NRC Workshop: HFE ISV Issue

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NUCLEAR ENERGY INSTITUTE

Background – NRC IAP MP4a Meetings

- NEI members acknowledge that there was limited MCR modernization discussion during NRC Integrated Action Plan MP4a meetings which resulted in the Alternate Review Process published in DI&C-ISG-06, Rev. 2
- NEI members did not consider significant changes to the HSI of safety system digital controls upgrades
- NEI members recognize to improve NPP safety and reliability, MCR modernization is needed
- Key industry objective for MP4a new licensing process discussions was earlier License Amendment issuance to support reduced project risk
- NEI members are hoping for a path forward, which continues to allow industry to perform safety-related digital control system upgrades with MCR modernization, with the early license amendment issuance

Background – Alternate Review Process (ARP)

- Utilizing the Alternate Review Process, the licensee submits digital I&C design information earlier in project lifecycle
  - Recognizes LAR includes an NRC approved software lifecycle process or information provided in the LAR describes lifecycle activities
  - ARP pilot LAR relied on Vendor Oversight Plan (VOP) and regulatory commitment for later lifecycle activities
  - Same process for potential I&C design changes post-License amendment approval apply to HFE design changes – 10 CFR 50.59 process applies
- Recognize that NRC plans to use NUREG-0711 for review of human factors engineering (HFE) information included in LAR
  - NEI members believe the underlying regulation is 10 CFR 50.9, *Completeness and accuracy of information*
- NEI members propose to include LAR content (e.g., Implementation Plans or Results Summary Reports or similar content) addressing early project lifecycle HFE activities (per EPRI Digital Engineering Guide):
  - Operating Experience
  - Functional Analysis and Allocation
  - Task Analysis
  - Staffing & Qualifications
  - For later HFE lifecycle activities, LAR will describe process for completion

Integrated System Validation (ISV)

- NEI members concerned that the Multi-Stage Validation (MSV) approach offered by NRC does not have precedent or clear guidance/acceptance criteria
- One option for consideration: Since Integrated System Validation (ISV) is a critical activity, LAR could include a license condition that ISV will be conducted in accordance with the LAR
    - NEI members understand that the NRC safety determination cannot depend on a license condition's closure; therefore LAR could be approved prior to ISV completion
- Strategy for addressing NUREG-0711 Verification & Validation (V&V) element will be included in the LAR
- Licensee will keep NRC apprised of ongoing activity schedule (e.g., task or design verification, use of glasstop simulator) to allow for potential audit/inspection
- NEI members request NRC make their safety determination for ARP LARs based on:
    - Early HFE activity IPs/RSRs (e.g., Operating Experience, Task Analysis) and
    - A HFE program plan, based on INL research (slides to follow) which describes the later HFE activities assuring a successful ISV

HFE LAR Strategy

- LAR (per 10 CFR 50.9) would include:
  - Early HFE activity IPs/RSRs (e.g., Operating Experience, Task Analysis)
  - HFE program plan, based on INL research, describing the later HFE activities assuring a successful ISV
  - License Condition to perform the ISV in accordance with the LAR
- Note that the ISV IP will be available for audit prior to ISV execution
- Perform the ISV to close the License Condition
- Note that the V&V Results Summary Report will be available for inspection

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LWRS LIGHT WATER REACTOR SUSTAINABILITY

Human Factors Engineering in Support of Control Room Modernization

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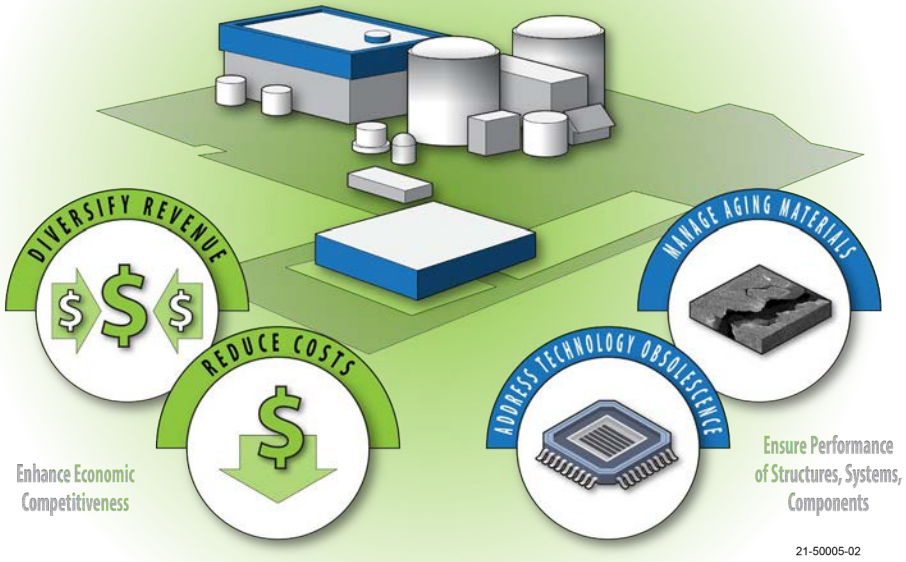
U.S. Department of Energy Light Water Reactor Sustainability (LWRS) Program

Goal

Enhance the safe, efficient, and economical performance of our nation's nuclear fleet and extend the operating lifetimes of this reliable source of electricity

Objectives

- Enable long-term operation of existing nuclear power plants
- Deploy innovative approaches to improve economics of light water reactors in the near-term and in future energy markets
- Sustain safety, enhance economics, enable revenue diversification



LWRS Plant Modernization Pathway

LWRS Program researchers conduct Human Factors R&D on control room modernization to:

- Ensure modernization activities are:
  - Technically sound
  - Regulatory compliant
  - Safety focused
- Develop principles and create state-of-the-art guidance on control room modernization
- Collaborate with industry (owners, operators, suppliers)
- Disseminate lessons learned to benefit industry and the regulator

History of Activities

Opportunity to address technological obsolescence issues in the control room

- Digital technologies present chance to improve human factors of control room designs

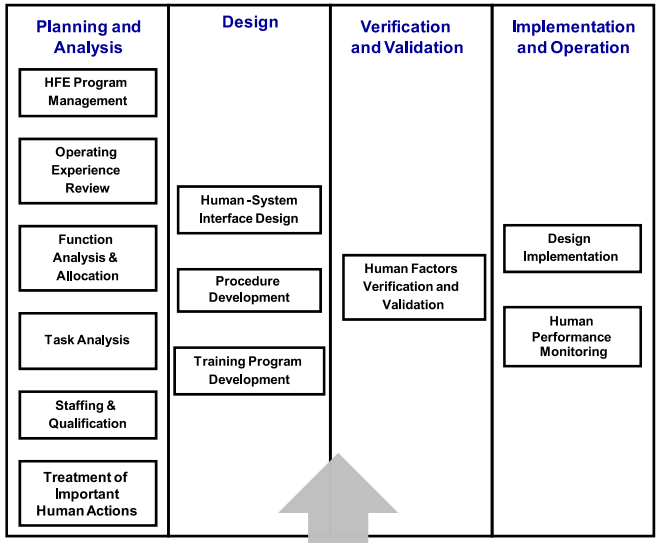
Industry expressed need for human factors support for modernization

- Guidance on applying NUREG-0711
- Experience on how to incorporate human factors in design
- Development of a flexible simulator for design engineering

Example of Meeting NUREG-0711 Requirements

Created process to support iterative design evaluations that align with NUREG-0711 phases

- Evaluations conducted early (formatively) build support for later (summative) integrated system validation



NUREG-0711, Rev. 3

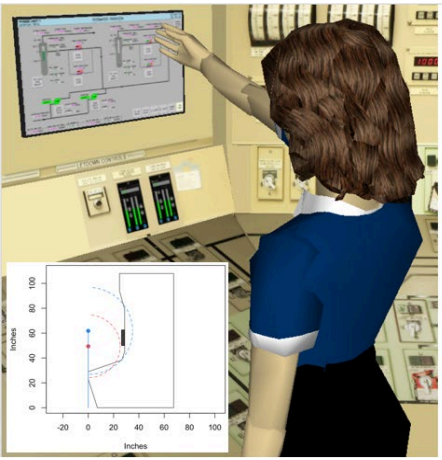
Evaluation Phase

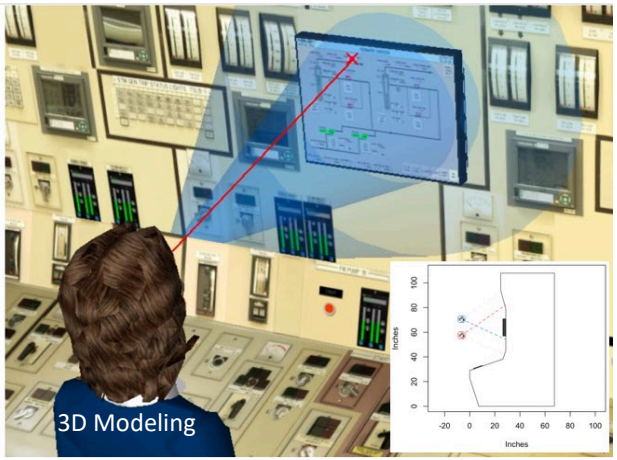
Evaluation Type	Pre-Formative (*Planning and Analysis*[1])	Formative (*Design*[1])	Summative (*Verification and Validation*[1])	Post-Summative (*Implementation and Operation*[1])
Expert Review *(Verification)*	[1] Design Requirements Review	[2] Heuristic Evaluation	[3] System Verification	[4] Requalification against New Standards
User Study *(Validation)*	[5] Baseline Evaluation	[6] Usability Testing	[7] Integrated System Validation	[8] Operator Training
Knowledge Elicitation *(Epistemiation)*	[9] Cognitive Walkthrough (Task Analysis)	[10] Operator Feedback on Design	[11] Operator Feedback on Performance	[12] Operating Experience Reviews

[1]Corresponding Phases in NUREG-0711.

Boring, Joe, et al. (2015)

Examples of HFE Activities





Planning and Analysis	Design	Verification and Validation	Implementation and Operation
HFE Program Management			
Operating Experience Review	Human-System Interface Design		Design Implementation
Function Analysis & Allocation	Procedure Development	Human Factors Verification and Validation	
Task Analysis	Training Program Development		Human Performance Monitoring
Staffing & Qualification			
Treatment of Important Human Actions			

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Tabletop reviews of the HSI


Operator-in-the-Loop Studies

HFE Activities Crosswalk

NUREG-0711 Elements in Black **New HFE R&D Activities in Blue**

Activity	Supports
HFE Program Management	Inserts HFE into overall Engineering process, establishes new end state vision, establishes HFE role as an integrator
Operational Experience Review	Capturing Lessons Learned and HFE design requirements for the new I&C system
Ergonomic Analyses of Control Room Layout and 3D Modeling	**Early (Formative) input into placement of new I&C indications and controls**
Function Analysis & Allocation, Task Analysis, Staffing & Qualification, Treatment of Important Human Actions	Early (Formative) analyses to support design and eventual installation of new I&C systems
Development of Initial Prototype Human System Interfaces (HSIs)	**Early input into HSI design**
Static and Dynamic workshops (at INL HSSL)	***Iterative evaluations* of the I&C system with a focus on its design and indications and controls (i.e., HSIs)**
Procedure Development, Training Program Development	HFE and human systems integration-based analyses to evaluate the potential changes to the concept and conduct of operations
HSI Inventory and Characterization, HSI Task Support Verification, HFE Design Verification (i.e., Design Verification)	Verification & Validation
Integrated System Validation	Verification & Validation
Design Implementation and Human Performance Monitoring	Implementation and Operation

HFE R&D for Control Room Modernization

- The LWRS Program's R&D collaborations support the long-term operation of the existing fleet by addressing technology obsolescence and human factors aspects of control room modifications
- HFE methods have been researched, developed, and deployed to produce results that are usable by the entire industry
- The HFE methods and HFE design recommendations support iterative design enhancements and produce results early in the modernization process
- Collectively, the HFE methods and recommendations address all elements of NUREG-0711 and increase the confidence in the final design

Questions?

Sustaining National Nuclear Assets

lwrs.inl.gov Program Information

www.osti.gov References

Biographical Sketches

Jeffrey C. Joe, M.S., is a Distinguished Research Scientist in the Human Factors and Reliability Department at Idaho National Laboratory. His research skills and expertise are in the areas of Human Factors R&D, Human Factors Engineering, human reliability analysis, safety culture, and social psychology. He has 10+ years as a Principal Investigator/technical lead for multiple R&D projects under the DOE Light Water Reactor Sustainability program.

Ronald L. Boring, PhD, is Department Manager for the Human Factors and Reliability Department at Idaho National Laboratory. He was the founder of the Human Systems Simulation Laboratory and leads development of prototyping tools such as the Advanced Nuclear Interface Modeling Environment (ANIME) and human factors evaluation methods like the Guideline for Operational Nuclear Usability and Knowledge Elicitation (GONUKE) to support control room development at nuclear power plants.

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