18.5 AP600 Task Analysis Implementation Plan

[*Task analysis, according to the Human Factors Engineering Program Review Model (Reference 1), has the following objectives:*

- *Provide one of the bases for the human system interface design decisions*
- *Match human performance requirements with human capabilities*
- *Provide input to procedure development*
- *Provide input to staffing, training, and communications requirements of the plant*]*

This section describes the scope of the AP600 task analysis activities and the task analysis implementation plan. In addition to Reference 1, References 2 through 12 are inputs to this plan. Execution and documentation of this task analysis implementation plan is the responsibility of the Combined License applicant.

18.5.1 Task Analysis Scope

[*The scope of the AP600 task analysis is divided into two complementary activities: function-based task analysis (FBTA) and traditional task analysis, or operational sequence analysis (OSA). The scope of the function-based task analysis is the Level 4 functions*]* identified in Figure 18.5-1. This figure is the functional decomposition (goal-means analysis) for normal power operations in a standard pressurized water reactor. Examples of functions at Level 4 are "Control RCS Coolant Pressure" and "Control Containment Pressure." This set of functions define the breadth of functions to be analyzed. The function-based task analysis will be expanded in scope to include any additional Level 4 functions identified.

[*The traditional task analysis, or operational sequence analysis, is developed for a representative set of operational and maintenance tasks. The following guidelines are applied to select tasks:*

- *Tasks are selected to represent the full range of operating modes, including startup, normal operations, abnormal and emergency operations, transient conditions, and low-power and shutdown conditions.*

- *Tasks are selected that involve operator actions that are identified as either critical human actions or risk-important tasks, based on the criteria in Reference 13.*

- *Tasks are selected to represent the full range of activities in the AP600 emergency response guidelines.*

- *Tasks are selected that involve maintenance, test, inspection, and surveillance (MTIS) actions. A representative set of maintenance, test, inspection, and surveillance tasks are analyzed for a subset of the "risk-significant" systems/structures/components (SSCs).*

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

The set of tasks to be analyzed are not identified as a part of design certification. The OSAs listed below are included in the set of tasks to be analyzed: (Each of these satisfies one or more of the selection criteria described above.)

- *Plant heatup and startup from post-refueling to 100% power*
- *Reactor trip, turbine trip, and safety injection*
- *Natural circulation cooldown (startup feedwater with steam generator)*
- *Loss of reactor or secondary coolant*
- *Post loss-of-coolant accident cooldown and depressurization*
- *Loss of RCS inventory during shutdown*
- *Loss of the normal residual heat removal system (RNS) during shutdown*
- *Manual automatic depressurization system (ADS) actuation*
- *Manual reactor trip via PMS, via diverse actuation system (DAS)*
- *ADS valve testing during Mode 1*

The human factors engineering program review model (Reference 1) indicates that task analysis should include tasks that are considered to be high-risk and tasks that require critical human actions. Reference 13 defines criteria for critical human actions and risk-important tasks and has identified a list of examples of AP600 tasks that meet these criteria.]*

Section 16.2 identifies the systems/structures/components included in the Reliability Assurance Program. A subset of these systems/structures/components and a representative set of associated maintenance, tests, inspection and surveillance tasks will be selected by an expert panel. This panel will be comprised of representatives with expertise from relevant groups in the design process, such as systems engineering, reliability engineering, probabilistic risk analysis, human factors engineering, and human system interface design. The set of maintenance, test, inspection and surveillance tasks identified through the expert panel process will be considered to be "risk important" tasks, and will be included in task analysis activities.

18.5.2 Task Analysis Implementation Plan

Figure 18.5-2 shows the proposed sequence of task analyses. Figure 18.5-2 provides information concerning the task analysis and human system interface design elements. [*Task analysis includes both a function-based task analysis and an operational sequence analysis.*]* In Figure 18.5-2, the operational sequence analysis in the task analysis box is designated as OSA-1 since two operational sequence analyses will be implemented.

18.5.2.1 Function-Based Task Analyses

Function-based task analysis is applied to each of the Level 4 functions. There are four components to a function-based task analysis. First, analysis is performed to identify the set of goals relevant to the function. Second, a functional decomposition is performed. This decomposition identifies the processes that, either individually or in combination, have a significant effect on the function. Third, a process analysis is performed by applying a set of questions derived from Rasmussen's model (References 6-9) analysis approach. [*The set of questions used and basis for the methodology is provided in Reference 12.*]* An example

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

of a question from the process analysis is "Are the process data valid?" The results of the process analysis identify the indications, parameters, and controls that the operator uses to make decisions about the respective function. Finally, there is a verification that the indications and controls, identified in the process analysis are included in the AP600 design.

From the function-based task analyses, the following types of information are obtained:

- A completeness check on the availability of needed indications, parameters, and controls. This includes indications and controls needed for supervisory control of automated systems and manual over-ride.

- Input to the specification and layout of functional displays.

18.5.2.2 OSA-1

The operational sequence analysis completed as part of the task analysis process focuses on specifying the operational requirements for the complete set of tasks selected. For each task, an operational sequence diagram of the task's performance is created that includes the following:

- Plant state data required at each step
- Source of the data (alarm, display, oral communication)
- Action to be taken or decision to be made from the data
- Relevant criterion or reference values
- Information that provides feedback on the action's adequacy
- Time available for action
- Other temporal constraints (ordering, tasks that need to be done in parallel)
- Task support requirements needed (required tools)
- Considerations of work environment

The operational sequence diagrams are developed from the emergency response guidelines, the Probabilistic Risk Assessment event sequences associated with critical or risk-important actions, and the function-based task analysis. The following potential limitations on task performance are considered:

- Limits on human performance
- Limits on hardware and software performance
- Limits on crew communications

This first operational sequence analysis provides the following types of information:

- Frequency and co-occurrence of plant state parameters and controls
- Display design and organization constraints
- Performance time constraints
- Inventory of alarms, controls, and parameters needed to perform the sequences

As shown in Figure 18.5.2, the function-based task analysis and OSA-1 feed into the human system interface design by providing a set of requirements and constraints on task performance. The display and operator workstation design is based on this information.

[*During human system interface design activities, concepts are tested by evaluating human performance in simulated tasks using prototype interface elements (Reference 14).*]* By prototyping, testing, and refining human system interface design concepts, the design moves toward the appropriate performance criteria.

18.5.2.3 OSA-2

The critical issues for the second operational sequence analysis are:

- Completeness of available information – This analysis determines whether necessary information is available to the operator performing the task activities. The human system interface design indicates the number of human system interface elements that are used for each action or decision to occur.

- Time to perform tasks – Operational sequence modeling tools are used to provide a set of performance time assumptions and then determine the time required for actions to be completed. Assumptions can be made about minimum times to access displays and controls and, by running the task modeling network with these assumptions, the time required to perform tasks can be determined. The operational sequence analysis begins with conservative assumptions regarding the performance of hardware, software, and humans, and assumes minimal use of parallel task performance. These assumptions provide a conservative estimate of task performance times that can be compared to performance time requirements.

- Operator workload measures – Task network modeling tools are used to evaluate the effect of the human system interface design on operator workload. Operator workload can be assessed at three levels of detail. First, workload can be measured against time available to perform each task related to time estimates to perform. When time to perform estimates are larger than the time available, operator workload is too high, and some corrective action is required. Second, operator workload estimates can be broken out into resource "channels." Typically, an analysis uses four to six independent channels, which may include visual, auditory, verbal, cognitive, psychomotor, and kinesthetic channels. For each task or activity, an assessment is made about the level of activity in each channel. When the task network model is executed, the workload values are accumulated over short time intervals (for example, every 2 seconds). Workload values on each channel are graphed and the analyst identifies points in task performance where workload exceeds some threshold value. When workload is too high, due either to demands from concurrent tasks or demands from a single task, some corrective action is required. The third approach to estimating operator workload is to add a consideration of cross-channel interference. Workload theories indicate that, although it is useful to think of multiple mental resources being tapped by task performance, there is also a need to be concerned with interference between concurrent activities. Several tools make it

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

possible to extend the analysis of separate channels and create an interference matrix that reveals additional demands on operator workload. These tools use task rating schemes with built-in assumptions about interference to produce the additional workload estimates.

- Operational crew staffing – The workload operational sequence analysis provides an indication of the adequacy of staffing assumptions. In cases where the operational sequence analysis indicates high operator workload values, or insufficient time available for performance, alternative staffing assumptions or changes to the human system interface design or task allocation to reduce operator workload is evaluated.

This second operational sequence analysis is performed for a representative subset of tasks that include the critical human actions and risk-important tasks and tasks that have human performance concerns (for example, potential for high workload or high error rates).

18.5.2.4 Task Analysis of Maintenance, Test, Inspection and Surveillance Tasks

The maintenance, test, inspection, and surveillance tasks that are identified to be "risk-important" are analyzed using operational sequence task analyses. OSA-1 analyses are conducted on the set of maintenance, test, inspection, and surveillance tasks identified to be "risk-important."

18.5.3 Job Design Factors

Section 18.6 addresses the control room staffing that applies to the AP600. The staffing level of the main control room, job design considerations, and crew skills are the responsibility of the Combined License applicant.

18.5.4 Combined License Information Item

Combined License applicants referencing the AP600 certified design will address the execution and documentation of the task analysis implementation plan presented in Section 18.5.

Combined License applicants referencing the AP600 certified design will document the scope and responsibilities of each main control room position, considering the assumptions and results of the task analysis.

18.5.5 References

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

2. U.S. NRC Guidance, NUREG/CR-3371, "Task Analysis of Nuclear Power Plant Control Room Crews."

3. IEC-964, "Design for Control Rooms of Nuclear Power Plants."

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

4. Department of Defense Documents: DI-H-7055, "Critical Task Analysis Report," and MIL-STD-1478, "Task Performance Analysis."

5. NATO Document, "Applications of Human Performance Models to System Design," edited by McMillan, Beevis, Salas, Strub, Sutton, & van Breda, New York: Plenum Press, 1989.

6. Rasmussen, J., "Information Processing and Human-Machine Interaction, An Approach to Cognitive Engineering," New York: North-Holland, 1986.

7. Hollnagel, E. and Woods, D. D., "Cognitive Systems Engineering: New Wine in New Bottles," International Journal of Man-Machine Studies, Volume 18, 1983, pages 583-600.

8. Roth, E. and Mumaw, R., "Using Cognitive Task Analysis to Define Human Interface Requirements for First-of-a-Kind Systems," Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting, San Diego, Ca., 1995, pp. 520-524.

9. Vicente, K. J., "Task Analysis, Cognitive Task Analysis, Cognitive Work Analysis: What's the Difference?" Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting, San Diego, Ca., 1995, pp. 534-537.

10. Drury, C. G., Paramour, B., Van Cott, H. P., Grey, S. N., and Corlett, E. N., "Task Analysis," Handbook of Human Factors, Salvendy, G. (ed.), New York: John Wiley & Sons, 1987.

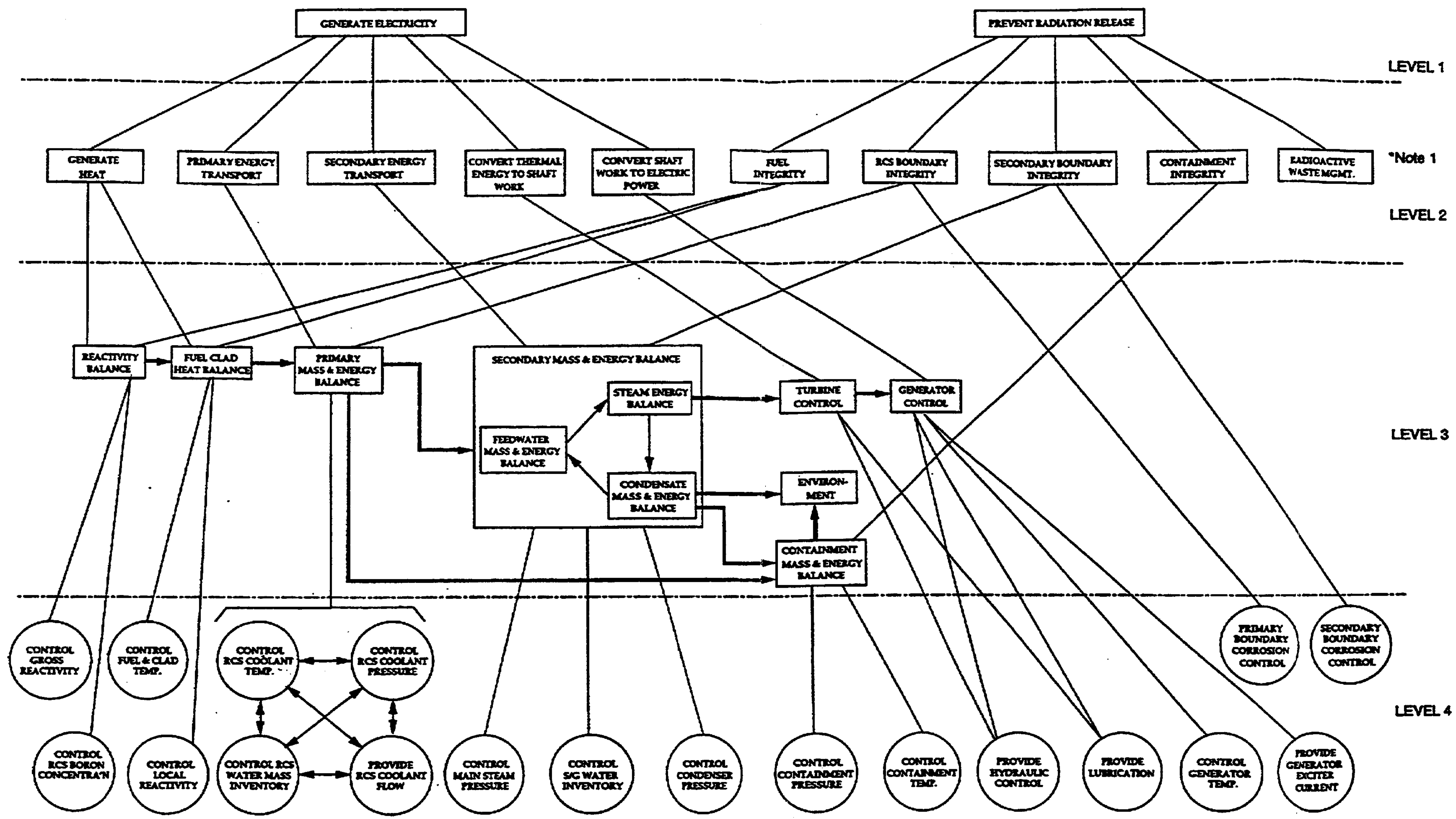
11. Woods, D. D., "Application of Safety Parameter Display Evaluation Project to Design of Westinghouse SPDS," Appendix E to "Emergency Response Facilities Design and V & V Process," WCAP-10170, submitted to the U.S. Nuclear Regulatory Commission in support of their review of the Westinghouse Generic Safety Parameter Display System (Non-Proprietary) (Pittsburgh, PA, Westinghouse Electric Corp.), April 1982.

[*12. WCAP-14695, "Description of the Westinghouse Operator Decision Making Model and Function Based Task Analysis Methodology," Revision 0, July 1996.*]*

[*13. WCAP-14651, "Integration of Human Reliability Analysis and Human Factors Engineering Design Implementation Plan," Revision 2, May 1997.*]*

[*14. WCAP-14396, "Man-in-the-Loop Test Plan Description," Revision 2, January 1997.*]*

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



*Note 1: Decomposition and subsequent task analysis of this activity is performed as part of a similar process applied to the radioactive waste control center.

Figure 18.5-1

Top Four Levels of the Normal Power Operation for a Westinghouse PWR

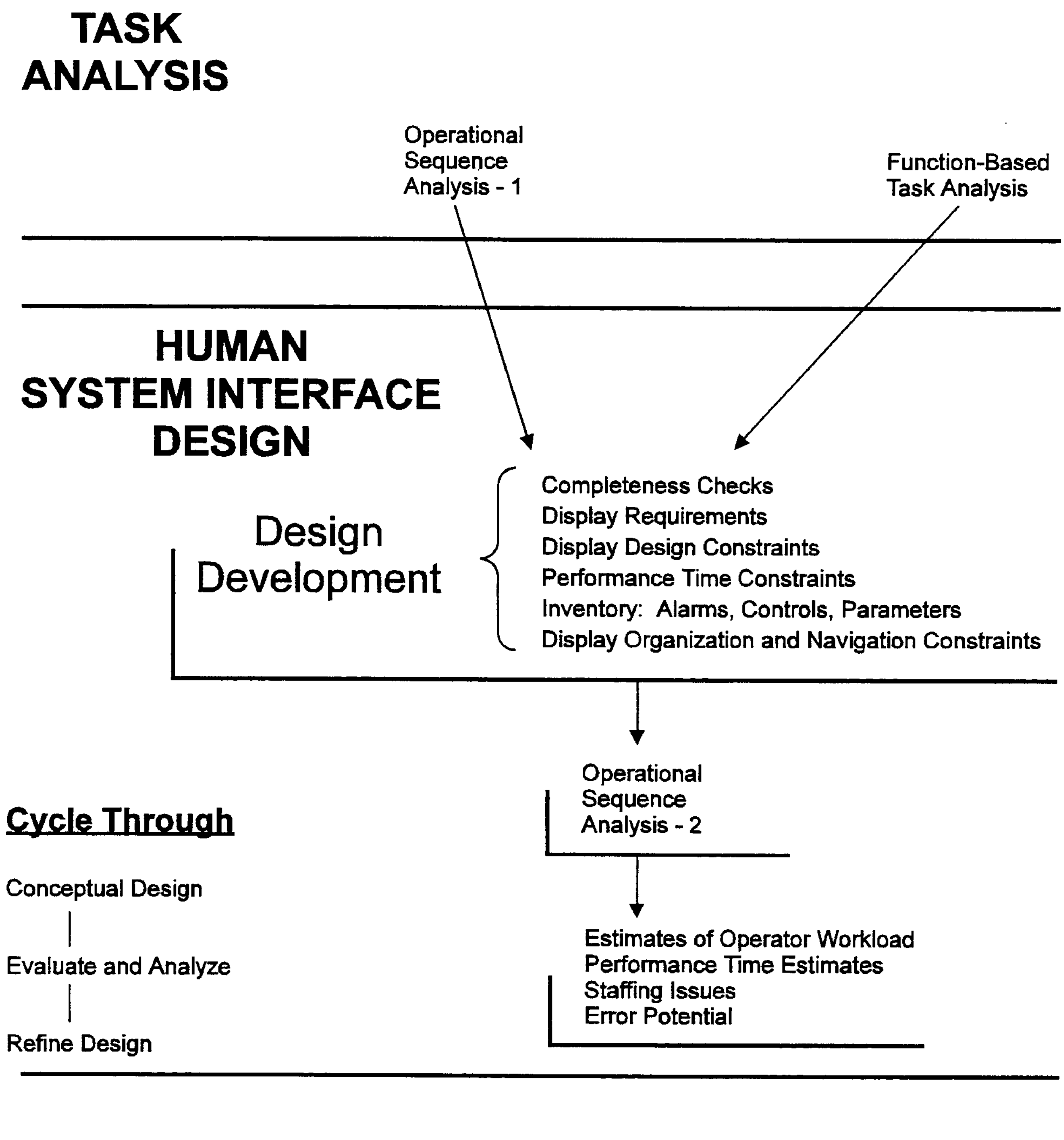


Figure 18.5-2

Task Analysis Utilized as Design Input