices directly used by personnel to control and monitor and interact with the plant and individual components, e.g., controls, display devices, formatted display screens, alarm messages, etc.
Integrated System Validation (ISV)	These are evaluations using performance-based tests to determine whether an integrated system design (i.e., hardware, software, and personnel elements) meets performance requirements and acceptably supports safe operation of the plant.
Operating Experience Review (OER)	A systematic review, analysis, and evaluation of operational experience that can apply to the development of the man-machine interface design.
Primary Task	Those tasks performed by the operator to supervise the plant; i.e., monitoring, detection, situation assessment, response planning and response implementation. See "secondary task"
Probabilistic Risk Assessment (PRA)	A systematic evaluation which demonstrates that the design poses acceptably low risk of core damage accidents and consequences.

Term (Acronym)	Definition
Risk-Significant Human Action	Actions that are performed by plant personnel to provide reasonable assurance of plant safety. Actions may be made up of one or more tasks. However, this designation shows that the actions have been evaluated and found to be above set criteria for contribution to plant risk.
Secondary Tasks	Those tasks that the operator performs when interfacing with the plant, but are not directed to the primary task. Secondary tasks may include: navigating through and paging displays, searching for data, choosing between multiple ways of accomplishing the same task, and making decisions regarding how to configure the interface.
Step	Individual actions or decisions that are part of a task
Task	A group of related activities that have a common purpose, often occurring in close temporal proximity.

1.7 Abbreviations and Acronyms

Acronym	Definition
CoO	Concept of Operations
FA	Function Allocation
FBT	Functional Branch Tree
FRA	Functional Requirements Analysis
GOMS	Goals, Operators, Methods, and Selection rules
HA	Human Action
HFE	Human Factors Engineering
HSI	Human-System Interface
HRA	Human Reliability Analysis
HTA	Hierarchical Task Analysis
MTIS	Maintenance Tests Inspections and Surveillance
OCS	Operational Conditions Sampling
OER	Operating Experience Review
PRA	Probabilistic Risk Assessment
PSF	Performance Shaping Factors
SDD	System Description Document
SGTR	Steam Generator Tube Rupture
SME	Subject Matter Expert
TA	Task Analysis
V&V	Verification and Validation

2.0 CODES, STANDARDS, AND REGULATIONS

2.1 Regulatory Requirements and Guidance

Applicable U.S. regulatory requirements are listed below

10 CFR 50 Appendix A	General Design Criteria for Nuclear Power Plants.
10 CFR 50.34(f)	Additional TMI-Related Requirements (on control room designs).
10 CFR 50.47	Emergency Plans
10 CFR 52.47(a)(1)(ii)	Content of Applications (for standard design certification dealing with compliance with TMI requirements).
NUREG-0654	Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants
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-3371	Task Analysis of Nuclear Power Plant Control Room Crews (1983).
NRC Info Notice 95-48	Results of Shift Staffing Study.
NRC Info Notice 97-78	Crediting of Operator Actions in Place of Automatic Actions and Modifications of Operator Actions, Including Response Times.
NUREG/CR-6393	Integrated System Validation: Methodology and Review Criteria (O'Hara, Stubler, Higgins, Brown, 1997).
NUREG/CR-6633	Advanced Information Systems: Technical Basis and Human Factors Review Guidance (O'Hara, Higgins, 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-6635	Soft Controls: Technical Basis and Human Factors Review Guidance (W. Stubler, O'Hara, and Kramer, 2000).
NUREG/CR-6636	Maintainability of Digital Systems: Technical Basis and Human Factors Review Guidance," March 2000.
NUREG/CR-6637	Human-System Interface and Plant Modernization Process: Technical Basis and Human Factors Review Guidance (Stubler, O'Hara, Higgins, and Kramer, 2000).

2.2 Industry HFE Codes and Standards

3.0 METHOD

3.1 Inputs

The inputs to TA come from the other HFE program elements. Other inputs into TA include vendor data, such as system and equipment specifications, and initial staffing assumptions and Concept of Operations (CoO) assumptions.

3.1.1 Inputs from Other HFE Program Elements

The inputs from other HFE program elements are described in Table 1-2 above.

3.1.1.1 TA Inputs from Operating Experience Review

[redacted]

3.1.1.2 TA Inputs from Function Requirements Analysis/Function Allocation

[redacted]

3.1.1.3 TA Inputs from HRA

HRA evaluates the potential for human error that may affect plant safety. HRA analysis considers several factors that affect human performance including accident analyses (indicating time available for action), task analyses, procedures, and HSI design. This analysis determines whether the HFE design provides adequate support to the operational staff when monitoring critical plant processes and executing risk-significant actions. Also, the HRA provides reasonable assurance that these control activities are accomplished with success probabilities consistent with those associated with the PRA. [8]

[redacted]

3.1.2 TA Inputs from System Data

3.2 Tools, Instruments, and Methods

3.2.1 Task Sequence Analysis

3.2.2 Goals, Operators, Methods, and Selection Rules (GOMS)

3.2.3 Hierarchical Task Analysis (HTA)

4.0 TA IMPLEMENTATION APPROACH

As HSI details become available, generic secondary tasks using the interfaces are analyzed and knowledge of how the secondary tasks are performed is considered as part of the analyses of primary tasks.

4.1 Identify Tasks to be Analyzed

Tasks are identified from the following categories for inclusion in the analysis. The analyzed tasks include a broad range, some being very limited specific component-level operations, up through representative system-level operations, and some integrated whole-plant evolutions such a plant start-up, shutdown and plant accident and transient response.

- The full range of plant operating Modes 1–6 (defined in the Technical Specifications) as well as
  - Abnormal and emergency operations
  - Transients
  - Low-power operations
  - Shutdown conditions
- Selected representative and important tasks from the areas of operations, maintenance, test, inspection, and surveillance
- Risk-significant HAs identified by the Probabilistic Risk Assessment (PRA) level I and II analyses
- Tasks identified through OER or HRA reviews shown to be problematic
- Automated tasks supporting critical safety-related functions with human interactions, including monitoring the automated system and executing backup actions if the system fails
- Actions identified in 10 CFR 50.47, NUREG-0654, and procedures to meet an initial accident response in key functional areas as identified in the emergency plan

The identification of tasks is derived from those functions following the guidelines set for Operational Conditions Sampling (OCS) described in the verification and validation implementation plan (Reference, [2]). Tasks identified include at a minimum those conditions that are representative of the range of events that could be encountered during operation of the plant. These tasks also represent the characteristics that are expected to contribute to system performance variation and consider the safety significance of HSI components.

4.1.1 Identify Plant-Level Tasks

[redacted]

4.1.2 Identify Component and System Level Tasks

[redacted]

4.2 Analyze Selected Tasks

[redacted]

4.2.1 Develop Task Descriptions

Once the tasks to be analyzed are identified, task descriptions are developed. Utilizing information from the system data and the results from FRA, the descriptions are developed to contain many of the following characteristics. Certain characteristics are only applied to the task as a whole whereas others are applied to each individual step.

- Purpose – Why is the task performed (i.e., to accomplish a system function).
- Initiation cues– What defines that the task needs to be done (i.e., the plant conditions, events, or situations that indicate that it is time to perform the task)
- Preconditions – What initial conditions must be met before a task can be undertaken (i.e., are there other tasks that must be completed first)

- Component or system statuses or parameters that must be satisfied
- Plant or system modes required
- Administrative requirements

- Decisions & actions – How is the task performed (i.e., the decisions and actions that need to be taken).
  - What parameter values are the operational decisions based on?

- Information – Is there any other information needed to perform the task (i.e., are there other functions, systems, or equipment involved, is status (open/closed) or parameter value (flow rate, temp) needed)
  - Controls – What are the specific controls needed to take the necessary actions at each step
  - HSI characterization – what are the desired HSI characteristics of the status/parameter display or control schemes for accomplishing the task (e.g., simple binary status lamp, analog format indicator, numerical indicator, trend plot for parameter display, simple open/close or throttling step controls)

- Response confirmation – How can it be determined that the desired action is taking place?
  - Indication of control action – how can it be confirmed that the desired control order was issued and that the actuator responded to the command?
  - Indication of desired system results – what plant parameters or component status provides direct or indirect indication that the initiated action has been effective.

- Failures – what are the plausible things that can go wrong, and what are the identifying cues and alternative actions if they do go wrong
  - Alarms - Are there any alarms related to the task or task step that may impact the user's ability to perform the task or may alter the actions the user takes
  - Cautions/Warnings – What cautions and warnings are related to task performance

- Task Termination – What are the plant conditions, events, or situations that indicate that it is time to stop the task

- Identify operational constraints – any specific operational constraints on the specific task beyond those listed under preconditions above.
  - Time – What are the time constraints, if any, on task performance: time available for the action and time required to do it
  - Personnel – Who performs the task, what qualifications and skills do they need, how many personnel are needed (including support personnel) to meet all the requirements of TA and all regulatory requirements. [4] [5]

4.2.2 Sequence Tasks

4.2.3 Assign Workload Values

4.2.4 Develop HSI Task Support Interface Requirements

4.3 Associate HSI Interfaces and Evaluate

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, as well as verify operator workload is at acceptable levels. Inputs to these analyses include the number of and skill set of crew members detailed in the staffing and qualification assumptions and the results of the FA. Details concerning the HSI design process and evaluations with simulation are described in the HSI Design Implementation Plan (Reference [12]). HSIs are identified by their individual ECS ID codes. Items appearing on HSI displays include the display code. Conventional panel-mounted items are identified by panel and panel item number.

4.4 Workload Analysis

Following the gross assignment of workload values discussed in Section 4.2.3 an operator workload analysis is performed on selected sets of tasks to evaluate the physical and cognitive demands on the operator based upon the HSIs assigned, the allocation of functions, and the staffing levels. The tasks selected include those tasks that include risk-significant human actions (HAs) identified by the PRA and other error-prone HAs identified by the OER. Additionally, tasks with potential for high workload or error and tasks identified to be time critical are selected for the workload analysis.

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4.5 Confirm FA Allocations

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4.6 Confirm Staffing and Qualification Needs

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5.0 RESULTS SUMMARY REPORT AND DOCUMENTATION

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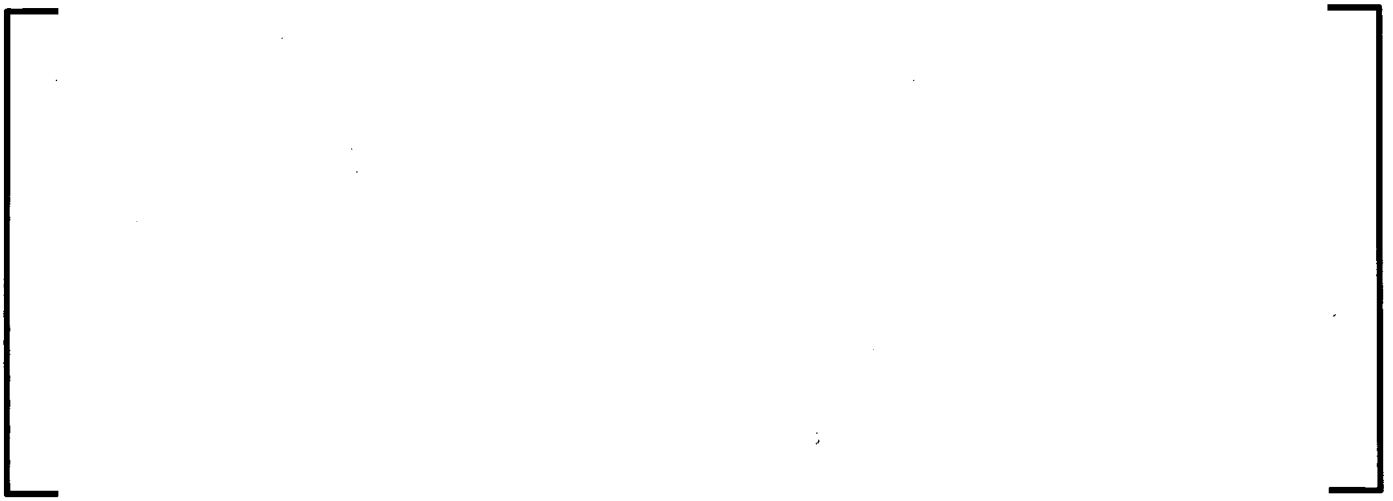

6.0 REFERENCES

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2. AREVA NP Document, "U.S. EPR Human Factors Verification and Validation Implementation Plan."

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6. Abdolmonhammadi, M. J. & Usoff, C. A. (2001). The Assessment of Task Structure, Knowledge Base and Decision Aids for a Comprehensive Inventory of Audit Tasks Quorum: Westport, CT

7. AREVA NP Document, "U.S. EPR Human Factors Operating Experience Review (OER) Implementation Plan."

8. AREVA NP Document, "U.S. EPR™ Implementation Plan for the Integration of Human Reliability Analysis (HRA) with the Human Factors Engineering (HFE) Program"

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10. Bisantz, A. M., & Vicente, K. J. (1994). Making the abstraction hierarchy concrete. *International Journal of Human Computer Studies, 40,* 83–117.

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APPENDIX A: TA PROCESS

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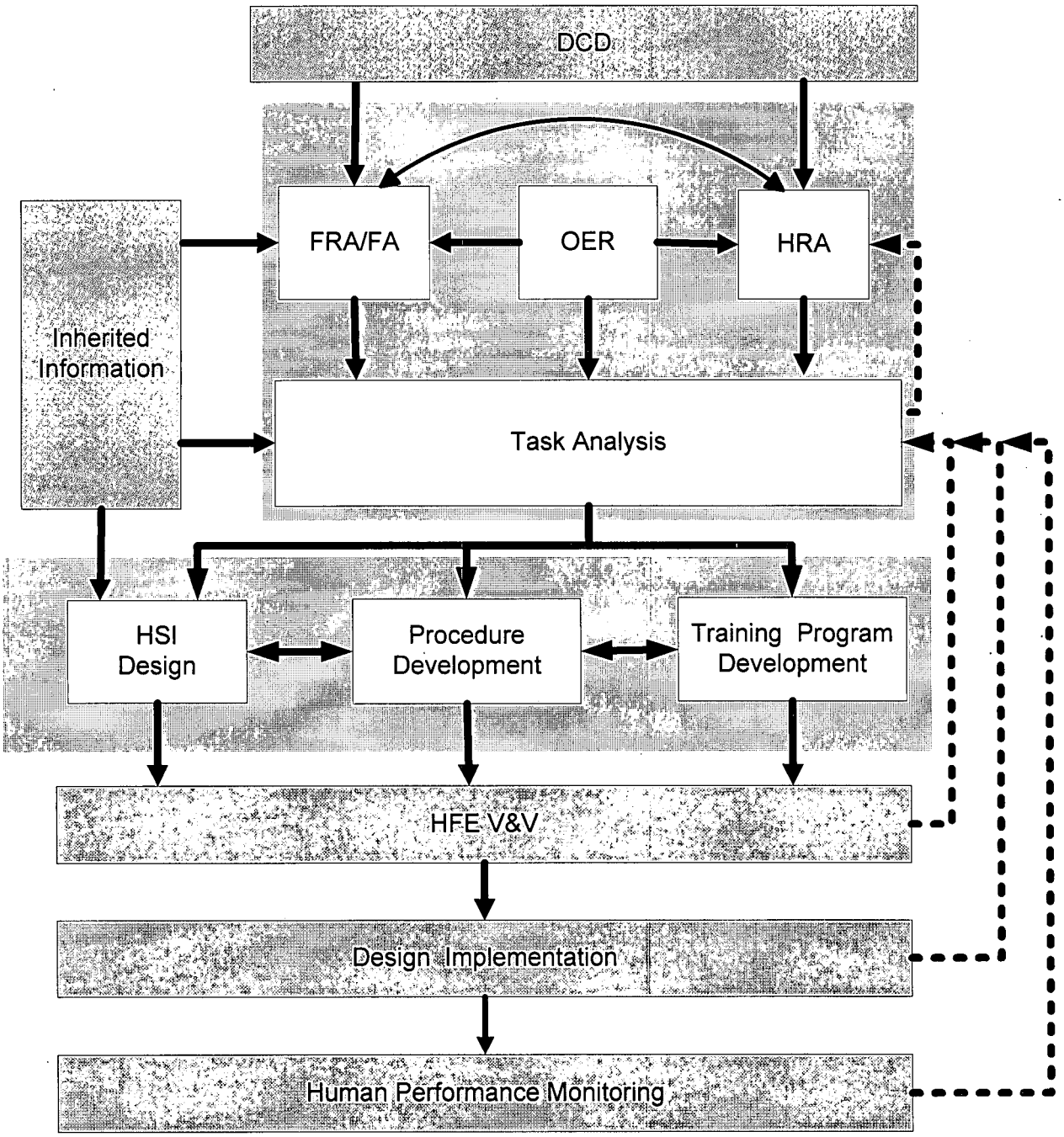
APPENDIX B: HFE PROCESS INTEGRATION



APPENDIX C: EXAMPLE OF TA TECHNIQUE FOR TASK SEQUENCE ANALYSIS

APPENDIX D: SAMPLE TA WORKSHEET