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Concept of Operations and Simulator Development

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Meeting Agenda

- Introductions
- Purpose & Outcome
- Overview of Concept of Operations
- Discussion on Multi-Unit Simulation Requirements
- Open Forum

Purpose and Outcome

- PURPOSE
  - To provide a high-level overview of the concept of operation and intended implementation plan with regards to Human Factors Engineering efforts and development of a Plant-referenced simulator.

- OUTCOME
  - To obtain feedback from the NRC staff on the execution plan for the simulator development with regards to
    1. Human Factors Engineering Verification and Validation IAW NUREG-0711
    2. Declaration of a Plant-Referenced Simulator for licensing examination IAW 10 CFR 55

Concept of Operations – Plant Design

- Passive safety systems relying on one time DC-powered valve actuation
- No credited operator actions during DBAs
- Minimum number of important human actions (IHAs) expected
  - No PSA-determined IHAs at this time
- Advanced digital system for automated controls reducing licensed operator workload

Concept of Operations – HSI Design

- The HSI is designed to reduce the operator's workload and minimize the potential for human errors.
- The HSI will detect and provide a means for recovery due to human error.
- The HSI provides all the support functions (indications, alarms, controls) the operator requires to monitor and control the plant.
- Automatic indications will be displayed for bypassed or inoperable safety systems/functions.
- The HSI contains computer-based procedures and displays the appropriate systems status and controls for the in-use procedure(s).
- The HSI provides the operator an opportunity to override an automatic function if the operator determines the need to do so.

Concept of Operations – Licensed Operators

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- The HSIs for each unit are represented on multiple Video Display Units (VDUs) at the RO and the SRO workstations.
- The plant is designed to be highly automated. The main role of the operator is to monitor the plant status and evolutions to ensure that the HSI is controlling properly and that the plant is responding correctly.

Concept of Operations – Operator Training

- The licensed operators are trained to
  - Provide backup monitoring of the automated functions or to override the automatic response and provide manual response if necessary.
  - Operate the safety and support systems of the plant.
- Training will cover not only plant systems' design and functions, but also how the HSI functions, potential failure modes of the HSI, and backup methods for monitoring and controlling the plant in the unlikely event of an HSI failure.

Human Factors Engineering

- The HFE process plays a critical role in determining control room operation through the following elements:
  - Operating Experience Review (OER) – identifies staffing related lessons learned
  - Functional Requirements Analysis/ Function Allocation (FRA/FA) – establishes actions necessary to support required functions and allocates to operator performed or automatic
  - Task Analysis (TA) – analyzes the comprehensive requirements and support needed to satisfy the task function
  - Staffing and Qualifications (S&Q) – evaluates operational workload to determine appropriate staffing levels and qualifications needed
  - Procedure Development (PD) – develops guidance for performing operator actions
  - Verification and Validation (V&V) – validates system and plant responses using the task analysis and procedure guidance with the expected staffing

Simulator Development

- From NUREG/CR-6838, Staffing Plan Validation methods include:
  - Table Top Analysis
  - Operating Experience Data
  - Simulator Studies
  - Human Performance Models
- The human performance measure used for validation will be identified and defined regardless of the method used.

Simulator Development

- The evaluation process will center on the below criteria based on the effects of the new concept of operation design:
  - Operator and team performance
  - Situation awareness
  - Cognitive workload
- NUREG/CR-7126
  - “Until such research in complete, HFE reviewers should request applicants to justify their proposed multi-unit operational strategy, e.g., by simulations.”

Simulator Development

- The use of a mix of validation methods will verify a comprehensive assessment of the proposed staffing plan.
- Provides the opportunity for convergence of the results from multiple approaches to increase the confidence level of the analysis.
- Alternate means allows for continued HFE refinement as the simulator is developed.

Simulator Development

- Recent multi-unit validations:
  - The SPV included simultaneous abnormal and emergency events on multiple modules to produce challenging and high-workload conditions
  - Successful task performance, adequate situation awareness, and manageable workload were used to validate the proposed minimum staffing level was acceptable
  - Integrated system validation (ISV) used performance-based tests to determine whether hardware, software, and personnel elements meet performance requirements.
  - Trained personnel perform preplanned scenarios, which consisted of a broad sample of normal, abnormal, and emergency plant events, in a multi-module control room simulator where all units are simultaneously and independently modeled with connected inputs of shared systems.

Simulator Development

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Simulator Development

- The bulk of HFE work including OER, FRA/FA, TA and initial Staffing and Qualification work will continue with the use of the Engineering Simulator and single unit Desktop Scaled Simulator with incorporated HSI.
- A dual unit simulator will be employed to validate the Staffing plan and integrated system design based on the intended Concept of Operations.

Open Forum

Backup Slides

Common Systems

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Design Configuration

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Plant-Referenced Simulator

10CFR 55.4

- "Plant-referenced simulator" means a simulator modeling the systems of the reference plant with which the operator interfaces in the control room, including operating consoles, and which permits use of the reference plant's procedures.

RG 1.149

- Expected plant response to operator input and to normal, transient, and accident conditions
- Sufficiency in scope and fidelity to allow conduct of the evolutions associated with operating test content and licensed operator requalification program on-the-job training, applicable to the design of the reference plant
- Simulator fidelity has been demonstrated so that significant control manipulations are completed without procedural exceptions, simulator performance exceptions, or deviation from the approved training scenario sequence.

Simulator Development

- From NUREG/CR-6838,
  - Using in-simulator studies for staffing plan validation will often be limited by simulator availability
  - Requires trained operators who understand the advanced design and HSI innovations compared to conventional plants
  - Simulators with lower levels of fidelity may be used to provide supporting data