HITACHI

GE Hitachi Nuclear Energy

James C. Kinsey
Vice President, ESBWR Licensing

PO Box 780 M/C A-55
Wilmington, NC 28402-0780
USA

T 910 675 5057
F 910 362 5057
jim.kinsey@ge.com

MFN 08-156

Docket No. 52-010

April 14, 2008

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

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 153 Related to ESBWR Design Certification Application – Human Factors Engineering – RAI Numbers 18.4-26 S01, 18.11-3 S01, 18.11-4 S01, 18.11-22 S01, and 18.11-27 S01**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) responses to the U.S. Nuclear Regulatory Commission (NRC) Requests for Additional Information (RAIs) received from the NRC in letter No. 153, dated February 12, 2008 (Reference 1).

RAIs 18.11-3 S01, 18.11-4 S01, 18.11-22 S01, 18.11-27 S01 were requested by Reference 1 and were previously responded to by Reference 2. The NRC originally sent these RAIs via Reference 3.

RAI 18.4-26 S01 was requested by Reference 1 and was previously responded to by Reference 4. The NRC originally sent this RAI via Reference 5.

GEH's response to RAIs 18.4-26 S01, 18.11-3 S01, 18.11-4 S01, 18.11-22 S01, and 18.11-27 S01 are addressed in Enclosure 1.

Also note that these RAI responses correspond to and answer several open items listed in Reference 6. Please consider these open items to be addressed by this letter.

D068
NRO

If you have any questions or require additional information, please contact me.

Sincerely,

James C. Kinsey
Vice President, ESBWR Licensing

References:

1. MFN 08-130 – Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 153 Related To ESBWR Design Certification Application*, dated February 12, 2008
2. MFN 06-446 – *Response to Portion of NRC Request for Additional Information Letter No. 74 – ESBWR Human Factors Engineering NEDO-33276, Rev. 0, HFE Verification and Validation Implementation Plan – RAI Numbers 18.11-1 through 18.11-33*, dated November 22, 2006
3. MFN 06-386 – *Request for Additional Information Letter No.74 Related to ESBWR Design Certification Application*, dated October 11, 2006
4. MFN 07-408 – *Response to NRC Request for Additional Information Related to ESBWR Design Certification Application – Human Factors Engineering – RAI Numbers 18.4-26, 18.5-18 S01, 18.6-11, 18.6-12, 18.8-12 S01, 18.8-43 S01, 18.8-44 S01, 18.8-45 S01*, dated July 24, 2007
5. MFN 07-317 – Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request for Additional Information Letter No.98 Related to ESBWR Design Certification Application*, dated May 29, 2007
6. MFN 08-194 – Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Economic Simplified Boiling Water Reactor (ESBWR) Chapter 18 Open Items,* dated February 28, 2008

Enclosure:

1. MFN 08-156 – Response to Portion of NRC Request for Additional Information Letter No. 153 Related to ESBWR Design Certification Application – Human Factors Engineering - RAI Numbers 18.4-26 S01, 18.11-3 S01, 18.11-4 S01, 18.11-22 S01, and 18.11-27 S01

Attachment:

1. MFN 08-156 –Attachment - Markup and Added Text for RAI 18.4-26 S01

cc:	AE Cubbage	USNRC (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	DH Hinds	GEH/Wilmington (with enclosure)
	GB Stramback	GEH/San Jose (with enclosure)
	eDRF	0000-0083-4711, RAI 18.4-26 S01 0000-0083-4278, RAI 18.11-3 S01, 18.11-4 S01, 18.11-22 S01 and 18.11-27 S01

Enclosure 1

MFN 08-156

Response to Portion of NRC Request for Additional Information Letter No. 153 Related to ESBWR Design Certification Application

Human Factors Engineering

RAI Numbers

18.4-26 S01, 18.11-3 S01, 18.11-4 S01, 18.11-22 S01, and 18.11-27 S01

For historical purposes, the original text of RAI 18.4-26, 18.11-3, 18.11-4, 18.11-22, 18.11-27 and the GE response are included. The response does not include any attachments or DCD mark-ups.

NRC RAI 18.4-26

Rev. 0 of NEDO-33219, Sections 7.1 and 7.2 described a method and the documentation that was to be developed for plant performance requirements and for system level functions. Sample tables were provided that included functions, parameters, ranges and limits on parameters, and related comments. This detail was judged to acceptably address NUREG-0711, Section 4, Criterion 4. This information no longer exists in NEDO-33219, Rev. 1, and it is not clear if or where the information on the parameters and functions will be provided when the functional requirements analysis (FRAs) are completed. Section 5 of Rev. 1 provides a brief description of the results summary report but does not include the parameters of Criterion 4. Please clarify where this information will be provided.

GEH Response

Detailed guidance for the conduct of the Plant Functional Requirements Analysis (PFRA) is contained in the PFRA Work Instruction that has been drafted to implement NEDO-33219, Revision 1. The work instruction requires that the information specified in NUREG-0711, Section 4, Criterion 4 be determined and documented for each high level function. This data for each high level function will be an integral part of the PFRA structure, and as such will be validated and summarized along with the PFRA data structure. A draft copy of the PFRA Work Instruction will be available for review during the on-site audit scheduled for July 25, 2007.

DCD Impact

No DCD changes will be made in response to this RAI.

No changes to the subject LTR will be made in response to this RAI.

NRC RAI 18.4-26 S01

Detailed guidance for the conduct of the Plant Functional Requirements Analysis (PFRA) is contained in the PFRA Work Instruction that has been drafted to implement NEDO-33219, Revision 1. The work instruction requires that the information specified in NUREG-0711, Section 4, Criterion 4 be determined and documented for each high level function. This data for each high level function will be an integral part of the PFRA structure, and as such will be validated and summarized along with the PFRA data structure. A draft copy of the PFRA Work Instruction will be available for review during the on-site audit scheduled for July 25, 2007.

Please include this description of the PFRA work instruction in the implementation plan, NEDO-33219.

GEH Response

The entire FRA program presented by NEDO-33219 is implemented through work instructions. A new section will be added in NEDO-33219 to incorporate the steps that determine and document NUREG-0711, Section 4, Criterion 4 for each high level function. The output of NUREG-0711, Section 4, Criterion 4 will be included in the Results Summary Report and the Outputs section of the NEDO. These changes to the NEDO will be implemented through a work instruction as described above.

DCD Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33219, Rev 1 will be revised adding new Section 4.3.3.8 and bullets added to section 4.3.4 and section 5.1 as noted in the attached markup (See Attachment).

NRC RAI 18.11-3

NEDO-33276, Sections 4.2.1 and 4.3.1.4.1 describes the sampling dimensions and indicates that a "multidimensional sampling strategy" (p. 18) will be used. Section 4.3.1.4.1, Items 1 through 3 largely restate the dimensions listed in NUREG-0711 (as presented in the sections below). While this is acceptable, the methodology or strategy that will be used to identify the sample of operational conditions that will reflect these dimensions is not identified. In the absence of such methodology, the staff has no basis to determine whether the sample characteristics described will be achieved. Please describe the method that will be used to the select the set of operational conditions along the sampling dimensions described in NEDO-33276.

GE Response

The multidimensional sampling strategy for establishing the sample of required operator actions for specific plant conditions to be used during simulations uses the actions defined as required to achieve the safety functions from the operations analysis.[2] The strategy will also sample human back up actions to automatic systems, actions required during normal startup, shutdown, and trip simulation scenarios. The strategy includes the use of risk important actions required in scenarios that lead to core damage as quantitatively identified in the PRA/HRA. The strategy also includes actions identified thru the OER process and a sampling of actions that exercise the use of the MMIS information and control features.

The method for selecting the actions to be sampled will incorporate the actions into a set of scenarios that cover all important actions, information, and control features that are tested under different conditions during each of the three V&V simulation phases.
The final set of scenarios defined for use in the integrated validation phase will satisfy the criteria for the range of plant conditions, personnel tasks, and situational factors known to challenge personnel performance, and the combined set of sequences will comprise all of the HSI and actions represented in the information and control needs derived from the operations analysis.

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 0 will be revised as described above at the next revision.

[2] "Operational analysis" includes the high-level FRA to determine critical safety functions, the plant level FRA (plant goal to subsystem functions), the SFRA (system functions as described in the system design specifications to discrete actions), the gap analyses (to reconcile inconsistencies between the above analyses), the allocation of functions, and the task analyses.

NRC RAI 18.11-3 S01

NRC Summary Text:
Operational conditions sampling: Sampling Dimensions

NRC Full Text:

NEDO-33276, Rev. 1 provides a high-level summary of the sampling dimensions in Section 4.1.4.1. Items 1 through 3 in the section largely restate the review criteria for sampling dimensions in NUREG-0711 (Section 11.4.1.2). The staff cannot perform an implementation plan review when the plan simply restates the staff's review criteria. The plan should identify the operational conditions to be used for V&V and the process by which the sampling dimensions were used to identify them. The staff can then use the NUREG-0711 criteria in NUREG-0711 to review the acceptability of the operational conditions that have been identified.

GEH Response

To reflect the level of detail required for an Implementation plan, both the text and document organization in NEDO–33276 will be revised. The final organization is incomplete, but the revision will include a section that details how operational condition sampling dimensions are used in the integrated system validation process.
The text below will be inserted in the Operational Condition Sampling section.

The purpose of the operational condition sampling process is to ensure that a broad and representative range of operating conditions are included in the sample population used to select integrated system validation scenarios. To ensure a representative sample that emphasizes safety significance, risk, and challenges to the operating crew, a weighted list of operational conditions is developed.

The ESBWR operational condition sampling process occurs in four major phases:

- Define weighting factors to be used in integrated system validation scenario selection.
- Define the minimum conditions and tasks to be represented in the scenarios selected for the integrated system validation.
- Develop a representative population of operational conditions and tasks from which to select integrated system validation scenarios.
- Select weighted scenarios from the defined population to be used to validate the integrated ESBWR systems and their controls.

Define Weighting Factors

The scenario selection process uses multidimensional selection criteria to identify integrated system validation scenarios that maximize relevance and significance while insuring all operational condition diversity is met. To accomplish this the following weighting factors will be used to sort scenarios (list presented in order of lowering weight):

- HRA/PRA significance of the event scenario
- Presence of PRA/HRA risk important human actions
- Presence of D3 credited human actions
- Task analysis results indicating high work load, high stress, or the presence of a critical task
- ESBWR Knowledge and Abilities (K/A) catalog importance ranking of task elements

These factors are used later in the process to select the most significant and relevant scenario when analysts encounter situations where more than one scenario can be used to validate the same operational conditions.

Define minimum conditions and tasks:

The following operational conditions or tasks are present in at least one integrated system validation scenario:

- Each human action identified in the HRA/PRA, DCD, and the NRC safety evaluation report (once written) as being risk important
- Each first of a kind system used in the ESBWR design
- Each leg of the EOP/SAMG flow charts
- Each safety system
- Support system failures affecting other systems (i.e. electrical, cooling water, and control air systems)
- Each major area of the HSI (QDCIS, NDCIS, RSS, MCR side panels, WDP)
- Plant startup from cold shutdown to critical
- Power ascension from critical to 100%
- Plant shutdown from 100% to cold shutdown
- Failure of NDCIS
- At least one error-forcing situation in each of the following areas:
    1) Administrative
    2) General plant maneuvering
    3) Emergency

4) Abnormal
5) Alarm response
6) Normal operations
7) Surveillance, test, and maintenance
8) Chemistry, radiochemical, and radioactivity control

- At least one procedure from every procedure class is exercised, including:
  1) Administrative
  2) General operating procedures (i.e., startup, shutdown, and power maneuvering)
  3) Emergency operating procedures
  4) Abnormal operating procedures
  5) Alarm response procedures
  6) System operating procedures
  7) Surveillance, test, and maintenance procedures (those portions involving the MCR, RSS, or risk significant LCS)
  8) Chemistry, radiochemical, and radioactivity control procedures (if not represented in the classes above)
- Communications involving each of the following in at least one scenario:
  1) Between control room personnel
  2) Between control room personnel and field operators
  3) Between control room personnel and emergency support centers
  4) Between control room personnel and plant management
  5) Between control room personnel and other organizations such as NRC or local authorities
- Instances of high and varying workload in at least one scenario in each of the following areas:
  1) Administrative
  2) General plant maneuvering
  3) Emergency
  4) Abnormal
  5) Alarm response
  6) Normal operations
  7) Surveillance, test, and maintenance
  8) Chemistry, radiochemical, and radioactivity control

- Instances of fatigue and circadian factors in at least one scenario in each of the following areas:
  1) Administrative
  2) General plant maneuvering
  3) Emergency
  4) Abnormal
  5) Alarm response
  6) Normal operations
  7) Surveillance, test, and maintenance
  8) Chemistry, radiochemical, and radioactivity control

Develop a representative population of operational conditions and tasks

In order to develop a satisfactory multidimensional sampling of conditions that results in the selection of integrated system scenarios that thoroughly evaluate the ESBWR design, one or more operational conditions or tasks representing each of the following are identified:

<u>Plant control</u>

- Design basis accidents identified in the ESBWR DCD
- Additional risk important scenarios within the scope of the EOPs and SAMGs
- License basis document abnormal operational occurrences
- Additional risk important abnormal events and transients within the scope of AOPs
- Additional risk important equipment degradations and failures within the scope of ARPs
- Normal plant operating manipulations ranging from cold shutdown/refueling to full power operations

<u>Personnel tasks</u>

- Human actions identified in the HRA/PRA, DCD, and the NRC safety evaluation report (once written) as being risk important.
- Historically problematic tasks as identified in the operating experience reports generated using the ESBWR operating experience process.
- Procedures from each class used in the operation of the plant including administrative, emergency, abnormal, alarm response, general operating, system operating, surveillance and testing, maintenance, chemistry control, and radiation control (those portions involving the MCR, RSS, or risk significant LCS)

- Knowledge-based tasks as identified in the ESBWR task analysis. Tasks in this population are those that analysts identified as containing relative or probabilistic decisions during detailed task analysis
- Tasks representing a broad range of human cognitive activities. Tasks in this population are those that analysts identified as containing the following attributes as in the response requirements portion of detailed task analysis:
    1. Detection and monitoring
    2. Diagnosis and situational assessment
    3. Decision making and planning
    4. Plant manipulation
    5. Monitoring plant response
- Tasks involving a range of human interactions and communications as identified in the ESBWR task analysis. Tasks in this population are those that analysts identified as containing communication interactions between the primary task performer and other personnel.
- Tasks performed with high frequency as identified in the ESBWR task analysis. Tasks in this population are those that analysts identified as having high repetition in the response requirements portion of detailed task analysis.

<u>Situational factors</u>

- Operationally difficult tasks as identified in the operating experience reports generated using the ESBWR operating experience process.
- Scenarios specifically designed to generate human errors. This allows error tolerance and error recovery to be evaluated.
- Scenarios performed with varying crew sizes. Variance between minimum and nominal crew size as discussed elsewhere in NEDO-33276.
- Instances of high workload as identified in the ESBWR task analysis. Tasks in this population are those that analysts identified as high workload in the workload determination portion of detailed task analysis.
- Instances of varying workload. Tasks in this area can vary by their nature (i.e. a scram during normal operations, or the cessation of work following the shutdown of a system the crew is controlling), or may vary due to sequencing high and low workload tasks.
- Fatigue and circadian factors. Tasks in this population are those performed with crews that are fatigued and off their normal circadian sleep cycles, prior to the performance of the scenario.

- Environmental factors such as poor lighting, high noise, radiological contamination, or other factors such as operator physical position identified in the ESBWR task analysis. Tasks in this population are those that analysts identified as having environmental factors of interest in the hazards or other factors portion of detailed task analysis.

Select weighted scenarios for use in integrated system validation

Scenarios are selected from the representative population that together fulfill all of the minimum condition and task requirements. When more than one scenario could be used to validate an operational condition or task, the scenario with the highest multidimensional weight is selected.

The scenario selection process uses multidimensional selection criteria to identify integrated system validation scenarios that maximize relevance and significance while insuring all operational condition diversity is met. To accomplish this the following weighting factors will be used to sort scenarios (list presented in order of lowering weight):

- HRA/PRA significance of the event scenario
- Presence of PRA/HRA risk important actions
- Presence of Defense-in-Depth and Diversity (D3) credited human actions
- Task analysis results indicating high work load, high stress, or the presence of a critical task
- ESBWR K/A catalog importance ranking of task elements as defined in the training analysis portion of detailed task analysis

<u>**DCD Impact**</u>

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 1 will be revised with the inserted text provided above.

NRC RAI 18.11-4

NEDO-33276, Section 4.3.1.4.2 describes the identification of scenarios. The section restates the two criteria from NUREG-0711. While this is acceptable, the methodology that will be used to develop the scenarios is not identified. In the absence of such methodology, the staff has no basis to determine whether the scenarios developed will acceptably meet the criteria. Please describe the method that will be used to develop the scenarios reflect the scenario characteristics described in NEDO-33276.

GE Response

V&V scenarios will be developed to call on the required human actions for normally operating the plant (e.g., startup and shutdown using manual trip, monitoring actions, surveillance actions, and tagging control processes). Scenarios will be developed to trigger each representative alarm type to verify the process for entering and acting upon the AOPs. Scenarios will be developed to verify human actions needed to monitor and respond to the design basis events; they will exercise all entry conditions and required actions in each EOP. Scenarios based on risk important PRA/HRA cutsets will be used to develop a set of ESBWR specific malfunctions for use in V&V simulations. The library of malfunctions and their combined use will support V&V and future training exercises.

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 0 will be revised as described above at the next revision.

NRC RAI 18.11-4 S01

NRC Summary Text:
Operational Conditions Sampling: Scenario Identification

NRC Full Text:

NEDO-33276, Rev. 1 provides a high-level summary of the scenario identification in Section 4.1.4.2. The section largely restates the review criteria for scenario identification in NUREG-0711 (Section 11.4.1.3). The staff cannot perform an implementation plan review when the plan simply restates the staff's review criteria. The plan should identify scenarios to be used and how the selected operational conditions were developed into scenarios. The plan should also identify how bias was avoided in the development of scenarios. The staff can then use the criteria in NUREG-0711 to review the acceptability of the scenarios that have been identified.

GEH Response

To reflect the level of detail required for an Implementation plan, both the text and document organization in NEDO–33276 will be revised. The final organization is incomplete, but the revision will include a section that details how selected operational conditions are developed into scenarios and how bias is avoided during scenario development in the integrated system validation process.
The text below will be inserted in the Operational Condition Sampling section.

The list of integrated system validation scenarios selected earlier in the V&V process inputs into the scenario development process described below.

Integrated system validation scenarios that exercise the selected operational conditions are developed using a structured process to ensure consistency, quality, and the minimization of bias. Procedures governing the performance of the integrated system validation process contain guidance regarding the requirements for development and documentation of all scenario attributes including:

- Objectives
- Initial conditions
- Selecting and documenting events
- Scenario attributes, both qualitative and quantitative
- Determining scenario endpoint
- Validation of the scenario itself
- Critical task determination

Each of the major activities that contribute to dynamic simulator scenario development is completed in accordance with the ESBWR simulator scenario development guide and is summarized below.

Identifying Scenario Objectives

Scenarios are assigned a predetermined set of specific objectives based upon the events that take place during the scenario and the attributes, abilities, procedures, and training to be validated. The basic objective of the scenarios is to evaluate the operators' ability to effectively use the ESBWR HSI to respond to the event being simulated. Specifically, each scenario validates the attributes of the associated HSIs and procedures, and the operators' training experiences with them, through observations of:

- Operator knowledge of integrated plant operations (gained through training)
- Operator ability to use the integrated HSI to gather, interpret, and validate indication and plant performance data
- Operator ability to diagnose abnormal plant conditions
- Operator ability to formulate mitigation strategies
- Operator ability to locate and use the appropriate procedures
- Operator ability to use the integrated HSI to implement the chosen mitigation actions
- Operator ability to effectively communicate within the control room environment

Additionally, each scenario contains objectives specific to the operational conditions and events that are contained in it, including:

- Validation of the ability to meet event and scenario acceptance criteria
- Validation of the ability to meet supplemental event and scenario criteria

Initial conditions

Scenarios are assigned a predetermined set of initial conditions established to allow the simulated scenario to commence realistically. The initial conditions are representative of typical plant status that would exist in the ESWBR at the time in the plant operating cycle in which the scenario is to take place. Additional initial conditions are included for realism and may include tagged out components or systems, in progress maintenance, or testing. To eliminate predictability, some initial conditions that have no bearing on subsequent scenario events are included. Specific initial conditions that are to be covered in the scenario shift turnover are identified.

Selecting and documenting events

After initial conditions are established, a sequence of events designed to achieve the scenario's objectives is developed. Each event either directly supports or contributes to the support of one or more objectives. Scenarios are developed so that various systems are affected by each type of event, such as:

- Degradation or failure of instruments, controls and components
- Major plant transients and accidents
- Normal plant maneuvering

Realistic conditions of this kind limit the predictability, recognizability, and potential bias from operator expectations of scenario event timelines. Some scenarios incorporate equipment failures that cause or exacerbate problems in other systems. This practice allows validation of the operators' understanding of system and component interactions, integrated system operations, and the integrated HSI performance across a broad range of conditions.

Scenarios are not a series of totally unrelated events. Integrated system validation scenarios are designed to flow from event to event, giving operators sufficient time to:

- Analyze what has happened
- Evaluate consequences of actions they might take (or inaction)
- Assign priorities to the event based upon plant conditions at the time
- Determine a course of action
- Implement the actions
- Observe and evaluate the plant's response

Scenario designers pre-determine each planned operation, malfunction, and transient and document them as a scenario timeline.

In addition to administrative data associated with the scenario, documentation includes:

- Event descriptions
- How and when the event is initiated
- A listing of the event cues, indications, and symptoms that are available to operators
- Expected actions to be taken
- Expected communications
- Procedures to be used
- Scenario endpoint

- Required operator actions to be observed, including any critical tasks contained within the scenario
- Other variable actions and behaviors that provide useful basis for evaluating operator and integrated HSI performance

Scenario Attributes, Both Qualitative and Quantitative

Integrated system validation scenarios are constructed to accurately test:

- Each individual operator's abilities and skills
- Crew member's team dependent abilities and skills
- The integrated HSIs support of safe and efficient operation
- Procedures
- Staffing and qualification criteria

Each scenario is of sufficient length, scope, and complexity to allow differentiation between acceptable and unacceptable performance. Scenario attributes consist of both qualitative and quantitative elements. Experienced scenario developers use scenario attributes to both construct and assess the quality of ESBWR integrated system validation scenarios. This assessment, combined with scenario validation, ensures the scenario is an acceptable tool to validate the integrated HSI and crew operating it. The following attributes used to develop and assess scenario acceptability are described in greater detail in the ESBWR Scenario development procedures:

Scenario Qualitative Attributes:

- **Realism/Credibility** – Initial conditions, external communications, plant response, and other similar scenario details are sufficiently similar to actual plant performance that the crew performance observed is representative of what can be expected in an operating ESBWR.
- **Event Sequencing** – Event sequencing supports the scenario objectives. Order of events can affect complexity and some events build upon the aftermath of others. Additionally, some scenario objectives may seek to validate the crew's ability to respond to simultaneous events.
- **Simulator Modeling** – The simulator model used in the scenario retains its ANS-3.5 fidelity and is not altered simply to derive the desired scenario results.
- **Evaluating Competencies** – Scenarios are of sufficient duration, complexity, and diversity that the competencies and attributes to be validated during the scenario can be adequately assessed.

- **Level of Difficulty** – Scenarios are sufficiently difficult to adequately validate that the integrated HSI and the crew's ability to safely and efficiently meet the scenario objectives. Scenarios that are too easy or too difficult are not effective discriminators.

Scenario Quantitative Attributes:

- **Normal Evolutions** – A sufficient number of normal system manipulations are incorporated into the scenario to meet the objective of validating the integrated HSI and its use.
- **Number and Sequence of Malfunctions** – The number of equipment malfunctions incorporated into the scenario and the sequence in which they are presented varies between scenarios and validates response to both minor inconveniences and loss of significant safety equipment and indications.
- **Abnormal Events and Major Transients** – The number, severity, and sequence of abnormal and major events adequately exercises the areas contained in the scenario validation objectives. The abnormal and major transients contained in the scenario meet the objective of validating the integrated HSI and its use.
- **EOPs and Contingencies Used** – The scenario is constructed so as to fully exercise any EOPs or contingencies designated as validation objectives for the scenario. The EOP exercises contained in the scenario meet the objective of validating the integrated HSI and its use.
- **Total Run Time and Run Time in EOPs** – Typical scenario run time is approximately 60-90 minutes though some scenarios may require either more or less time based upon their content. The scenario duration is sufficient to meet the objective of validating the integrated HSI and its use.
- **Critical Tasks** – The number of critical tasks contained in a scenario and scenario difficulty varies but is also adjusted to ensure that scenarios are not so easy nor so difficult that they are not valid measures of performance. Scenario critical tasks and difficulty is sufficient to meet the objective of validating the integrated HSI and its use.

Determining scenario endpoint

A scenario endpoint is selected and documented. The endpoint specified identifies a particular plant condition, procedural step, plant parameter, or other clearly recognizable condition. The endpoint parameter is specifically selected to allow completion of all scenario objectives prior to scenario termination.

Validation of the scenario
The structure, timeline, flow, and all other aspects of integrated system validation scenarios are validated prior to use of the scenario in ESBWR V&V. Scenario validation ensures that the scenario runs as intended and that supporting scenario development and execution materials are accurate.

Critical task determination
Critical tasks are those human dependant actions or controlled parameters that evaluate crew performance on tasks that are safety significant to the plant or to the public. As such, critical tasks are objective measures for determining whether the performance of the integrated HSI, crew, or individual is satisfactory or unsatisfactory.

The following attributes used to identify and document critical tasks are described in greater detail in the ESBWR Scenario development procedures. Critical tasks contain all of the following elements:

- **Safety Significance** – A task where performance, or omission by an operator will result in direct adverse consequences or significant degradation in the mitigative capability of the plant.
- **Cueing** – External stimulus must prompt at least one operator to perform the task.
- **Measurable Performance Indicators** – The task must consist of positive action taken by at least one operator that an observer can objectively identify.
- **Performance Feedback** – The task must provide at least one member of the crew with feedback information regarding the affect of the crew's action or inaction in relation to the critical task.

Bias
Bias represents any influence, condition, or set of conditions that singly or together distort the data. Bias can produce systematic (but unexpected) variation in a research finding, and can invalidate any conclusions made based on a biased sample. Therefore, when selecting operational conditions and developing scenarios, care must be taken to avoid creating a biased sample.

Measures Taken to Eliminate or Control Bias During Scenario Development

The professionals on the ESBWR HFE evaluation team, control scenario bias through a number of means. These include:

- Procedurally controlled scenario development and validation process
- Validation tests performed using scenarios that are developed by selecting from the full range of operational conditions, and that cover a representative range of conditions

- Scenario validation, which includes an evaluation of scenario attributes and their distribution
- Pilot studies to identify possible sources for scenario bias and develop controls

After scenario development is complete, the resulting set of scenarios are evaluated for selection bias in any of the following areas:

- Scenarios for which only positive outcomes are expected – This is avoided in part by selecting operating conditions for use in scenarios identified in the PRA/HRA as risk important, risk important accident scenarios within the scope of EOPs and SAMGs, and conditions known to challenge human performance, and by including these conditions in scenarios. This type of bias is also avoided by following the "backcasting" methodology described below.
- Scenarios are relatively easy to conduct administratively (scenarios that place high demands, data collection or analysis are avoided) – scenarios are developed that best accommodate all of the selected tasks and conditions, not which scenarios are the easiest to conduct.
- Scenarios that are familiar and well structured (i.e., which address familiar systems and failure modes that are highly compatible with plant procedures such as "textbook" design-basis accidents) – because scenarios are developed from selected operational conditions, and because event sequencing is built in as part of scenario definition, it is not expected for scenarios to follow highly familiar sequences.

"Backcasting"

- Part of the scenario identification and development process involves "backcasting." Backcasting involves identifying a future state (both desirable and undesirable) as identified in SAMGs, EOPs, AOPs, ARPs, and Normal operating conditions, and constructing paths that connect the specified end condition to the conditions and actions required to achieve or avoid them.

- This approach can reduce the risks of hidden bias in construction of scenarios. By selecting both desirable and undesirable outcomes, and by developing scenarios with conditions and events that vary the likelihood of reaching the outcome, a representative and balanced set of scenarios is identified.

If development bias is detected, scenarios will be analyzed for alternatives to create a more fair and representative range of events. Any occurrences of significant sampling bias should be logged as issues in the HFEITS for tracking and resolution.

DCD Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 1 will be revised with the inserted text provided above.

NRC RAI 18.11-22

While NEDO-33276, Section 4.3.4.5 lists generic considerations for scenario development, NEDO-33276 does not address the specific scenarios to be used in validation or how they will be defined. Please provide information on the specific scenarios to be used in validation and how they will be defined.

GE Response

The following paragraphs will be added to section 4.3.4.5:
"Specific scenario details are not included in this implementation plan as they will be developed as the ESBWR design progresses. The scenarios will be defined to challenge the human actions identified through the operational analysis, the risk important PRA/HRA actions, and the OER and procedural actions. The scenarios will address normal startup and shutdown for each system and the plant. The scenarios will include each initiating event group that is expected to impact power operation, and is modeled in the PRA. The risk important sequences that lead to core damage will be evaluated. Complex sequences will be developed considering realistic loss of electrical power events, fires and floods that impact a zone or an adjacent zone. Computer control system faults identified through experience will be developed."

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 0 section 4.3.4.5 will be revised as described above at the next revision.

NRC RAI 18.11-22 S01

NRC Summary Text:
Scenario Definition

NRC Full Text:
In RAI 18.11-4, the staff asked how the selected operational conditions were developed into scenarios. This RAI addresses the detailed definition of the scenarios so they can be run on the validation testbed. GEH's response to the original RAI indicated that specific scenario details are not included in the implementation plan as they will be developed as a part of the ESBWR design process. While in the context of a programmatic review, the staff agreed that this level of detail would be premature at this point in the process, GEH should provide this information if the staff is to conduct an Implementation Plan level review. The descriptions should provide sufficient detail so they can be reviewed using the criteria in NUREG-0711, Section 11.4.3.2.4.

GEH Response

To reflect the level of detail required for an Implementation plan, both the text and document organization in NEDO–33276 will be revised. The final organization is incomplete, but the revision will include a section that details how validation scenarios are defined.
The text below will be inserted in the Operational Condition Sampling section.

Scenario Definition
The purpose of scenario definition is to provide a consistent, objective, and high fidelity environment in which to validate performance of the integrated systems. The defined scenarios involve major plant evolutions or transients, and reinforce team concepts and identify the role each individual plays within the team.

For each scenario, the following information is developed and provided:

- A coversheet and revision log
- An administrative information sheet
- Console operator instructions
- Evaluator information sheet
- One or more event guides
- Scripting for communications with outside personnel expected to take place during the scenario
- A critical task (CT) summary
- Shift briefing/ transfer of authority information (plant turnover sheets may be used)

- Questionnaires for determining where and when HFE aspects of the HSI contribute to problems with response to the various tasks/events during the scenario (provided for crew members, console operators, and trained observers)
- Termination criteria for completion of the scenario

In addition, the following information is established for each scenario:

- Event and task fidelity in scenario development
- Realistic simulation of remote responses during scenarios
- Staffing objectives

Coversheet

The coversheet contains the following information:

- Title and number of the simulator exercise
- Revision level of the document
- Date of the current revision
- The program for which the simulator exercise was designed
- Signature blocks for the author, validator, and customer representative, as appropriate

Administrative Information Sheet

The administrative information sheet should contain the following information:

- Title of the evaluation guide
- Approximate length of the scenario
- Scenario objectives (as required)
- References used to develop the attributes of the scenario. The list should include specific plant procedures, industry and plant events.
- A scenario summary that provides a brief description of initial plant conditions, a sequential listing of the events or evolutions encountered during the scenario, and additional key points of interest to be observed during the scenario (a sequenced list including starting conditions, percent power, BOL/EOL, major equipment out-of-service and major malfunctions that will occur).

Console Operator Instructions

Console operator instructions provide a detailed "road map" of planned events for a given scenario. The instructions provide the following information:

- The initial conditions to be established, which include: the initial simulator setup to be used, any malfunctions, remote functions or overrides to be inserted, and the equipment configurations (such as valve or handswitch positions and clearance tags).
- The timing or event sequence for the entry of malfunctions, with a brief description of the failure (including associated details such as: severity, ramp rates, delay times, and any other needed defining factors).
- The remote functions that may be used to support event recovery or in-plant actions.
- Specific information on simulator configuration (including workplace factors such as environmental conditions).
- A list of task support needs such as specific procedures or documents needed for the scenario beyond the Tech Specs and procedures normally available to the crew in the simulator or control room.

Evaluator Information Sheet

The information sheet provided to the V&V team members contains the following information:

- The crew assignments, as designated by the V&V team lead
- Any special instructions or simulator limitations that are unique to the scenario
- Directions for shift briefing
- Specific information on simulator configuration (including workplace factors such as environmental conditions)
- Termination cues (as applicable)
- Reactivity/control manipulations covered by the scenario

Event Guide

The event guide contains a description of each event or major evolution to be conducted during a testing scenario. Each event or evolution and the key actions performed therein by specific crew members are identified.

Additional spaces are provided for comments by the trained observers and the V&V team members. A section is also provided for additional information regarding role-play cues, specific actions to evaluate, and/or additional crew directions. The event guide provides for the designation of conservative decisions/actions.

The event guide contains the following information:

- Event title
- The expected crew member actions
- Comments, notes and evaluation section
- Termination cues (on the last event guide used during the exercise)
- Critical tasks and associated acceptance criteria
- All applicable Technical Specifications and other regulatory requirements
- All applicable radiological emergency plan classifications

Critical Task Summary

The V&V team uses a critical task (CT) summary to identify safety significant tasks that should occur during each scenario. CTs provide objective measures by which evaluators can determine if the integrated system does or does not support satisfactory crew performance.

A critical task must include the following elements:

- Safety significance to the plant or the public
- Appropriate cues to at least one operator
- Measurable performance indicators
- Feedback for at least one operator regarding the crew's action or inaction

Safety Significance

In reviewing the proposed CTs, scenario developers assess each task to determine if it is essential to safety. A task is essential to safety if, in the judgment of scenario developers, improper performance or omission of the task results in direct adverse consequences or significant degradation in the mitigative capability of the plant.

For example, a task is classified as a safety significant CT if incorrect performance of that task leads to:

- Degradation of any barrier to fission product release
- Degradation to a safety system or emergency power capacity
- A violation of a safety limit
- Incorrect reactivity control (such as failure to initiate Standby Liquid Control)
- A significant reduction of safety margin beyond that which is irreparably introduced by a scenario

A task is also classified as a safety significant CT if failure to perform that task leads to the inability of a crew to:

- Effectively direct or manipulate engineered safety feature (ESF)
- Control a parameter that results in any condition described in the previous paragraph
- Recognize a failure or an incorrect automatic actuation of an ESF system or component
- Take one or more actions that would prevent a challenge to plant safety
- Prevent inappropriate actions that create a challenge to plant safety (such as an ESF actuation)

Appropriate Cues

For a CT to be considered valid, an external stimulus prompts at least one crew member to perform the task. The cue provides initial conditions and prompts the operators to respond by taking certain actions. The cue need not indicate the task as "critical."

Measurable Performance Indicators

The scenario developer establishes measurable performance indicators for each CT. A measurable performance indicator consists of positive actions that an examiner can objectively identify as being taken by at least one member of the crew.

Examples of measurable performance indicators include:

- Control manipulations such as a manual reactor trip or the start of a safety system
- Verbal reports or notifications of abnormal parameters or conditions such as "all control rods are not inserted" or "containment pressure is greater than 2 psi"

Feedback

Feedback allows the operator to determine if actions/manipulations have corrected the adverse trend or component failure he attempted to correct.

Examples of feedback include:

- Reversal of water level trend after the initiation of a standby pump
- Rising system flow after opening a bypass valve, etc.

Shift Briefing Information/Transfer of Authority

The shift briefing included in the scenario guide will provide the crew with the conditions of the plant when they assume control (this includes plant parameters appropriate to the scenario such as power, level, pressure, load, mode, etc). Also provided will be any Tech Spec limiting conditions of operation (LCO) conditions and required actions currently in effect and, any equipment out of service due to preventative or corrective maintenance. Any normal evolutions expected of the crew during the shift are listed. The briefing can be removed from the scenario and used by the crew for their briefing prior to assuming shift. No indication of the expected events or final outcome of the scenario will be provided by the briefing.

Questionnaires

Questionnaires request input from each crew member, console operator, and evaluator to identify any problems experienced during each event in the scenario and any issues/concerns to be resolved. The questions used should address specific events or actions required during the scenario and note any problems in recognizing or responding to these events.
Evaluator notes taken during the scenario can be used to aid crew members in recalling items/actions that presented any unexpected challenges.

Event and Task Fidelity

The scenarios for integrated system validation use the results of the HFE Task Analysis for the various ESBWR systems as one basis for scenario development. Each scenario should include normal, abnormal and emergency events requiring crew response. The actions taken by each crew member will be tasks that can be traced to the Task Analysis results.

Realistic Simulation of Remote Responses

Responses requested from outside personnel or external agencies use time delays before completion is reported to the crew. Time for gathering tools and/or procedures necessary for task completion and delays associated with the radiological and environmental conditions in the area are realistically simulated. The times noted during the development and verification of the procedures required for task completion are used when applicable and available.

Staffing Objectives

Staffing for performance of integrated system validation testing scenarios use licensed personnel for crew members or participants enrolled in training classes for the purpose of ESBWR licensing. Crews are selected to ensure that both experienced and new operators are evaluated and provide input on the HFE aspects of the controls. Test participants are not allowed to act as a crew member in a given scenario more than once.

Scenario events and tasks that result in common problems for crew members will be documented as HEDs in HFEITS to track the HFE or HSI factors changed to resolve the problem. Tasks that result in the failure of the plant or crew to meet established acceptance criteria will also be added as HEDs and tracked to resolution in HFEITS.

DCD Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 1 will be revised with the inserted text provided above.

NRC RAI 18.11-27

NEDO-33276 does not provide detailed information on test design. Please provide descriptions of the methodology used for the following aspect of test design:

- *presentation of scenarios to crews*
- *test procedures*
- *training of test conductors*
- *training of test participants*
- *pilot studies*

GE Response

NEDO-33276 will add a section on test design in the next revision to address the issues identified:

A. Presentation of scenarios to crews

A discussion prior to the simulations will be conducted to describe the overall objective of the testing process which is to validate the MMIS and for operating team to consider difficulties and issues they have in using the MMIS for the planned scenarios (e.g., normal operational startups, shutdowns, accidents from full power or partial power, and management of outage conditions). A shift turnover process will be used to define the plant status including possible equipment tagouts. The use of the simulation freeze capability for questions about situational awareness is discussed.

B. Test procedures

A simulation scenario known to the observers is selected from at least five different ones.

The simulation start will be announced.

The initial condition will last for several minutes before any new malfunction is introduced. Recording of plant alarms, screen changes, control actions and key parameter traces is maintained throughout the simulator training interface. The timing for each malfunction will be entered from a preset file that permits each simulation to be repeated for other crews. The simulation continues until the planned actions are completed and the plant reaches a stable state. Records of the simulation from the simulation are saved in an electronic file for future use. The operators are debriefed after the simulation to obtain information that made control tasks difficult.

C. Training of test conductors

The test conductors include the simulator operator, training instructors, and observers with control room and simulator observation experience. The training of the this team can be performed by setting up scenarios with set malfunctions, or by running through existing scenarios to define possible and expected responses based on procedures and general operating rules. Also, protocols such as how to interact with the crew during the simulation, non-intrusive locations, use of recording devices, development of the information check list for taking notes during the simulation, and focus on the MMIS, procedure or tasks of importance for the specific simulation.

D. Training of test participants

The test participants should have had basic operator training on ESBWR technology, use and meaning of the screen protocols and MMIS interaction processes, have completed training on each procedure to be used, and have training on potential human errors (e.g., STAR).

E. Pilot studies

Initial pilot studies on use of the MMIS by the designers and the HFEs can be used to test out scenarios and interactions on computers that provide simulation capability. The pilot studies address resolution of issues identified early in the process.

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 0 will be revised as described above at the next revision.

RAI 18.11-27 Supplement 1

NRC Summary Text:
Test Design

NRC Full Text:
In the original RAI the staff requested the detailed test design methodology. In NEDO-33276, Rev. 1, GEH added a new section 4.4.9 to present a high level description of test design. However, GEH should provide the detailed information requested if the staff is to conduct an Implementation Plan level review. Please provide descriptions of the following aspect of test design (consistent with NUREG-0711, Section 11.4.3.2.6):

- *presentation of scenarios to crews*
- *test procedures*
- *training of test conductors*
- *training of test participants*
- pilot studies

GEH Response

To reflect the level of detail required for an Implementation plan, both the text and document organization in NEDO–33276 will be revised. The final organization is incomplete, but the revision will include a section that details how scenario presentation, test procedures, training (of both test administrators and participants), and pilot studies are used in the integrated system validation process.

The text below will be inserted in the Integrated System Validation section.

Test Design

Test design is the process of developing the integrated validation test such that the required attributes for scenario assignment, the qualifications of the test conductors and training and briefing of participants permit the observation of integrated system performance in a manner that avoids or minimizes bias, confounds, and noise (error variance).

Coupling Crews and Scenarios

The coupling of crews and scenarios determines how the test participants experience the test scenarios.

Scenario Assignment

Scenario assignment to crews is made prior to the initiation of the integrated test sequence. Depending upon the number of available crews during testing, some crews may not participate in all scenarios. The set of scenarios, selected by the validation team and presented to a crew, should be carefully balanced to ensure that each crew receives a similar and representative range of scenarios (difficult scenarios are not only assigned to above average crews). To establish adequate test data reliability, each validation scenario should be run on a minimum of three crews.

Scenario balance among crews is maintained by providing the validation team with a checklist for making assignments. This checklist requires scenario selection to be based on scenario complexity, operating conditions, and expectations during the scenario (i.e. each crew receives scenarios that test their abilities and plant responses during normal, abnormal and emergency plant conditions). The checklist also ensures that the crews do not repeat scenarios.

Presentation of the same scenario to the same crew for a second time may not occur in the context of integrated system validation.

Scenario Sequencing

The validation team should balance the order in which scenarios are presented to crews. The same type of scenario is not presented in the same linear position (i.e. avoiding always presenting the easy scenarios first) and the scenario sets do not always occur in the same sequence. Control of scenario sequencing also serves to minimize any bias resulting from crew expectations of scenario type.
Test Procedures

The following outlines steps that are taken to perform evaluation procedures for HFE validation activities using the simulators:

1. A simulation scenario that evaluates the ESBWR features being considered is assigned to a crew. An alternate scenario selected using the same criteria and methodology and that evaluates the same ESBWR features as the primary scenario is designated for use should it become necessary. These scenarios should be known to the test conductors and observers, but not to the participating crew.
2. Each crew is briefed prior to the performance of a scenario. The briefing procedure follows a detailed script that is prepared during scenario development. At a minimum, these briefings should describe the following:
   - Test objectives
   - Crew assignments
   - Plant status with any expected normal operations for the crew

- Use of human performance tools during manipulations
- Test conductor/participant interface after scenario initiation

3. The crew enters the simulator and performs a walkdown of the simulator panels, a verification of initial conditions, and a shift turnover.

4. The scenario is conducted according to the applicable scenario guide. This guide delineates the manipulations required by the simulator operator and the expected simulator responses to these manipulations.

   If the simulator fails to perform as expected, the operator should request instruction or corrective actions from the lead test conductor. If the failure cannot be resolved, or if the test conductors feel the failure has invalidated the scenario as an evaluation tool, the scenario is terminated. An alternate scenario may be selected for evaluation of the crew and integrated HSI.

5. The scenario guide also includes the following information:
   - A coversheet and revision log
   - An administrative information sheet
   - Console operator instructions including timeline and manipulations required for initiation of the scenario events
   - Evaluator information sheet
   - Event guides with expected crew and simulator responses
   - Scripting for required communications with outside personnel during the scenario
   - Critical task summary for determination of satisfactory crew/simulator response to events
   - Shift briefing / transfer of authority information
   - Questionnaires to be used in association with the scenario
   - Termination criteria for completion of the scenario
   - Questionnaires for specific crew positions that request responses on events that required increased situational awareness or that caused a significant change in operator workload

6. Data collection during performance of a scenario uses methods to minimize bias in both the conductors and participants in the test. Automatic collection by videotaping and recording of plant parameters and control board manipulations in response to event initiation is used to the maximum extent possible. The videotape system and simulator times are synchronized so that event response can be recreated.

   Test conductors receive training in the methodology for minimizing conductor-to-participant interactions during scenario events. Training in techniques for measuring conditions such as situational awareness and cognitive workload are provided. This includes training for automatic measuring instruments.

7. A scenario should continue until the planned actions are completed and the termination criteria in the scenario guide are met.
8. If deemed necessary during testing, the simulator may be frozen at any point in order to question crewmembers or resolve issues. Planned 'freezes' of the simulator after scenario events that have increased cognitive workload may also be used.
9. If simulator or testing difficulties arise, the difficulty is documented. When or how test personnel interact with crewmembers is guided by established procedures.
10. All records and results from the integrated validation tests are retained for review.
11. The operators are debriefed after a scenario to gather information about events and required actions that resulted in problems manipulating controls or obtaining data required to perform these actions.

Briefing Participants

A standardized discussion prior to a simulation is conducted to describe the overall objective of the testing process. The crew is instructed to consider difficulties and issues they have while using the HSI during the testing scenario (e.g., normal operational startups, shutdowns, accidents from full power or partial power, management of outage conditions, etc). A shift turnover process is used to define the plant status including possible equipment tagouts. The use of the simulation freeze capability for questions about situational awareness is discussed. The crew is instructed to refrain from discussion of the scenario with other test personnel until all test crews have performed the scenario.

Conducting Scenarios

For details regarding specific criteria for the conduct of scenarios, such as when to start and stop scenarios, when events are introduced, etc., see "Scenario Definition."

Scripts

When possible, test personnel role-playing plant personnel during test scenarios should adhere to prepared scenario scripts when interacting with crew members. Scenario guides provide responses to likely crew questions. Responses should only provide information that would normally be available in a real plant situation. These guides also establish delay times, both due to environmental conditions and to the complexity/ location of the selected task, before completion of the task is reported. Some remote tasks requested are not performed due to expected plant conditions or the availability of equipment requested. These remote tasks are delineated in the scenario guide along with the required reports and time delays.

If a crew member asks a question that requires input not covered by a script, the test personnel should attempt to respond to the question in manner consistent with how such a question would be addressed in a real plant. In addition, any such occurrences should be documented, and if deemed necessary, additional scripts should be written.

Interaction of Test Conductors with Test Participants

Once scenario testing has begun, test conductors and participant interactions should only occur if required by the scenario (i.e. the crew requests input from an outside source that requires a meeting in the control room). These interactions are scripted in the scenario guide. Protocols such as when and how to interact with the crew during the scenarios, non-intrusive locations, and unobtrusive use of recording devices are part of test conductor training.

If interaction is required due to failure of the scenario to run as expected or simulator problems due to simulator operator error, test conductors should follow established procedures and minimize the impact of the situation or error on crew performance. If the failure or error affects the usefulness of a scenario as an evaluation tool, test conductors should freeze the simulator and determine if the remaining events in the scenario can still allow an evaluation to occur. If not, the crew should receive a replacement scenario.

Data Collection

Validation activities with the Part Task Simulator (ANSI/ANS-3.5 compliant) and the Full Scope Simulator use the following:

1. Videotaping – Each scenario run is recorded from the start of a simulation until the stop of the simulation. At least one video camera is positioned to record a general overview of the control room, including general crew task performance and movement. In addition, where deemed applicable, an additional camera or cameras are placed to record specific crew actions or specific panels. Decisions regarding additional cameras are made on a case-by-case basis.
2. Data collection forms and checklists – to be completed by observers
3. Interviews using established analysis tools such as the NASA Task Load Index (TLX) to supplement analytic data. Interviews are conducted after scenario completion or during a scenario freeze
4. Questionnaires – to be completed by crew members

5. Simulator recording of chronological event logs
6. Simulator recordings (logs) of process variables
7. Written observations, notes and commentary – to be completed by observers
8. Timelines of operator activities while performing tasks identified in the TA and PRA/HRA, used to identify periods of overloading and underloading. The timelines show phasing, frequency, durations, and time limits for tasks. Other actions (reactions to secondary effects, diagnostic actions), if defined, can be included in the timeline.
9. Operator movement pattern diagrams may be developed using videotapes and visual observation records. However, because operating experience has shown that MCR traffic and crew movement patterns are generally not significant in modern digital control rooms, movement pattern diagrams may be developed to resolve HEDs or related issues, but are not developed as part of routine validation testing.

TRAINING

Test Conductors

The test conductors include V&V team members, simulator operators, training instructors, and observers with control room and simulator observation experience. Test conductors will receive training similar to the training required by ACAD97-014 for simulator instructors/evaluators prior to initiation of the integrated validation tests. Some components of this training include:

- Planning and coordinating simulator sessions
- Observing operator performance
- Evaluating operator performance
- The use and importance of test procedures
- Experimenter bias and the types of errors that may be introduced into test data through the failure of test conductors to accurately follow test procedures or interact properly with participants.
- The importance of accurately documenting problems that arise in the course of testing, even if due to test conductor oversight or error.
- Test conductors should be qualified as simulator operators and familiar with the capabilities of the partial scope or full scope simulator.

Also included in training are protocols such as when and how to interact with the crew during the simulation, non-intrusive locations, use of recording devices, development of the information check list for taking notes during the scenario, and focus on the HSI, procedure or tasks of importance for the specific scenario.

Test Participants

Test participant training may vary based on the experience and education of the individual and the requirements of the integrated validation tests. Integrated system testing using part task simulator requires comprehensive knowledge of the systems included in the test. This knowledge is attained through formal classroom and simulator training. After training is complete, a comprehensive examination on the received training and job performance measures for system manipulations on the simulator will be conducted to prove the success of the training.

Test participants who will be used during the full scope simulator integrated validation tests will be trained as follows:

- Test participants that were licensed on previous generation BWRs are required to receive ESBWR systems training, procedure training and simulator training for familiarization with the controls for the specific ESBWR systems. This training is similar to existing BWR license training in content.

- Test participants with no previous BWR operating experience are required to receive additional training for BWR general fundamentals. The ESBWR systems and procedure training required for these personnel is similar to existing BWR initial license training. The formerly licensed personnel should attend integrated plant simulator training with the new trainees to promote teamwork and allow the new trainees to benefit from their experience.

- All personnel receive a comprehensive operating test in the full scope simulator before participating in the full scope simulator V&V testing.

Pilot Testing

A pilot study will be performed prior to the initiation of the V&V process in the simulator. This study is used to test the process for determining adequate design and determining the correct data collection techniques.

Components and requirements of a pilot study include:

- Scenario guides written to the same level of complexity as the guides prepared for the actual V&V testing.

- Crew composition and numbers for test participants are equivalent to the actual V&V testing. This includes all necessary training and testing as referenced above.
- Test conductor training and expectations for the conduct of the pilot tests are maintained at the same level as the actual testing.
- Data collection setups, methods and determination if validation criteria are met will match those used in actual testing.

Personnel used during pilot testing should not be the same personnel to be used as test participants during integrated validation tests. If integrated validation test personnel must be used, the scenario sets must be different from those developed for the integrated validation test, and participant exposure to the data collection process should be minimized.

DCD Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 1 will be revised with the inserted text provided above.

MFN 08-156

Attachment 1

Markup and Added Text for RAI

18.4-26 S01

4.3.3 Process

4.3.3.1 System Function Comparison

Compare and match plant functions and system functions.

4.3.3.2 Link PFRA to SFRA

Tie the PFRA data structure to the SFRA data structure where system functions match one another.

4.3.3.3 Determine Differences

Identify plant functions that are not supported by a system function.

4.3.3.4 Validate Systems Functions

Identify system functions that do not support plant functions.

4.3.3.5 Resolve Differences

Reconcile discontinuities between PFRA and SFRA where possible.

4.3.3.6 Create Design Inputs

When plant functions are not supported by system functions:

- Verify that the plant requirements are necessary
- Process the design input according to the HFE and MMIS Implementation Plan
- Provide the Responsible System engineer with design inputs
- Re-perform the applicable portion of the FRA to confirm resolution
- Document the root of the process issues in HFEITS

4.3.3.7 Validate Design Input Effectiveness

When system functions are not required based on the PFRA:

- Verify that the system functions are required or are justified
- Process the design input according to the HFE and MMIS Implementation Plan
- Provide the Responsible System engineer with design inputs
- Re-perform the applicable portion of the FRA to confirm resolution
- Document out of process issues in HFEITS

4.3.3.8 Plant Function Operational Summary

Determine the following for each high-level plant function related to the plant safety goal:

- Purpose of the plant function
- The plant condition(s) which require the plant function
- Parameter(s) that represent the availability of the plant system designated to support the plant function
- Parameter(s) that represent operation of the plant system in support of the plant function
- Parameter(s) that represent the success of the plant system in support of the function and that represent when support from the plant system can or should be terminated.

4.3.4 Outputs

The results of the SFGA generate:

- Design inputs
- Links between the PFRA and SFRA data structures
- Inputs to subsequent iterations of the FRA, AOF and TA
- Requirements for HSI design
- Plant function operational summary for high-level functions that support plant safety

5 RESULTS

5.1 Results Summary Report

Following each iteration, FRA results are recorded in a data structure and rendered in a form that accommodates validation and verification. Once rendered and verified, results are attached to the SDS as Appendices. FRA Results Summary Reports (RSR) may be combined with the AOF and/or TA RSRs.

Results Summary Reports contain:

- Roster of team members and their roles in performing the FRA.
- Inputs and Outputs, and
- Issues carried forward in HFEITS.
- The plant function operational summary for each high-level plant function that specifies when support of the function is required and specifies the parameters necessary to monitor availability, operation, and success of this support.