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December 15, 2011

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-11433

Subject: MHI's Responses to US-APWR DCD RAI No. 781-5886 REVISION 3 (SRP 18)

Reference: 1) "Request for Additional Information No. 781-5886 REVISION 3, SRP Section: 18 - Human Factors Engineering, Application Section: 18.4" dated July 20, 2011.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No. 781-5886 Revision 3."

Enclosed are the responses to the RAI contained within Reference 1.

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of the submittals. His contact information is below.

Sincerely,

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosure:

1. Responses to Request for Additional Information No. 781-5886 REVISION 3

D081
NRO

CC: J. A. Ciocco
C. K. Paulson

Contact Information

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Enclosure 1

UAP-HF-11433

Docket No. 52-021

Responses to Request for Additional Information No. 781-5886
REVISION 3

December, 2011

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/15/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 781 COLP 5886 REVISION 3**
SRP SECTION:	**18. - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.4 – TASK ANALYSIS**
DATE OF RAI ISSUE:	**7/20/2011**

QUESTION NO. : 18-130

MUAP-09019 (R0), Part 2, Section 3, Task Analysis, presents the results of the task analyses of risk-important human actions. The results are provided in Tables on pages 162 through 190 encompassing approximately 30 actions. MHI's response to RAI No. 664-5046, Question No. 18-95 provides a table of risk-important operator actions identified by the PRA. It contains more actions that were analyzed in MUAP-09019. Will the additional actions be analyzed as part of Phase 2b evaluations? Further, as the design of the US-APWR's HSIs and procedures evolve, will their impact on risk-important human actions be addressed?

Reference: MHI's Responses to US-APWR DCD RAI No. 664-5046; MHI Ref: UAP-HF-10340; dated December 22, 2010; ML103620627.

ANSWER:

The risk important human actions listed on MHI's response to RAI No. 664-5046, Question No. 18-95 which were not analyzed in MUAP-09019 will be analyzed as part of the Phase 2b task analysis, utilizing the methodology described in MUAP-09019 (R0), Part 2, Section 3.

Verification and validation processes for HSI designs and operating procedures will ensure that risk important human actions continue to meet the requirements of the PRA.

Impact on DCD

There is no impact on the DCD

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

There is no impact on the Topical/Technical Report

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/15/2011

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APPLICATION SECTION:	**18.4 – TASK ANALYSIS**
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QUESTION NO. : 18-131

DCD Tier 2, Revision 3, 18.4.1, "Objectives and Scope", states that the task analysis is based on the Japanese APWR design with "additional analysis performed for differences in the US-APWR design." Since the only task analyses performed have been for risk-important actions and the DCD indicates that the analyses to be performed only address the difference between the Japanese and US-APWR's, a question arises as to specifically what human actions will be addressed in the Phase 2b analyses? Further, for the aspects of the Japanese APWR design that are the same as the US-APWR, were personnel tasks that fall into the categories other than risk-important subject to task analysis?

ANSWER:

MUAP-09019 demonstrates task analysis implementation for risk important human actions. Other human actions will be analyzed using the same implementation process as described in MUAP-09019. The risk important human actions which are identified in the response to RAI No. 18-130 which were not analyzed in MUAP-09019 will be analyzed and documented in the revision to Section 3.2 of MUAP-09019, utilizing the methodology described in MUAP-09019 (R0), Part 2, Section 3. ITAAC Table 2.9-1 lists the task analyses which will be performed based on the task analysis implementation plan. Since the implementation plan in the ITAAC table utilizes the same methodology as described in MUAP-09019 and MUAP-09019 does not identify the other human actions, MUAP-09019 (R0), Part 2, Section 3 will be revised as follows:

3.2 Scope

The Task Analysis performed in Phase 1 included US-APWR risk important human actions (HAs) from the PRA results which covered the full range of plant operations. These HAs are documented in HRA report (MUAP-09019, Part 2 Section 2). In Phase 2b, the task analysis scope will be expanded to include human actions which are not risk important, including:

- Selected representative and important tasks from operations, maintenance, test, inspection, and surveillance performed
- Full range of plant operating modes, including startup, normal operations, abnormal and emergency operations, transient conditions, and low-power and shutdown conditions
- All human tasks where critical functions are automated and monitoring of the automated system and execution of backup actions if the system fails.

Phase 2b task analysis will be performed in conjunction with operating procedure development and HSI design development utilizing the methodology described in MUAP 09019 (R0) Part 2, Section 3.

A results summary report will be submitted upon completion of the Phase 2b task analysis.

The following paragraph will be added as a new Subsection 3.8.3.8 "Results Summary Report" to MUAP-09019;

The Phase 2b US-APWR task analysis Results Summary Report will include:

- The Task Analysis team members and backgrounds
- The scope of the Task Analysis
- A description of the implementation methodology
- Task descriptions and implementation results

DCD Tier 2, subsection 18.4 will be revised to refer to the revised MUAP-09019 as the TA Implementation Plan, instead of MUAP-07007 and the Japanese APWR design, as follows.

Impact on DCD

For these changes, see Attachment-3.

Section 18.4.1 first paragraph

The objective of the task analysis is to identify the specific tasks that are needed for function accomplishment and the associated information, control, and task-support requirements.

Section 18.4.2 first paragraph

The detailed methodology for conducting the task analysis and integrating it into the HFE analyses is documented in this section and in Section 3 of Reference 18.4-4; this is considered the Task Analysis Implementation Plan.

Section 18.4.2.1 first sentence

The general task analysis methodology is described in Part 2, Section 3 of Reference 18.4-4.

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

The impact on Technical Report MUAP-09019 is described in above answer

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The OSD methodology in MUAP-07007 (R3) is not described in sufficient detail to provide reasonable assurance that the analysis will achieve its objective. To make such an evaluation, the methodology described in the implementation plan should be:

- complete; i.e., the scope, inputs, analyses to be performed, outputs, and documentation are described in the plan.
- described in a detailed step-by-step format. This level of detail supports the determination that the IP can be reliably used by design personnel and that consistent results will be achieved by knowledgeable engineering personnel.
- executable; i.e., the methodology in the IP can be used to produce the final results that can be reviewed using NUREG-0711 criteria, and the methodology provides a sufficiently detailed description of the product (expected results of the methodology) that it can be used to establish acceptance criteria for verifying ITAAC completion.

Please provide additional detail on the methodology to be used for the Phase 2b task analyses.

ANSWER:

The following step-by-step detailed TA methodology will be incorporated in the TA section of MUAP-09019. Since MUAP-09019 provides the results summary report for the TA conducted in Phase 2a, the methodology for the TA to be conducted during Phase 2b will be clearly identified. This section for Phase 2b will constitute the TA Implementation Plan, which establishes the basis for ITAAC closure.

3.8 Future Phase 2b Task Analysis Implementation Plan

3.8.1 Introduction

For the remaining tasks that are outside the risk important actions described above the Implementation Plan for Phase 2b task analysis uses the same methodology as that used in

Phase 2a described above, however there may be some variations to that methodology as described below.

3.8.2 Background

The operational sequence diagram (OSD) is utilized to indentify simplified operator action patterns and break down complicated or integrated operator's actions to those OSD patterns in order to evaluate operator's physical and cognitive work load. The OSD patterns are also utilized for breaking down operator's task to sub tasks which can be evaluated by the OSD pattern template.

The OSD provides operator's task sequence and patterns with illustrated pictures and flows. The OSD also provides interactions between operators and human system interface systems. The OSDs are assigned to several general tasks such as alarm acknowledgement and component actuations, and then categorized as specific patterns. Operator actions in these general tasks are broken down into sub-tasks utilizing the OSD patterns to evaluate operator's physical/cognitive work load. The resulting sub-tasks are evaluated from other task evaluation point of view which is explained in Table 3.4-1 utilizing table top evaluation method.
Goals, operators, methods, and selection rules (GOMS) which is described in Appendix 3.9.2 Section 2 or engineering judgment will be utilized supporting operator's action time and cognitive work load to evaluate how long (what time order- second, tens of seconds, or minutes) operator take for performing the dedicated OSD patterns.
The actual scope and input for task analysis will be identified in a plant licensing document.

The OSD represents operator and computer tasks (HSIS interactions) in graphical scheme sequentially. The symbols which shall be utilized for the OSD, are shown in Figure 3.9.1. In Figure 3.9.1, task symbols are defined for human (operator's) actions and machine (HSIS's) interactions using shape codes. Supplemental task information to represent each task will be added inside the shape code using letter code (i.e. S, V, W, and T).
Operator's actions shall be presented using the task symbols (shape and letter codes) connecting each task in chronological order. Table 3.9-1, OSD Pattern Sheet, shows an example of an operator's task flow diagram. In Table 3.9-1, task descriptions to explain the task code, person or HSIS who shall take actions shall also be identified within the sequence of steps.

3.8.3 Methodology

3.8.3.1 Introduction

Operator tasks are broken down into sub-tasks which can be evaluated by the OSD patterns. In Phase 2b task analysis, if a new task pattern needs to be developed during the identification of subtasks, a new task pattern shall be developed and defined as described in Subsection 3.8.3.3 below. Subtasks are listed in a task analysis and evaluation table (Table 3.7-1) and evaluated from other HFE task analysis aspect as listed in Table 3.4-1.

After developing the task flow diagram, a task analysis summary sheet shall be developed for each typical task in order to evaluate action time and cognitive workload. Table 3.9-4 shows an example of the OSD Task Analysis Summary Sheet. In the OSD Task Analysis Summary Sheet, task symbols which are used in the task flow diagram are counted. If the task activities are categorized as a primary role, then they shall be categorized as "Primary Loop." If the task activities are categorized as a secondary role (i.e. supervisory role as SRO or monitoring automation), they shall be categorized as "Secondary Loop".GOMS and/or experienced operator knowledge are used to evaluate action times.

In summary, the general steps for task analysis are as follows:

- Step 1: Identify typical operator's actions (i.e. substeps of the task, such as acknowledgment of alarms, start/stop pumps, etc)
- Step 2: Assign a pre-developed task flow diagram or develop a new one as shown in the Table 3.9.1 and described in Subsection 3.8.3.2 below for each typical operator's action using task symbols.
- Step 3: Develop OSD Task Analysis Summary Sheet Table 3.9-4, for evaluating action time and cognitive workload.
- Step 4: Categorize above typical tasks as the OSD pattern (i.e. Acknowledge/reset the alarm, Start or stop the pumps as a template utilized for evaluating sub-task's workload
- Step 5: Break down tasks into sub-tasks which can be evaluated by the OSD pattern.

The following subsection provides each step process in detail.

3.8.3.2 Typical operator's actions identification

A sub set of operator actions are identified based on operating experiences and existing operating procedure review. An existing sub set of operator actions include:

- Verify parameters
- Energize the valves
- Open or close valves
- Start or stop the pumps
- Set or reset the designated signals
- Connect or disconnect the load to the bus
- Unlock the valves
- Acknowledge/reset the alarm, etc.

Additional OSDs may need to be developed during task analysis implementation for Phase 2 task analysis as described in Subsection 3.8.3.3 below.

3.8.3.3 Task flow diagram development

The task symbols which present operator's and HSIS's actions in the OSD shall be pre-determined and listed in the Figure 3.9.1. If new symbols have to be developed to represent specific tasks, the new symbols shall be added in the Figure 3.9.1.
Human action's (operator's action's) symbols are represented using single a single line layer and machine reaction's (HSIS reaction's) are represented using a double line layer.
Both of actions are represented with shape codes, which consist of geometric configurations. Supplemental task information which represent actions, such as visual, touch etc., will be added inside the shape code using letter code (i.e. S, V, W, and T).

Then, operator's actions shall be presented using the task symbols (shape and letter codes, as described above), making a flow diagram by connecting each task symbol in chronological order as in Table 3.9-1.

The task flow diagrams shall be allocated in the OSD Description column. Who (or which HSIS) takes each action shall be identified and allocated in each human's role or HSIS role column in OSD Description column.
Action steps which correspond to the task symbols, shall be provided in the Operating Procedure column and each task's explanation shall be filled out in the Task Description column to complete Table 3.9-1.

In summary, for each typical sub set of tasks which are identified, the following steps are executed:

Step 1:
List all specific sub-tasks by sequential order in the operating procedure column as listed in Table 3.9-1.

Step 2:
Indicate graphical task flows with interactions of humans (i.e. RO, SRO and other personnel) and systems/component (i.e. Displays/Controls) in the OSD Description column as listed in Table 3.9-1. The OSD Description symbols represent operator and computer tasks. The symbols for OSD Description are shown in Figure 3.9-1.

Supplemental task information which represent actions, such as visual, touch etc., shall be added inside the shape code using letter code (i.e. S, V, W, and T) if task can be represented by that supplemental information.

Step 3:
Describe each sub task represented by OSD symbols accordingly in the Task Description column as listed in Table 3.9-1.

Step 4:
Complete the OSD pattern sheet Table 3.9-1 for each typical sub set of tasks. If new tasks are identified during task analysis, a new OSD task pattern has to be developed using this methodology.

3.8.3.4 Development of OSD task analysis summary sheet

After completing OSD pattern sheet for each sub set of tasks, the OSD Task Analysis Summary Sheet, Table 3.9-4 shall be developed for each sub set of tasks in order to evaluate action time and cognitive workload as follows:

Step 1:

Fill out each action step in the "Activity" column in the Table OSD Task Analysis Summary Sheet, Table 3.9-4. If the task activities are categorized as a primary role, then they shall be categorized as "Primary Loop." If the task activities are categorized as a secondary role (i.e. supervisory role as SRO or monitoring automation), they shall be categorized as "Secondary Loop." The categorization is used to evaluate if that task has interaction with others. If secondary role is identified, count number of interaction with the primary role, then fill out the number in either and/or both of "Parallel Monitoring" and "Parallel Operation."

Step 2:

Count task symbol's numbers which are used in the task flow diagram and fill them in the summary table as listed in OSD Task Analysis Summary Sheet, Table 3.9-4.

The OSD Description symbols are categorized for communication, monitoring, decision making and operation (manipulation) so that total number of task symbols shall be filled out for each categorized symbol's column.

The greater the number in each category is, the more complicated the task is regarded. If parallel activities between personnel are required for each subsequent task, the number shall also be tracked in that table. That also impacts on the complexity of that task.

Step 3:

"Necessary Time" shall be determined by evaluating total number of OSD symbols including "Parallel Monitoring and Operations" which represents interaction with other tasks and the other complexities which the task originally has. (For example, adjusting the present setpoint value during the task stressful? conditions shall be regarded as "more complex task." If specific reasons exist, they have to be described as a remark in that column of OSD Task Analysis Summary Sheet Table 3.9-4.

In general, if the number is less than 10 without any specific remarks, that task could be conducted within a few minutes.

Goals, operators, methods, and selection rules (GOMS) which will be described in Appendix 3.9.2, or engineering judgment will support those time evaluations. Experienced operator feedback and simulator V&V shall also be considered for that evaluation.

3.8.3.5 Categorization above typical tasks as the OSD pattern

Specific task patterns are identified based on the development of task flow diagrams as described in Section 3.8.3.3.
Those patterns are utilized for evaluating a task's workload as a template.
If no other factors from Table 3.4-1, influence the subtask performance, then the response time to complete the substep is the OSD time only.

3.8.3.6 Task Decomposition

As in Phase 2a task analysis, tasks shall be broken up into several sub tasks which can be evaluated by the OSD pattern.
If a new task pattern needs to be developed during decomposition of the tasks, a new task pattern shall be developed and defined using above approach.
The sub tasks are listed in a task analysis and evaluation table as shown in Table 3.7-1, and then evaluated not only from workload and time as described in Section 3.8.3.5 but also from other HFE task analysis aspects as listed in Table 3.4-1.

As in Phase 2a task analysis, for each sub task, required functions for human task accomplishment (i.e. "Information Requirement" column through "Workplace Factors & Hazard" column) are evaluated and filled out. Evaluation items and criteria for each item are described in Table 3.4-1.

In the OSD Pattern column, pre-defined OSD patterns from Section 3.8.3.2 or new patterns that were developed in Subsection 3.8.3.3 above shall be entered. In the "Response Time (OSD Time)" column, an "A" indicates performance is within specified time requirements and shall be filled out with rational reasoning. The OSD task analysis summary sheet in Section 3.8.3.4 and its GOMS evaluation and/or engineering judgment can support that evaluation.

As in Phase 2a task analysis, after evaluating required functions (Table 3.4-1 Evaluation Items) for human task accomplishment, Result columns, i.e. "Allocation of Monitoring", "Allocation of Control Tasks", "Number of Crew members" and "Personal Skill level" shall be filled out based on its required function evaluation results.

For example, in the "Allocation of Monitoring" and "Allocation of Control Tasks" column, indicate specific plant parameters and control actions which shall be used for accomplishing that sub task accordingly. In the "Number of Crew members" and "Personal Skill Level" column, specific number of plant personnel and their qualification (i.e. RO, SRO, or AO (Non-licensed operator) shall be filled out.

3.8.3.7 Results

As in Phase 2a task analysis, table top based task analysis and evaluation results shall be recorded and documented as per Table 3.7-1.
"Results" column in Table 3.7-1 identifies necessary information, actions/controls, number of crew and their skill level.
That information shall be utilized as input information of operating procedure development, HSI design and training program development.
The actual implementation results will be developed and documented in the plant licensing document.

Table 3.7-1 and 3.4-1 are shown in Attachment 1 and 2.

Please also see the response to RAI No. 18-131.

Impact on DCD

Same as RAI NO. 18-131.

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

The impact on Technical Report MUAP-09019 is described in above answer

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/15/2011

US-APWR Design Certification
Mitsubishi Heavy Industries
Docket No. 52-021

RAI NO.:	**NO. 781 COLP 5886 REVISION 3**
SRP SECTION:	**18. - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.4 – TASK ANALYSIS**
DATE OF RAI ISSUE:	**7/20/2011**

QUESTION NO. : 18-133

Table 5.4-1 of MUAP-07007 (R3) identified task considerations used in task analysis that are consistent with Table 5.1 of NUREG-0711. However, the OSD task analysis methodologies described do not appear to address these considerations. The OSD steps described do not reference the Table, nor does the example worksheet or summary table appear to identify them. Where and how are the task considerations listed in MUAP-07007, Table 5.4-1 used as part of task analysis?

ANSWER:

MUAP-09019 (R0), Part 2 Section 3 will be revised as described in the response to RAI No. 18-132 for comprehensive task analysis methodologies using the OSD.

DCD Tier 2, subsection 18.4.1 will be revised to refer to the revised MUAP-09019 instead of MUAP-07007, as in the response to RAI NO. 18-131.

Impact on DCD

Same as RAI NO. 18-131.

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

The impact on Technical Report MUAP-09019 is described in above answer

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Goals, operators, methods, and selection rules (GOMS) is used as a detailed task analysis methodology as identified in MUAP-07007 (R3), section 5.4.3.2. While GOMS is a well-know analysis methodology, several questions arise concerning its use for the analysis of nuclear power plant operator tasks.

- For the perception, cognition, and motor elements evaluated with the GOMS methodology, please explain the basis of the three time estimates. As GOMS was originally developed to address relatively simple human-computer actions such as typing on a keyboard, are these estimates representative for NPP operations?
- Table 5.4-4 provides factors for each element as a function of action type. How were these factors derived and how are they applicable to NPP tasks?
- GOMS does not consider problem solving cognitive activities or performance shaping factors. The GOMS time estimates, therefore, may be idealized; i.e., do not reflect factors that can complicate task performance. Please address how these will be applied to NPP operator tasks.
- As GOMS is developed for the evaluation of human-computer interaction tasks, how is it adapted for use with other types of operator actions, such as local non-computer tasks or local operator actions?
- How are the time estimates used to calculate cognitive workload?

Please provide additional detail on the methodology to be used for the Phase 2b task analyses.

ANSWER:

GOMS is used as an optional detailed task analysis methodology.

As identified in MUAP-07007 (R3), section 5.4.3.2. GOMS is a well-know analysis methodology,

For Staff's questions concerning GOMS analysis:

- The US-APWR control room utilizes computerized human system interface, which is similar to touch typing. Therefore, in order to evaluate cognitive workload, human processor model driven by the "Psychology of Human-Computer Interaction" by Stuart K. Card, Thomas P. Moran and Allen Newell is considered as one of computer-human interface psychological evaluation method. As described in the "Psychology of Human-Computer Interaction", Section 2.1, the model human processor can be divided into three interacting subsystems: (1) the perceptual system, (2) the motor system, and (3) the cognitive system, each with its own memories and processors. The perceptual processor's cycle time Tp is identifiable with the so-called unit impulse response (the time response of visual system to a very brief pulse of light) and its duration is on the order of

  - Tp = 100 [50~200] msec.

  The motor system is transaction system by activating patterns of voluntary muscles. For computer user (i.e. operators who will take any actions on VDU screens), the two most important sets of effectors are the arm-hand-finger system and the head-eye system. Movement is not continuous, but consists of a series of discrete micro-movements, each requiring about

  - Tm = 70 [30~100] msec.

  which is the cycle time of the Motor Processor.

  The recognize-act cycle, analogous to the fetch-execute cycle of standard computers, is the basic quantum of cognitive processing. On each cycle, the contents of Working Memory initiate associatively-linked actions in Long-Term Memory ("recognize"), which in turn modify the contents of Working Memory ("act"), setting the stage for the next cycle. Plans, procedures, and other forms of extended organized behavior are built up out of an organized set of recognize-act cycles.

  Like the other processors, the Cognitive Processor seems to have a cycle time of around a tenth of a second:

  - Tc = 70 [25~170] msec.

  The cycle times differ based on type of tasks. The times vary in the 25~170 msec/cycle range, depending on the specific experimental phenomenon and experimental circumstances with which one wishes to identify the cycle. The human processor model is defined as a general human cognitive action process and applied to general human action interfacing display system and is not limited to the specific tasks, typing a keyboard or touching the screens.

  In accordance with above described task are summarized as follows and incorporated to the Table 3.9-2 in Part 2, MUAP-09019.

Work item	Abbreviation	Explanation	The number of times of processor processing		
			tp	tc	tm
1) Simple reaction	sr	Work of "cognitive processor" represented by the action of "pushing a button if some are displayed on a VDU screen" does not move only once for of reaction determination	1	1	1
2) Physical matches	pm	Work of "cognitive processor" represented by the action of "pushing a button if the 2nd sign is the same type as the 1st sign when two signs are displayed on a VDU screen by	1	2	1

		something in order" makes collation and a reaction decision			
3) Name matches	nm	Work of "cognitive processor" represented by the action of "pushing a button if the 2nd sign is the same name as the 1st sign when two signs are displayed on a VDU screen by something in order" makes a character check, collation, and a reaction decision	1	3	1
4) Class matches	cm	Work " cognitive processor" represented by the action of "pushing a button if the 1st sign belongs to the class with the 2nd same sign when two signs are displayed on a VDU screen by something in order" makes a character check, a classification, collation, and a reaction decision	1	4	1

- As the Staff pointed out, GOMS is used for relatively simple human-computer actions. MHI expanded above evaluation table to meet tasks executed in nuclear plant operations as follows, and also incorporated to the Table 3.9-2 in Part 2, MUAP-09019.

Work item	Abbreviation	Explanation	The number of times of processor processing		
			tp	tc	tm
5) Simple reaction without perception	mo	Work similar to item 1) "simple reaction" which only movement of "it thinking that a button will be pushed and pushing a button" which does not include the consciousness reaction of "if some are displayed on VDU"	0	1	1
6) Simple reaction without motor	sr*	Work similar to item 1) "simple reaction" without movement of "pushing a button"	1	0	0
7) Physical matches without motor	pm*	Work similar to item 2) "physical matches" without movement of "pushing a button"	1	1	0
8) Name matches without motor	nm*	Work similar to item 3) "name matches" without movement of "pushing a button"	1	2	0
9) Class matches without motor	cm*	Work similar to item 4) "class matches" without movement of "pushing a button"	1	3	0
10) Memory reference	mr	Work which refers to long-term memory, such as "remembering the following operation item as something in the light of the operation point in the head."	0	1	0

- In order to consider problem solving cognitive activities or performance shaping factors, MHI is to utilize OSD analysis as described in Part 2 MUAP-09019 Chapter 3, Table 3.7-1.
- GOMS is used only for tasks that meet all of the following criteria:
  - Significant changes from the reference design or tasks where there is no operating history in the reference design.
  - Where the tasks are identified as risk significant through the HRA element.
  - Where the task is time critical.

  GOMS can only be applied to the computerized human-computer interaction tasks which are evaluated as important to safety and/or time critical human actions and integrated in the MCR. Other types of operator actions, such as local non-computer tasks or local operator actions are to be evaluated by the OSD analysis.
- The PRA and safety analysis provides the time in which the task must be performed, GOMS and other task analysis methodologies determine the time it takes the operator to actually perform the task. GOMS is used to confirm that the time required to perform the task is be less than or equal to the time in which the task must be performed, as specified in the PRA.

For the detailed methodology to be used for the US-APWR Phase 2b task analyses, please see the response to RAI NO. 18-132.

Impact on DCD

Same as RAI NO. 18-131.

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

There is no impact on the Topical/Technical Report

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/15/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 781 COLP 5886 REVISION 3**
SRP SECTION:	**18. - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.4 – TASK ANALYSIS**
DATE OF RAI ISSUE:	**7/20/2011**

QUESTION NO. : 18-135

The OSD and GOMS methodologies were used in the analysis of risk-important actions as is described in MUAP-09019, Part 2, Section 3, Task Analysis, Appendix 3.9.1, and Appendix 3.9.2 .The results are presented in Table 3.7.1. However, the results contain more information than is addressed by the methodology described in Appendix 3.9.2.

For example, columns are provided for many of the task considerations noted in Table 5.4-1 of MUAP-07007. Thus, the results do not appear to flow from the methodology described and a question arises as to the completeness of the methodology description for the U.S. APWR task analysis methodology described in MUAP-07007. Please clarify the relationship between the methodology described and the results obtained.

ANSWER:

Please see the RAI 18-132 response. The TA methodology in MUAP-09019 will be revised to address each task consideration in Table 3.7-1.

Impact on DCD

Same as RAI NO. 18-131.

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

The impact on Technical Report MUAP-09019 is described in above answer

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/15/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 781 COLP 5886 REVISION 3**
SRP SECTION:	**18. - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.4 – TASK ANALYSIS**
DATE OF RAI ISSUE:	**7/20/2011**

QUESTION NO. : 18-136

Results are provided in summary fashion for risk-important actions. The results provide detailed breakdown of the task into actions, indication of task requirements, indication the number of crewmembers and their skill level, and overall time estimates for completion of the action. These time estimates are compared with time available in MUAP-09019 (R0), Appendix 3.9.1. However, the summary tables are so high-level that it is not possible to determine how the OSD and GOMS were used to produce them.

Please provide complete analyses for selected risk-important human actions.

ANSWER:

MHI will revise and provide more description to explain the break-down of task analysis in the MUAP-09019 technical report.
The complete analysis for several tasks will be added to Part 2 Section 3 of the MUAP-09019 technical report.

Impact on DCD

Same as RAI NO. 18-131.

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

The impact on Technical Report MUAP-09019 is described in above answer

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/15/2011

US-APWR Design Certification
Mitsubishi Heavy Industries
Docket No. 52-021

RAI NO.:	**NO. 781 COLP 5886 REVISION 3**
SRP SECTION:	**18. - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.4 – TASK ANALYSIS**
DATE OF RAI ISSUE:	**7/20/2011**

QUESTION NO. : 18-137

MUAP-09019 (R0), Appendix 3.9.1 indicates a time required for the human action associated with Event 1 and identifies engineering judgment as the basis. However, the applicant's task analysis methodology states that a GOMS evaluation was used to derive time estimates for risk-important human actions. Please clarify.

ANSWER:

The following explanation will be added after the last paragraph of Section 3.7 "Results" of MUAP-09019:

The time required for human actions for events in Appendix 3.9.1 are based on both engineering judgment and GOMS evaluations. Column 7 of each Task Analysis and Evaluation Table (Table 3.7-1) specifies an Operational Sequence Diagram (OSD) for each sub-step of a risk important human action. As specified in Appendix 3.9.2, OSD patterns clearly identify operator decision and action functions required to perform that sub-step. GOMS is then used to assess the workload and evaluate time requirements for each OSD pattern specified for each sub-step of the risk important human actions performed in the main control room. For example, OSD pattern 1 in Table 3.9-1 of Appendix 3.9.2 would be appropriate to analyze a sub-step of a task that requires the operator to verify a single plant parameter in the main control room as illustrated below.
GOMS applies the Model of Human Information Processor by Card, et al. as specified in Figure 3.9.2 of Appendix 3.9.2 to determine time requirements for OSD patterns. Basic human actions specified in Table 3.9-2 of Appendix 3.9.2 are assigned to each sub-step of each OSD pattern and evaluated for response time requirements using the Card et al. approach in the "Internal Processing" and "Workload" columns in Table 3.9-3 of Appendix 3.9.2. The OSD pattern sub-step response times are then summed and the total time required to perform each OSD pattern is specified in the applicable Table 3.9-3 of Appendix 3.9.2.
For example, the total time required to verify a plant parameter (OSD pattern 1) is approximately 2.31 seconds; the total time required to start a pump (OSD pattern 4) from the main control room is approximately 3.48 seconds. Response times for some OSD patterns are based on engineering judgment. For example, OSD pattern 2, "Energize a valve", OSD

pattern 8 (open or close the valve- local action) and OSD pattern 9 (unlock the valve- local action) response times are estimated to require approximately 10 minutes, the basis of which is given in Table 3.9-3 for that OSD pattern. As indicated in Section 3.4, "Methodology", the engineering judgment applied in the Phase 1 Task Analysis was verified through a table-top analysis performed by two operations experts (both SRO Instructors with plant experience) who are familiar with U. S. NPP operations and the MHI U S Basic HSI as implemented in the MEPPI simulator.
It can now be shown how engineering judgment and GOMS evaluation are both used in determining the response time for risk important human actions specified in Table 3.7-1.

Example 1: In Table 3.7-1 (36/44), "RCS water level recovery and Charging Injection System Establish Operation Failure (LOCA, OVDR, LORH, LOOP, FLML)" is decomposed into seven sub-steps with each sub-step assigned an OSD pattern, the time response requirements which have been analyzed by the GOMS approach (for OSD patterns 1, 3, and 4) and engineering judgment (for OSD pattern 8) in Table 3.9-3. The time required to perform each sub-step of this risk important human action would be:

Sub-step 1: 2.31 sec (OSD 1; response time based on GOMS)
Sub-step 2: 3.48 sec (OSD 4; response time based on GOMS)
Sub-step 3: 2.31 sec (OSD 1; response time based on GOMS)
Sub-step 4: 3.48 sec (OSD 3; response time based on GOMS)
Sub-step 5: 10 min (OSD 8; response time based on engineering judgment)
Sub-step 6: 10 min (OSD 8; response time based on engineering judgment)
<u>Sub-step 7: 3.48 sec</u> (OSD 4; response time based on GOMS)
Total time: 20 min.,15.06 sec.

Based on the time summary above, it is shown that the time required to perform this risk important human action is "About 30 minutes" as indicated in column 6 of Table 3.7-1 (36/44), "Time required (OSD time)". This time is also specified in Appendix 3.9.1 table "Response Time Criteria for Risk significant human actions" in the "Time Required" column, which is less than the time of one hour specified in the "Time Available" column, indicating that there is sufficient margin between the Time Available (as defined in the safety analysis or PRA) and the Time Required (as determined by the HFE task analysis).

Example 2: In Table 3.7-1, (3/44), "Failure to Start the Standby Charging Injection Pump B (PLOCW, ATWS)" is decomposed into two sub-steps with each sub-step assigned an OSD pattern, the time response requirements which have been analyzed by the GOMS approach only (for OSD patterns 1 and 4). The time required to perform each sub-step of this risk important human action is:

Sub-step 1: 2.31 sec (OSD 1; response time based on GOMS)
<u>Sub-step 2: 3.48 sec</u> (OSD 4; response time based on GOMS)
Total time: 5.79 sec

Again, it is shown that the time required to perform this risk important human action is "Within a few minutes" as indicated in column 6 of Table 3.7-1 (3/44), "Time required (OSD time)". This time is also specified in Appendix 3.9.1 table "Response Time Criteria for Risk significant human actions" in the "Time Required" column, which is less than the time of one hour specified in the "Time Available" column, indicating that there is sufficient margin between the Time Available (as defined in the safety analysis or PRA) and the Time

Required (as determined by the HFE task analysis). The methodologies are based on the Japanese HFE program.

The "Time Required to complete actions" in Examples 1 and 2 above are merely a summation of the times required to perform each OSD as specified in Table 3.9-3 because the substeps for these risk important human actions are not influenced by any other qualitative factors, such as Task Support Requirements, Situational and performance shaping factors, or Workplace Factors & Hazards.

Impact on DCD

There is no impact on the DCD

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

The impact on Technical Report MUAP-09019 is described in above answer

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/15/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 781 COLP 5886 REVISION 3**
SRP SECTION:	**18. - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.4 – TASK ANALYSIS**
DATE OF RAI ISSUE:	**7/20/2011**

QUESTION NO. : 18-138

The task analysis methodology described in the DCD and in MUAP-07007 does not describe how the analyst will treat the number of crew members, the skills needed to perform the task, and the allocation of tasks to crewmembers as part of the analysis.

Please provide the methodology for these aspects of the task analysis methodology.

ANSWER:

DCD Tier 2, subsection 18.4.1 will be revised to refer to the revised MUAP-09019 instead of MUAP-07007. MUAP-09019 (R0), Part 2 section 3 will be revised as described in the response to the RAI No. 18-132 for comprehensive task analysis methodologies using the OSD.
Please see response to RAI NO. 18-132.

Impact on DCD

Same as RAI NO. 18-131.

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

The impact on Technical Report MUAP-09019 is described in above answer

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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QUESTION NO. : 18-139

DCD Tier 1, Revision 3, Section 2.9, "Human Factors Engineering." Table 2.9-1, Item 5 indicates that the analysis will be conducted "in accordance with the requirements of the Task Analysis Implementation Plan." Please clarify what document constitutes the Task Analysis Implementation Plan. In addition, the acceptance criteria presented states that a results summary report exists and concludes that the analysis has been conducted in accordance with the plan. This statement is not adequate as the acceptance criteria. The applicant should provide a more explicit description of the contents of the plan.

ANSWER:

Please see response to RAI NO. 18-131.

Impact on DCD

Same as RAI NO. 18-131.

Impact on R-COLA

There is no impact on the R-COLA

Impact on S-COLA

There is no impact on the S-COLA

Impact on PRA

There is no impact on the PRA

Impact on Topical/Technical Reports

The impact on Technical Report MUAP-09019 is described in above answer

This completes MHI's responses to the NRC's questions.

Attachment 1

Table 3.7-1 Task Analysis and Evaluation Table

This page shows the format of task analysis and evaluation table.

Title													
		Required Functions for Human Task Accomplishment								Result			
1. No.	2. Action Steps	3.Information Requirement	4.Decision Making	5.Communication Requirements	6.Time Required (OSD time)	7.OSD Pattern	8.Task Support Requirements	9.Situational and Performance Shaping Factors	10.Workplace Factors & Hazard	11.Manual Monitoring Tasks	12.Manual Control Tasks	13.Number of Crew Members	14.Personal Skill Level

Attachment 2

Table 3.4-1 Required Functions for Human Task Accomplishment (1 of 2)

No.	Evaluation Items	Acceptance Criteria	Remarks
1	Information Requirement	The plant information needed to accomplish the subset (e.g., flow and pressure indication)	
2	Decision-making	The type of decision required. Ab (Absolute information): Prompting information in the MCR (such as an alarm) that notifies the operators of the plant situation. R (Relative information): Plant symptom information (such as changes in plant parameters and/or component status indications caused by plant malfunctions) is presented in the MCR that enables the operators to gain awareness of the plant situation. P (Probabilistic): Information is available at the local area but is not directly indicated in the MCR, so that operators would only become aware of the plant situation from the local area (e.g., during periodic inspections). "Ab", "P", and "R" appear in this column of Table 3.7-1 to indicate the type of decision required for the action.	Decision making requirements are specified for the first substep of a task sequence. This defines how the decision to initiate the task is determined.
3	Communication Requirements	Type of communication required V: Verbal communication between RO and SRO in the control room R: Remote communication between RO (AO) and SRO can be performed. "V" and "R" are listed in this column of Table 3.7-1 to indicate the type of communication required for the action.	
4	Time Required (OSD time)	The time in this column of Table 3.7-1 is the time required to complete the HA based only on the summation of the individual times for each OSD pattern (See Table 3.9-3 in Appendix 3.9.2). The total Time Required, which includes additional considerations for qualitative factors (Columns 6-8), is shown in Note 1 of the table. An 'A' in this column of Table 3.7-1 indicates that the total Time Required to complete the HA is acceptable.	

Table 3.4-1 Required Functions for Human task Accomplishment (2 of 2)

No.	Evaluation Items	Acceptance Criteria	Remarks
5	OSD Pattern	The HA is composed of subtasks which are represented by the standard OSD Patterns. The numbers in this column of Table 3.7-1 indicate the specific OSD Pattern from Appendix 3.9.2.	
6	Task Support Requirements	Specific job aids, tools, or protective clothing needed. D: Support material such as some reference document or calculation sheet for dedicated action. T: Some support apparatus such as valve handling tool if required in the action. "D" or "T" appear in this column of Table 3.7-1 if either is required to support the action.	
7	Situational and Performance Shaping Factors	Whether there are any situational factors such as high stress, or reduced staffing that may affect the required action. An 'A' in this column of Table 3.7-1 indicates that no factors exist that influence performance of the action; otherwise the factors are listed.	These factors are considered for the difficult action and high workload action.
8	Workplace Factors & Hazard	Whether there are any significant workplaces factors that may affect actions required in the local area. These factors are considered only for local actions. Most actions are taken in the control room. The control room is good environment and no consideration for this issue is required. Any hazards that may affect required actions. These factors are considered only for local actions. The control room is good environment and no consideration for this issue is required. An 'A' in this column of Table 3.7-1 indicates that no workplace factors or hazards exist that influence performance of the action; otherwise the factors and/or hazards are listed.	Examples of significant workplace factors considered are high or low temperature, radiant heat by high energy piping, noise, radiation, lighting, roaring sound by turbine rotation etc. Examples of potential hazards considered are falling materials, actions on the ladder, actions at height etc.

18.4 Task Analysis

18.4.1 Objectives and Scope

~~The task analysis is based on the Japanese APWR design with additional analysis performed for differences in the US-APWR design.~~ The objective of the task analysis is to identify the specific tasks that are needed for function accomplishment and the associated information, control, and task-support requirements. DCD_18-131

Scope of the task analysis includes the following:

- Selected representative and important tasks from areas of the following:
  - Operations
  - Maintenance
  - Test
  - Inspection
  - Surveillance
- Full range of plant operating modes, including the following:
  - Startup
  - Normal operations
  - Abnormal and emergency operations
  - Transient conditions
  - Low-power and shutdown conditions
- HAs that have been found to affect plant risk by means of probabilistic risk assessment (PRA) importance and sensitivity analyses may also be considered risk-important. Internal and external initiating events and actions affecting the PRA Level I and II analyses are considered when identifying risk-important actions.
- Where critical functions are automated, the analyses consider all human tasks; including monitoring of the automated system and execution of backup actions if the system fails.
- The task analysis identifies information and control requirements to enable specification of detailed requirements for alarms, displays, data processing, and controls.

The task analysis also addresses issues such as the following:

- Operating personnel staffing

- Procedure development
- Operating personnel skill requirements
    - Job formation and training
    - Physical workload
    - Cognitive workload

The scope of the task analysis encompasses the MCR, RSC, TSC and LCSs. Task analysis for the EOF that is within the scope of the US-APWR HFE program is limited to (1) the information needed on displays at the EOF and (2) the EOF communication requirements with the MCR. Task analysis to address the complete EOF will be conducted in accordance with the site specific HFE program for compliance with NUREG-0696. DCD_18-129

18.4.2 Methodology

The detailed methodology for conducting the task analysis and integrating it into the HFE analyses is documented in this section and in Section 3 of Reference 18.4-~~1~~4; this is considered the Task Analysis Implementation Plan. DCD_18-131, 132, 133, 134, 135, 136, 138, 139

Task analyses begin on a gross or high level and involve the development of detailed narrative descriptions of what personnel have to do. The analyses define the nature of the input, process, and output needed by and from personnel.

Detailed narrative task descriptions address (as appropriate) the following topics:

- Information requirements
- Decisions making requirements
- Response requirements
- Communication requirements
- Workload
- Task support requirements
- Workplace factors
- Situational and performance shaping factors (PSFs)
- Hazard identification

The task analysis is iterative and becomes progressively more detailed over the design cycle. The task analysis is detailed enough to identify information and control requirements to enable specification of detailed requirements for alarms, displays, data processing, and controls for human task accomplishment. The task analysis addresses issues such as the following:

- The number of crew members
- Crew member skills
- Allocation of monitoring and control tasks for the following purposes:
  - Definition of a meaningful job scope
  - Management of crew member's physical workload
  - Management of crew member's cognitive workload

18.4.2.1 Description of the Methods Used to Analyze Tasks

The general task analysis methodology is described in Part 2, Section 3 of Reference 18.4-~~41, Subsection 5.4.3~~. The operational sequence diagram (OSD) method is used to conduct functional-based task analysis. The goals, operators, methods, and selection (GOMS) method (Reference 18.4-2) was used to conduct cognitive skills task analysis. DCD_18-131, 132, 133, 134, 135, 136, 138, 139

18.4.2.2 General Task Analysis Methods

The OSD method is applied for analysis of US-APWR operations. OSD is used because it is applicable from the initial facility design phase to the final design phase. An OSD represents operator and computer tasks in graphical scheme sequentially and indicates actions, data transmitted or received, inspections, operations, decisions, and data storage. The information flow is shown in relation to both time and space. This method is used to develop and present the system reaction to specific inputs and display the interrelationship between operators and equipment. Detailed task analysis tools (e.g., task description method or functional flow diagram, Reference 18.4-3) are employed to supplement OSD, as needed.

The HEDs identified during the performance of the task analyses are documented, tracked, and dispositioned.

18.4.2.3 Detailed Cognitive Task Analysis Methods

In order to evaluate a crewmember's cognitive workload, an interaction analysis between human and computer systems is necessary. GOMS is a method for the analysis of the cognitive skills involved in human-computer tasks. It is based upon an information-processing framework that assumes a number of different stages or types of memory and separate perpetual, motor, and cognitive processing times. Selected scenarios are analyzed using this method and detailed quantitative metrics are obtained. This information is used to develop the HSI design.