18.2 Human Factors Engineering Program Management

The purpose of this section is to describe the goals of the AP1000 human factors engineering program, the technical program to accomplish these goals, the human system interface design team, and management and organizational structure that support the implementation of the technical program.

Human factors engineering is the system engineering of human system interfaces. The program management tools and procedures that govern the design of AP1000 systems apply to the human factors engineering activity. This approach integrates the design of human system interfaces with other plant systems.

18.2.1 Human Factors Engineering Program Goals, Scope, Assumptions, and Constraints

18.2.1.1 Human Factors Engineering Program Goals

The goal of the human factors engineering program is to provide the users of the plant operation and control centers effective means for acquiring and understanding plant data and executing actions to control the plant's processes and equipment.

The objective is to enable personnel tasks to be accomplished within time and performance criteria.

18.2.1.2 Assumptions and Constraints

There are a number of inputs to the human factors engineering design process that specify assumptions or constraints on the human factors engineering program and the human system interfaces design.

Major design inputs include regulatory guidelines, guidance from utilities and utility representative groups, utility requirements documents, and AP1000 plant systems design specifications. The requirements resulting from these design inputs are captured in human system interface specification documents and functional requirements documents.

While assumptions and constraints specified by design inputs are provisionally treated as design requirements, the appropriateness of these requirements is evaluated as part of the human factors engineering design process. Results of human factors engineering activities such as operating experience review, task analyses, mockup activities and verification and validation activities are used to provide feedback on the adequacy of initial human system interface design assumptions and constraints. If results of human factors engineering analyses or evaluations indicate that initial human system interface design assumptions or constraints are inadequate, then the human system interface design requirements are revised utilizing the standard AP1000 design configuration change control process.

Listed below are some of the major inputs to the AP1000 human system interface design and the assumptions and constraints they impose on the AP1000 human system interface design process and human system interfaces design.

Regulatory Requirements

One of the requirements for the AP1000 human factors engineering program is that it complies with applicable regulatory requirements. [*The human factors engineering process is designed to meet the human factors engineering design process requirements specified in NUREG-0711 (Reference 1).*]*

Utility Requirements

Another source of design input is utility customer requirements. Utility input can take the form of utility requirements documents, and/or input from utility representative groups serving in an advisory capacity.

Examples of utility requirements that impact the human system interface design are:

- **Operating staff assumptions.** A single reactor operator (RO) should be able to control major plant functions performed from the main control room during normal power operations.

- **Assumptions with respect to human system interface resources.** The human system interface design shall include an integrating overview display and mimic in the main control room.

The AP1000 design goals with respect to control room staffing are addressed in Section 18.6 and WCAP-14694 (Reference 3). As noted in WCAP-14694, a number of elements of the AP1000 human factors engineering design process are used to help achieve, verify and validate the control room staffing design goal. These include operating experience review, function analysis and allocation, task analysis, human reliability assessment, human system interface design, procedures, training, and human factors engineering verification and validation.

As described in Section 18.8, one of the human system interface resources is a wall panel information system. The wall panel information system is intended to meet the utility requirement for an integrating overview display and mimic in the main control room. A number of design activities establish the basis and functional requirements for the wall panel information system. Design activities include conducting operating experience reviews in nuclear power plants and related industries to examine the requirements for individual and group situation awareness and how these can best be supported.

Plant System Design Information

The design of the plant systems is an essential input to the human system interface design process. The physical implementation specifications as well as the systems designer's intent with regard to expected systems operation and performance are used as input to the design of the AP1000 human system interfaces. System design data are documented in the individual system specification documents. The input representing the plant's physical structure is represented by the piping and instrumentation drawings, general arrangement drawings, and equipment drawings.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

System design specifications include specifications with respect to function allocation between automated systems and human operators. The system design specifications indicate which functions are to be automated, which are to be manual, and which require joint input of person and machine. In addition, the system design specifications indicate the set of instruments and controls that are implemented in the AP1000.

The AP600 function requirements analysis and function allocation document (Reference 4) provides information on the approach to initial function allocation and presents the results for AP600 safety functions. The results include a specification of level of automation and personnel responsibility for AP1000 safety functions, processes, and systems. The results also document the rationale for function allocation decisions for AP1000 safety functions.

The report also describes human factors activities that are conducted as part of the AP1000 human system interface design process to verify the adequacy of function allocation decisions, and establish the ability of operators to perform the role assigned to them. Function-based task analyses are used to verify that the sensors and controls that are provided are sufficient to enable operators to perform the role assigned to them in system performance. Workload analyses are used to evaluate the adequacy of the integrated roles assigned to operators across systems. Integrated system validation is used to establish the adequacy of the function allocation using man-in-the-loop tests in dynamic simulated plant conditions.

Technology Limits

Recent advances in the technology of digital computing have made it possible and practical to change the performance and role of the human system interface in a process control application such as a nuclear power plant. For the AP1000, a position regarding the limits of the implementation technology to be assumed for the human system interfaces is derived from assessment of existing technology and anticipated advancements. An emphasis is placed on utilization of proven, reliable technology. The decision on the specific technology to be employed is made on a case-by-case basis after available technology alternatives are evaluated.

18.2.1.3 Applicable Facilities

[*Facilities included in the scope of the AP1000 human factors engineering program are the main control room (MCR), the technical support center (TSC), the remote shutdown room, the emergency operations facility (EOF), and local control stations.*]*

The EOF is designed as discussed in subsection 18.2.6, including specification of a location, in accordance with the AP1000 human factors engineering program. Communication with the emergency operations facility is also as discussed in subsection 18.2.6. Section 13.3 discusses the responsibility for emergency planning.

18.2.1.4 Applicable Human System Interfaces

[*The scope of the human system interfaces encompasses the instrumentation and control systems which perform the monitoring, control, and protection functions associated with all modes of plant normal operation as well as off-normal, emergency, and accident conditions. Both the*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

physical and the cognitive characteristics of those humans involved in the use, control, maintenance, test, inspection, and surveillance of plant systems are accommodated.]*

18.2.1.5 Applicable Plant Personnel

[*The AP1000 human factors engineering program and the design of the human system interfaces includes the selection, synthesis, and distribution of process data to plant operations personnel as well as other plant personnel. These additional users include management, engineering, maintenance, health physics and chemistry personnel.*]*

18.2.1.6 Technical Basis

[*The human factors engineering program is performed in accordance with accepted industry standards, guidelines, and practices.*]* The references listed at the end of each Chapter 18 section and within any supporting documentation and reports are used to guide the human factors engineering program. [*The human factors engineering process specified in Reference 1 is used.*]*

18.2.2 Human System Interface Design Team and Organization

The human system interface design team is part of the AP1000 systems engineering function and has similar responsibility, authority, and accountability as the rest of the design disciplines. Figure 18.2-1 depicts the process used by the human system interface design team members. Figure 18.2-2 shows the organization of the human system interface design team and its relationship to the AP1000 design organization.

18.2.2.1 Responsibility

[*The mission of the human system interface design team is to develop the main control room and ancillary control facilities (such as remote shutdown workstation) that support plant personnel in the safe operation and maintenance of the plant. The human system interface design team is responsible for coordinating the human factors aspects associated with designing the structures, systems, and components that make up the main control room and ancillary control facilities.*

The human system interface design team is responsible for:

- *Development of human system interface plans and guidelines*
- *Oversight and review of human system interface design, development, test, and evaluation activities*
- *Initiation, recommendation, and provision of solutions for problems identified in the implementation of the human system interface activities*
- *Assurance that human system interface activities comply with the human system interface plans and guidelines*]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

18.2.2.2 Organizational Placement and Authority

The organization of the human system interface design team and its relation to the AP1000 design organization is depicted in Figure 18.2-2. The structure of the organization may change, but the functional nature of the human system interface design team is retained through the change. The human system interface design team consists of an instrumentation and control system manager, advisors/reviewers team, core human system interface design team, and human system interface technical lead. The technical disciplines described in subsections 18.2.2.3 and 18.2.2.4 are organized by function within the core human system interface design team. The core human system interface design team and the advisors/reviewers team report to the instrumentation and control system manager. The human system interface technical lead works within the human system interface design function and reports to the instrumentation and control system manager through the manager of the human system interface design function. The instrumentation and control system manager is responsible for the design of the AP1000 instrumentation and control systems which include the human system interfaces. The instrumentation and control system manager reports to the AP1000 project manager.

The manager of the human system interface design function, who performs the function of technical project management for the human factors engineering design process, is responsible for the overall human system interface design and for integration of the human system interface design with the overall plant design. The advisors/reviewers team is responsible for overseeing the general progress of the human system interface design, providing guidance within the core human system interface design team, reviewing and providing comments on documents, specifications, and drawings pertaining to the human system interface design, and providing supplemental expertise in particular areas of design. The responsibility of the core human system interface design team is to produce the detailed design of the human system interfaces. The human system interface design function is responsible for the functional design of the human system interfaces, main control room and workstation layout (ergonomics), controls, the information system (displays), the wall panel information system, the qualified data processing system, the alarm system, and computerized procedures system design and specification. The responsibilities of the human system interface technical lead include coordinating the technical work of the functional engineering groups, providing the administrative and technical interface between the functional engineering groups and the advisors/reviewers team, and tracking the identification and resolution of human factors engineering design issues through operating experience review.

18.2.2.3 Composition

[*The human system interface design team consists of a multi-disciplinary technical staff. The team is under the leadership of an individual experienced in the management of the design and operation of process control facilities for complex technologies. The technical disciplines of the design team include:*

- *Technical project management*
- *Systems engineering*
- *Nuclear engineering*
- *Instrumentation and control (I&C) engineering*
- *Architect engineering*

- *Human factors engineering*
- *Plant operations*
- *Computer system engineering*
- *Plant procedure development*
- *Personnel training*
- *Systems safety engineering*
- *Maintainability/inspectability engineering*
- *Reliability/availability engineering*]*

The responsibilities of the individual technical disciplines include:

- Technical Project Management
  - Provide central point of contact for management of the human factors engineering design and implementation process
  - Develop and maintain schedule for human factors engineering design process
- Systems Engineering
  - Provide knowledge of the purpose, technical specifications, and operating characteristics of plant systems
  - Provide input to human factors engineering task analyses
  - Participate in development of procedures and scenarios for task analyses, and integrated system validation
- Nuclear Engineering
  - Provide knowledge of the processes involved in reactivity control and power generation
  - Provide input to human factors engineering task analyses
  - Participate in development of scenarios for task analyses, and integrated system validation
- Instrumentation and Control (I&C) Engineering
  - Provide knowledge of control and display hardware design, selection, functionality, and installation
  - Provide input to software quality assurance programs
  - Participate in the design, development, test, and evaluation of the human system interfaces

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

- Architect Engineering
  - Provide knowledge of plant component layout and the overall structure of the plant including design characteristics and performance requirements for the containment building, control room, remote shutdown room, and local control stations
  - Provide input to human factors engineering task analyses
  - Participate in development of scenarios for task analyses, and integrated system validation
- Human Factors Engineering
  - Provide knowledge of human performance capabilities and limitations, human factors design and evaluation practices, and human factors principles, guidelines, and standards
  - Develop and perform human factors analyses and participate in resolution of human factors problems
- Plant Operations
  - Provide knowledge of operational activities relevant to characterizing tasks and environment and development of human system interface components, procedures, and training programs
  - Participate in development of scenarios for task analyses, and integrated system validation
- Computer System Engineering
  - Provide knowledge of data processing required for human system interface displays and controls
  - Participate in design and selection of computer-based equipment
  - Participate in development of scenarios for task analyses, and integrated system validation, particularly those involving failures of the human system interface data processing systems
- Plant Procedure Development
  - Provide knowledge of operational tasks and procedure formats
  - Provide input for development of emergency operating procedures, computer-based procedures, and training systems
  - Participate in development of scenarios for task analyses, and integrated system validation

- Personnel Training
  - Develop content and format of personnel training programs
  - Participate in development of scenarios for task analyses, and integrated system validation
- Systems Safety Engineering
  - Identify safety concerns
  - Perform system safety hazard analysis such as thermal atmospheric analysis, toxicology analysis, and radiological analysis
- Maintainability/Inspectability Engineering
  - Provide knowledge of maintenance, inspection, and surveillance activities
  - Provide input in the areas of maintainability and inspectability
  - Support design, development, and evaluation of control room and other human system interface components
  - Participate in development of scenarios for task analyses, and integrated system validation
- Reliability/Availability Engineering
  - Provide knowledge of plant system and component reliability and availability and assessment methodologies
  - Provide input to design of human system interface equipment
  - Participate in development of scenarios for task analyses, and integrated system validation

18.2.2.4 Team Staffing Qualifications

In choosing the human system interface design team members, greater emphasis is placed on the individual's relevant experience to the specific discipline than on formal education. Alternative personal credentials may be selectively substituted for the education and experience requirements specified below. The professional experience of the human system interface design team as a

collective whole satisfies the experience qualifications. The human system interface design team members have the following backgrounds:

- Technical Project Management
  - Bachelor's degree
  - Five years experience in nuclear power plant design or operations and three years of management experience
- Systems Engineering
  - Bachelor of Science degree
  - Four years of cumulative experience of the following areas of systems engineering: design, development, integration, operation, and test and evaluation
- Nuclear Engineering
  - Bachelor of Science degree
  - Four years of experience in the following areas of nuclear engineering: design, development, test, or operations
- Instrumentation and Control (I&C) Engineering
  - Bachelor of Science degree
  - Four years of experience in hardware and software design aspects of process control systems; familiarity with software quality assurance and control
  - Experience in at least one of the following areas of instrumentation and control engineering: development, power plant operations, test evaluations
- Architect Engineering
  - Bachelor of Science degree
  - Four years experience in design of power plant structures and building services
- Human Factors Engineering
  - Bachelor's degree in Human Factors Engineering, Engineering Psychology, or related science
  - Four years experience in the following areas of human factors engineering: human factors aspects of human system interfaces (design, development, and test and evaluation of human system interfaces for process control applications) and four years

experience in human factors aspects of workplace design (design, development, and test and evaluation of workplaces)

- Plant Operations
  - Current or prior senior reactor operator (SRO) license/senior reactor operator instructor certification
  - Two years experience in PWR nuclear power plant operations
- Computer System Engineering
  - Bachelor's degree in Electrical Engineering or Computer Science or graduate degree in other engineering discipline
  - Four years experience in design of computer systems and real-time system applications; familiarity with software quality assurance and control
- Plant Procedure Development
  - Bachelor's degree
  - Four years experience in developing nuclear power plant operating procedures
- Personnel Training
  - Bachelor's degree
  - Four years experience in the development of personnel training programs for power plants and experience in the application of systematic training development methods
- Systems Safety Engineering
  - Bachelor of Science degree or Bachelor's degree in Science
  - Experience in system safety engineering, such as thermal atmospheric analysis, toxicology, radiological analysis and applicable OSHA limits
- Maintainability/Inspectability Engineering
  - Bachelor of Science degree or Bachelor's degree in Science
  - Four years of cumulative experience in at least two of the following areas of power plant maintainability and inspectability engineering activity: design, development, integration, test and evaluation, and analysis/resolution of maintenance problems.

- Reliability/Availability Engineering

  – Bachelor's degree

  – Four years of cumulative experience in at least two of the following areas of power plant reliability engineering activity: design, development, integration, and test and evaluation. Knowledge of computer-based, human system interfaces.

18.2.3 Human Factors Engineering Processes and Procedures

Activities performed relating to human factors engineering are performed in accordance with documented procedures under the quality assurance program for the AP1000. These procedures provide for control of processes as described below.

18.2.3.1 General Process and Procedures

The instrumentation and control system function is responsible for development of the AP1000 instrumentation and control (I&C), including human system interfaces, and coordinating and integrating AP1000 instrumentation and control and human system interfaces with other AP1000 plant design activities. The overall operation of the project instrumentation and control systems function is defined. The function includes human system interface design of control rooms and control boards, instrumentation and control design, and control room/equipment design. The function includes definition of an engineering plan, review of inputs, production of system documentation, verification of work, procurement and manufacturing follow-up, and acceptance testing. An iterative feature is built into the process.

Documents produced as part of the instrumentation and control and human system interface design process include:

- Operating experience review documents
- Task analysis documents
- Functional requirements documents
- Human system interface design guidelines documents
- Design specification documents
- Instrumentation and control architecture diagrams
- Block diagrams
- Room layout diagrams
- Instrumentation lists
- System specification documents

The procedures governing instrumentation and control engineering work specify methods for verification of work. The types of verification include:

- Design verification by design reviews
- Design verification by independent review/alternative calculations
- Design verification by testing

System Specification Documents

System specification documents identify specific system design requirements and show how the design satisfies the requirements. They provide a vehicle for documenting the design and they address information interfaces among the various design groups.

System specification documents follow established format and content requirements. The content of a system specification document includes:

- Purpose of the system
- Functional requirements and design criteria for the system
- System design description including system arrangement and performance parameters
- Layout
- Instrumentation and control requirements
- Interfacing system requirements

The section on interfacing system requirements describes the support needed from and provided to other systems.

System specification documents document human factors and human system interaction requirements. This includes specification of task requirements, information requirements, and equipment requirements for operations, surveillance, test, and maintenance activities.

System specification documents provide specification of instrument and control requirements including:

- System input to the I&C channel list
- Reference to control logic diagrams
- Alarm requirements and characteristics
- Requirements and characteristics of plant status indications

A system specification document for the operation and control centers system provides a mechanism for documenting and tracking human system interface requirements and design specifications. The operation and control centers system specification document is the umbrella document for capturing generic human factors requirements. It provides a uniform operational philosophy and a design consistency among human system interface resources, including alarm system, plant information system, wall panel information system, and computerized procedures.

Functional requirements and design specifications for the AP1000 operation and control centers system, including the main control room, the technical support center, the remote shutdown room, and local control stations are provided in the operation and control centers system specification document. Functional requirements documents and design specification documents are generated for each of the individual human system interface resources (including alarm system, plant information system, wall panel information system, computerized procedures, controls). Functional requirements documents specify the applicable codes, standards, and design requirements and constraints to be met by the design. These documents are referenced by the operation and control centers system specification document.

Design specification documents provide the design specifications for individual human system interface resources and their integration. Included in these specifications are layout and arrangement drawings, algorithms, and display system descriptions, including display task descriptions, display layouts, and navigation mechanisms.

The operation and control centers system specification document, the functional requirement documents, and design specification documents provide input to the generation of I & C system specification documents such as the system specification document for the data display and processing system.

Design Configuration Change Control Process

Design changes are controlled to assure that proposed changes to design documents under configuration control are appropriately evaluated for impacts and that approved changes are communicated to the responsible design organizations.

The design configuration change control process is used to control and implement changes to the design. It is used when the design to be changed has been previously released in a document for project use and placed under configuration control. A design change proposal is the vehicle used to initiate and document review of proposed design changes. Design change proposals include identification of impacts of the proposed design change from affected functional groups. In some instances, human factors engineering issues are addressed by the initiation of design change proposals. In other instances, they are addressed as a consequence of human factor engineering review of design change proposals originating from other disciplines. Design change proposals are maintained in a database that is used to track the status of each design change proposal from initiation through implementation and closure.

Design Review of Human Factors Engineering Products

Design reviews by a multi-disciplined review team are established as a verification method. Requirements for the design review process, including selection of the review team, preparation of information for review, identification and follow of action items, and documentation of the proceedings, are defined.

Design reviews provide a method of design verification consisting of a systematic overall evaluation of a design that is conducted by an independent design review team. Design reviews are conducted at appropriate stages of design development to provide an objective, independent review of design adequacy, safety, performance, and cost. Design reviews are performed by persons not directly associated with the specific design development, but who, as a group, are knowledgeable in the appropriate technical disciplines.

Original designs, as well as major design changes, are subject to the design review process. For each design review, a design review data package is prepared. It includes checklists, including one specifically addressing human factor engineering questions, which are used by design review committee members to aid their review. For each design issue identified through the use of checklists or otherwise, an action item is initiated.

[*Action items are tracked through the design issues tracking system database as described in subsection 18.2.4. The responsibility of entering design review action items into the design issues tracking system database is assigned to the manager responsible for the system reviewed. The responsible design manager is responsible for tracking and addressing open action items.*]*

18.2.3.2 Process Management Tools

Tools are provided to facilitate communication across design disciplines and organizations to enhance consistency. An AP1000 design database enables parties involved in the engineering design of the plant to access up-to-date plant design data. Procedures define requirements and responsibilities for moving data into the database.

Tools are provided to guide the design review process. These include design review checklists that support evaluation of design adequacy, and a database for tracking action items generated as a result of the design review process. Further details on the process of tracking action items generated by design reviews are provided in subsections 18.2.3.1 and 18.2.4.

A design configuration change control process is used to control and implement proposed design changes. Design change proposals are maintained in a database that is used to track the status of each design change proposal from initiation through implementation and closure.

A design issues tracking system database is used to document and track design issues that are identified during the plant design process. Further details on the design issues tracking system are provided in subsection 18.2.4.

18.2.3.3 Integration of Human Factors Engineering and Other Plant Design Activities

The AP1000 design process provides for the integration of human factors engineering activities among the design groups.

The instrumentation and control systems design function is responsible for the development of the AP1000 instrumentation and control systems, including the human system interface. Coordination and integration of the instrumentation and control and human system interface design with other plant design activities is performed by the instrumentation and control systems design function. An iterative design process that includes review and feedback from other engineering and design groups at the design interface is specified. Subsection 18.2.3.1 describes the responsibilities and design process of the instrumentation and control system design function.

System specification documents provide the primary vehicle for transmitting system design data and interface requirements, including human factors engineering and human system interface requirements, to the affected AP1000 design and analysis groups. The system specification documents include a section on interfacing system requirements that describes the support needed from and provided to other systems in the plant. Interface control is performed at the design interfaces and design changes affecting the interfaces are coordinated. Subsection 18.2.3.1 provides details on system specification documents.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

A design configuration change control process provides the process and actions to implement design changes. Subsection 18.2.3.1 provides further details on this process.

Engineering design databases serve as a repository of AP1000 design data for parties involved in engineering design activities of the plant. A technical document control system is used to track the status of AP1000 documents. By using the engineering design databases and the technical document control system, parties have access to up-to-date design data to perform their respective design activities.

Section 18.8 presents the implementation plan for the design of the human system interface. Figure 18.2-3 provides an overview of the AP1000 human factors engineering process, including the design stages of the human system interface. The relationship of other human factors engineering process elements to the human system interface design is shown.

18.2.3.4 Human Factors Engineering Documentation

Procedures address documentation for AP1000, including document preparation, review, retention, access, and configuration control. These procedures apply to all AP1000 activities, including human factors engineering.

Documents refer to any self contained portrayal of the AP1000 design or its basis. These include design criteria, descriptions, specifications, drawings, analysis reports, safety reports and calculations.

A procedure establishes requirements and responsibilities for the preparation, review, and approval of AP1000 design documents. The procedure specifies that documents are to be reviewed by appropriate reviewers, and comments are to be resolved prior to issuance of the document. Appropriate reviewers include responsible engineers or managers impacted by the information in the document.

Changes to released documents are reviewed and approved in accordance with the design configuration change control procedure for the AP1000 program.

Procedures establish content and format requirements for system specification documents. Other procedures addressing documentation requirements include those for design configuration change control, design reviews, design criteria, and control of subcontractor submittals.

Sections 18.3 through 18.12 provide information on the types of documents that are generated as part of the AP1000 human factors engineering program.

18.2.3.5 Human Factors Engineering in Subcontractor Efforts

Human factors engineering and human system interface requirements are passed on to subcontractors through engineering documents including design criteria and system specification documents.

Activities within subcontractor design organizations are performed in accordance with the written procedures of those organizations. [*The AP1000 Program Procedure Matrix in WCAP-15847 (Reference 6) identifies the procedures that apply to subcontractor design organizations. The procedures of WCAP-15847 that describe the design documentation, apply to these external organizations with respect to content and format requirements. Effective implementation of each organization's quality assurance program is monitored by their respective internal audit programs, and by supplier audits.*]* See Section 17.3 for quality assurance requirements associated with subcontractor human factors engineering design efforts.

18.2.4 Human Factors Engineering Issues Tracking

A tracking system is used to address human factors issues that are known to the industry and/or identified throughout the life cycle of the human factors engineering/human system interface design, development, and evaluation. The tracking system enables the documentation and tracking of issues that need to be addressed at some later date.

Tracking of human factors engineering issues is accomplished within the framework of the overall plant design process. In this manner, human factors engineering issues are addressed in the same way as those for other disciplines.

[*The design issues tracking system database is used to track AP1000 design issues to resolution, including human factors engineering issues. This database receives input from the following three sources:*

- *Operating experience review*
- *Design reviews*
- *Design issues associated with the design of the human system interface and the operation and control centers system*]*

For each design issue entered into the database, the actions taken to address the issue and the final resolution of the issue are documented.

The human factors issues in the operating experience review report (Reference 1) that are identified as requiring further consideration by the AP1000 design are entered into the design issues tracking system database.

[*The design review process also provides input to the design issues tracking system database. For each design issue identified through the design review process, an action item is initiated. Action items are entered into the design issues tracking system database. Human factors action items from design reviews are included in the database. For preliminary and intermediate design reviews, some action items may be deferred to a more appropriate, subsequent design review. The responsibility of entering design review action items into the design issues tracking system database is assigned to the manager responsible for the system reviewed.*]*

Human factors engineering design issues directly associated with the AP1000 human system interfaces and the operation and control centers system (such as the main control room, remote shutdown room, and technical support center) are entered into the design issues tracking system

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

database. These are design issues that are identified by the human system interface and operation and control centers system designers as issues that need to be addressed by the human system interface design.

The AP1000 project manager, as shown on Figure 18.2-2, is responsible for the maintenance and documentation of the design issues tracking system. For each issue entered into the design issues tracking system database, a "responsible engineer" field is used to assign an engineer the responsibility for resolution of the issue.

18.2.5 Human Factors Engineering Technical Program and Milestones

[*The human factors engineering program is performed in accordance with the human factors engineering process specified in NUREG-0711 (Reference 1).*]* Figure 18.1-1 shows the elements of the AP1000 human factors engineering program. [*These elements conform to the elements of the Program Review Model specified in Reference 1, as augmented by Reference 7.*]*

Human factors engineering Program Management is addressed in Section 18.2. The remaining elements are addressed in Sections 18.3 through 18.11, 18.13, and 18.14.

These sections address the activities conducted as part of the corresponding human factors engineering element, including the accepted industry standards, guidelines, and practices used as technical guidance, the inputs to the element, and the products, including documents that are generated as output. The facilities, equipment, and tools employed are also addressed in the section corresponding to each element.

Figure 18.2-3 provides an overview of the Westinghouse human factors engineering process. The figure summarizes the major activities of the human factors engineering program, their relative order, and the inputs and outputs for the major activities. The boxes in the diagram indicate major human factors engineering activities. The activities are presented in approximate chronological order, with the outputs of each activity serving as inputs to subsequent activities. The items listed below the activity boxes are the document outputs from that human factors engineering activity. The human factors engineering process includes iterations considering the outcomes of subsequent analysis and design activities, design reviews, and testing. In this approach, design issues are addressed and resolved through the iterative stages of the human factors engineering process. Potential points of iteration are indicated in Figure 18.2-3. Further details on the activities, inputs, and output documents associated with the various elements of the human factors engineering program are provided in the sections corresponding to each human factors engineering element.

Figure 18.2-3 provides a program milestone schedule of human factors engineering tasks showing relationships between human factors engineering elements and activities, products, and reviews. Internal design reviews are performed at various points throughout the design process.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

18.2.6 Combined License Information

18.2.6.1 Human Factors Engineering Program

The Combined License information requested in this subsection has been fully addressed in APP-OCS-GBH-001 (Reference 8), and the applicable changes are incorporated into the DCD. No additional work is required by the Combined License applicant to address the Combined License information requested in this subsection. The work that has been done is summarized in the following paragraph:

> The AP1000 Human Factors Engineering Program Plan (Reference 8) fully captures the information certified in Section 18.2. Reference 8 provides execution guidance for the NRC-approved HFE program. The ongoing confirmation that the AP1000 HFE Program Plan is being executed as required is demonstrated by fulfillment of the other COL Information Items in Chapter 18. The final confirmation that the HFE Program Plan has been executed will be demonstrated by completion of the ITAAC (Tier 1 Material, Table 3.2-1, Items 1 to 13).

The following words represent the original Combined License Information Item commitment, which has been addressed as discussed above:

> The Combined License applicant referencing the AP1000 certified design is responsible for the execution of the NRC approved human factors engineering program as presented by Section 18.2.

18.2.6.2 Emergency Operations Facility

The Combined License information requested in this subsection has been partially addressed in Reference 9 (APP-GW-GLR-136). No additional work is required to address the information as delineated in the following paragraph:

> Reference 9 captures the method by which the AP1000 Human Factors Engineering Program Plan (Reference 8) will be applied to TSCs and EOFs that support an AP1000 plant.

The following activities are to be addressed by the Combined License applicant:

> Specific information regarding EOF and TSC communications, and EOF and TSC human factors attributes will be provided by the Combined Operating License applicant to address the Combined License information requested in this subsection.

The following words represent the original Combined License Information Item commitment, which has been addressed as discussed above:

> The Combined License applicant referencing the AP1000 certified design is responsible for designing the emergency operations facility, including specification of the location, in accordance with the AP1000 human factors engineering program.

18.2.7 References

[*1. NUREG-0711, "Human Factors Engineering Program Review Model," U.S. NRC, July 1994.*]*

2. WCAP-14645, "Human Factors Engineering Operating Experience Review Report For The AP1000 Nuclear Power Plant," Revision 3.

3. WCAP-14694, "Designers Input to Determination of the AP600 Main Control Room Staffing Level," Revision 0, July 1996.

4. WCAP-14644, "AP600/AP1000 Functional Requirements Analysis and Allocation," Revision 1.

5. Reason, J. T., "Human Error," Cambridge, U.K., Cambridge University Press, 1990.

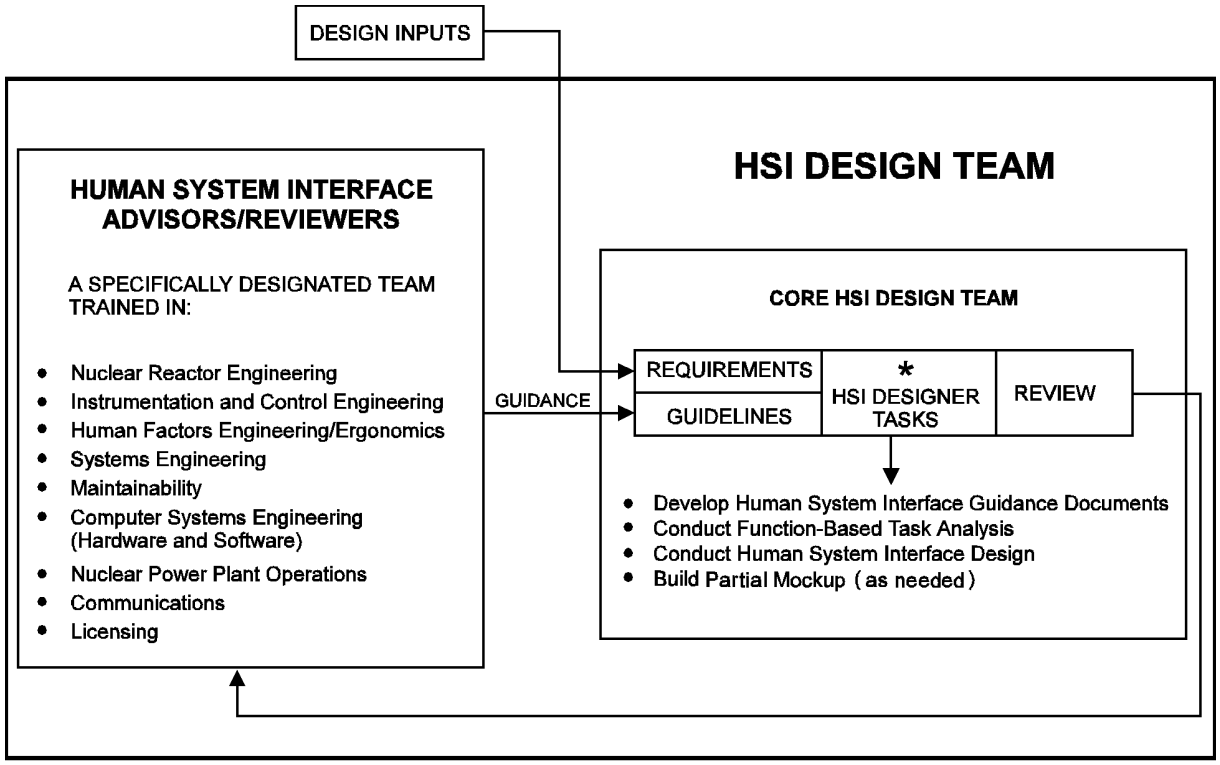
[*6. WCAP-15847, "AP1000 Quality Assurance Procedures Supporting NRC Review of AP1000 DCD Sections 18.2 and 18.8," Revision 1, December 2002.*]*

[*7. NUREG-0711, Rev. 1, "Human Factors Engineering Program Review Model," U.S. NRC, May 2002.*]*

8. APP-OCS-GBH-001, "AP1000 Human Factors Engineering Program Plan," Westinghouse Electric Company LLC.

9. APP-GW-GLR-136, "AP1000 Human Factors Program Implementation for the Emergency Operations Facility and Technical Support Center," Westinghouse Electric Company LLC.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.



* FOR EACH HSI TASK, THE HSI ADVISORS/REVIEWERS WILL PERFORM THE FOLLOWING:

- Provide Advisory Input/Guidance
- Review Task Table of Contents and Abstract Prepared by HSI Designers
- Review Intermediate Draft Document
- Review Final Document
- Review Overall Compatibility in the Design

Figure 18.2-1

[Human System Interface (HSI) Design Team Process]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

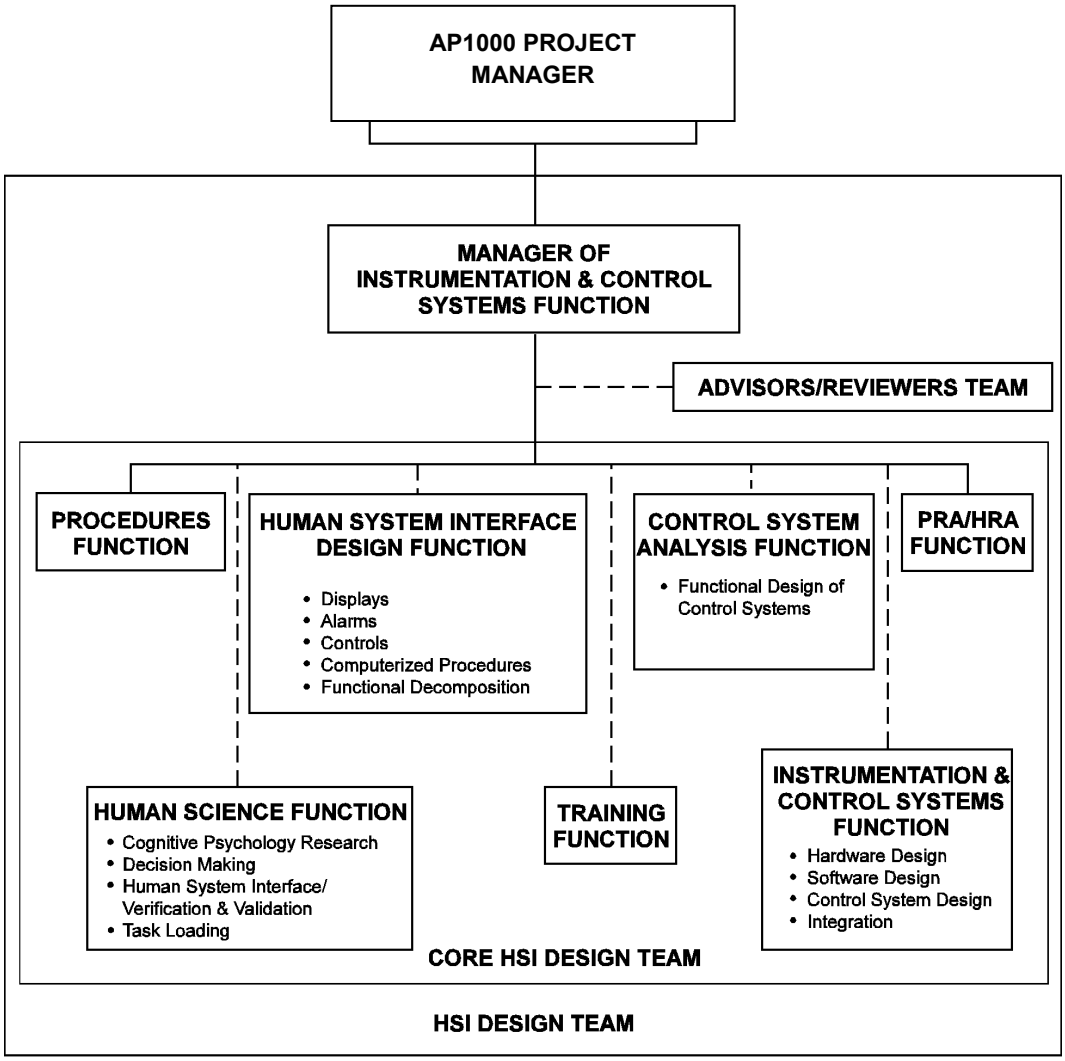


Figure 18.2-2

Human System Interface (HSI) Design Team Organization and Relationship to AP1000 Organization

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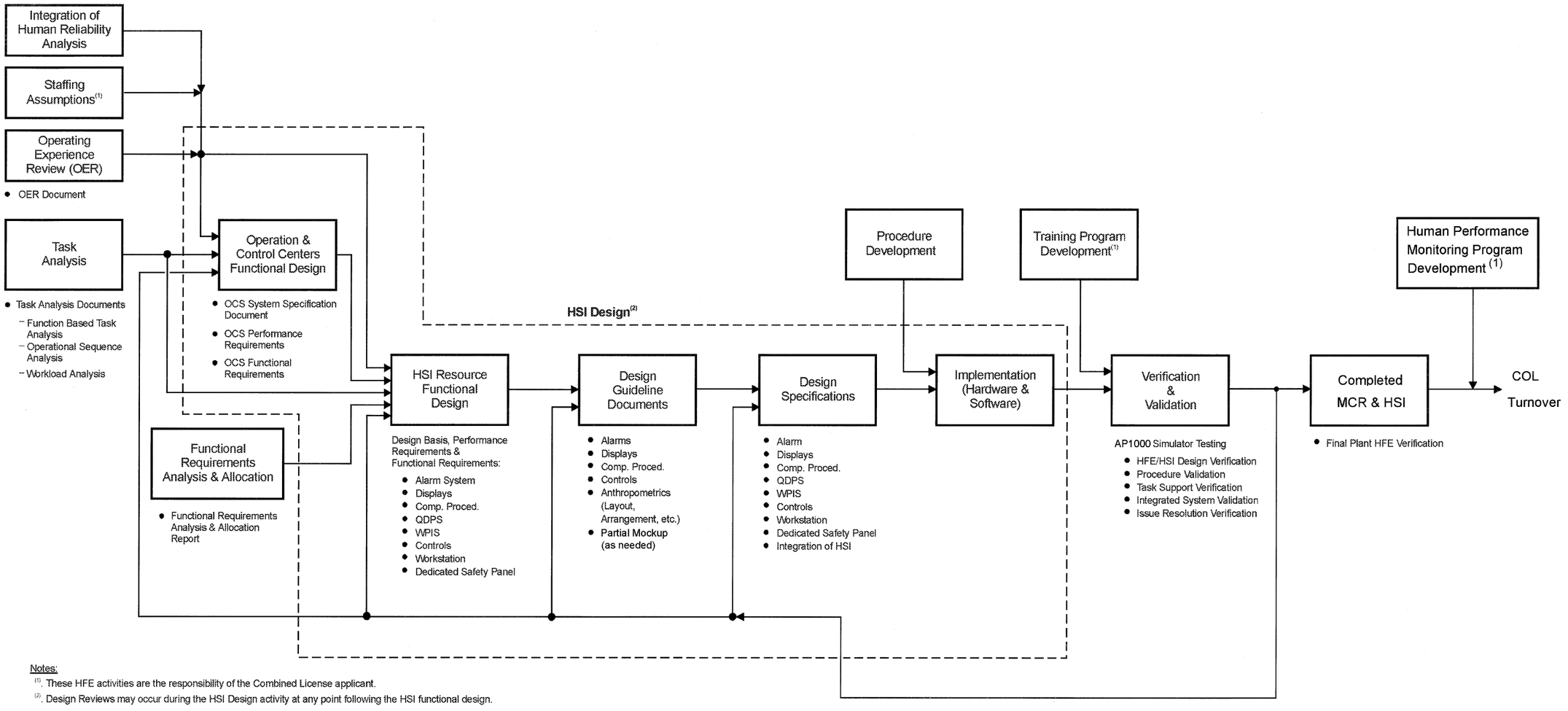

Figure 18.2-3

Overview of the AP1000 Human Factors Engineering Process