

Control Room Modernization: R&D Performed Under the LWRs Program Plant Modernization Pathway

**Advanced Sensors and Instrumentation
Annual Webinar**

October 31 – November 1, 2018

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CRM Human Factors Overview

- LWRS Program researchers conduct Human Factors R&D on control room modernization approaches to:
 - Evaluate the impact of modernization activities on human-system performance.
 - Establish the technical bases for upgrade decisions.
- Human factors experts:
 - Collaborate with industry partners by evaluating designs to ensure human-system performance is not impacted.
 - Research a variety of data collection methods to provide the basis for design decisions and provide evidence of human performance impacts of design.
 - Develop principles and create state-of-the-art guidance on control room modernization to inform the LWR fleet.

Current Work

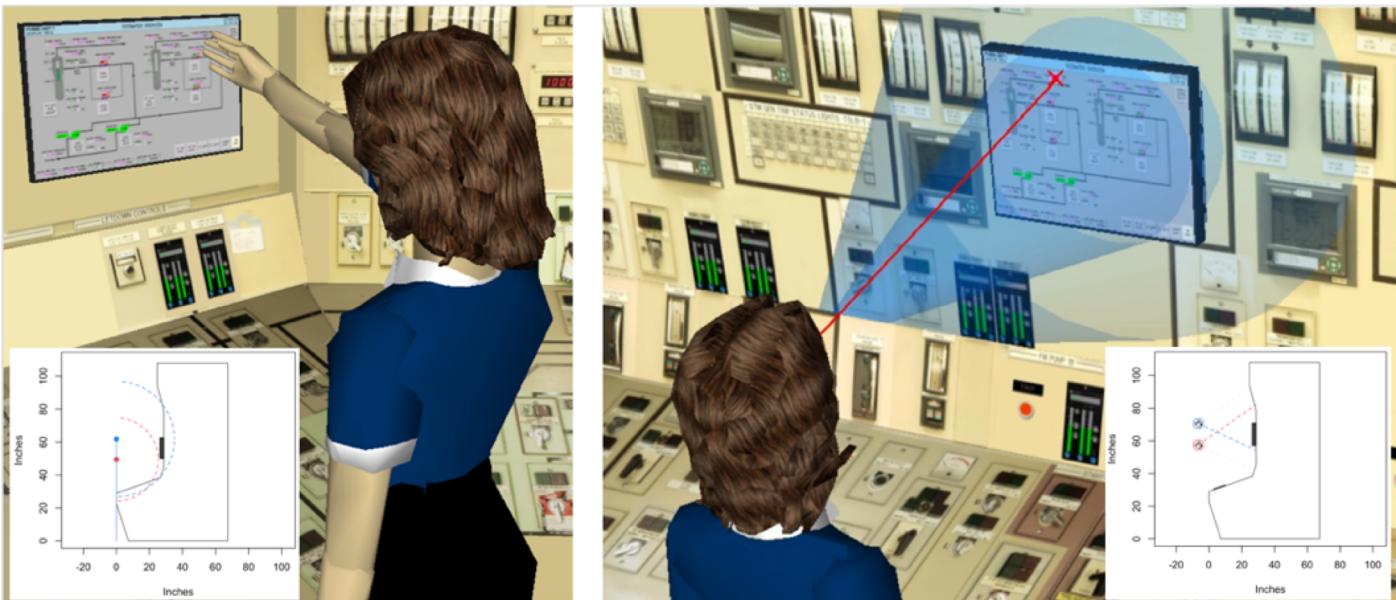


Typical utility/regulatory approach is to perform:

1. Engineering Analyses against Standards
2. Calculations
3. Verification & Validation

to Minimize Risk

- 3-D Modeling
- HFE Analyses
- Using
- NUREG-0700



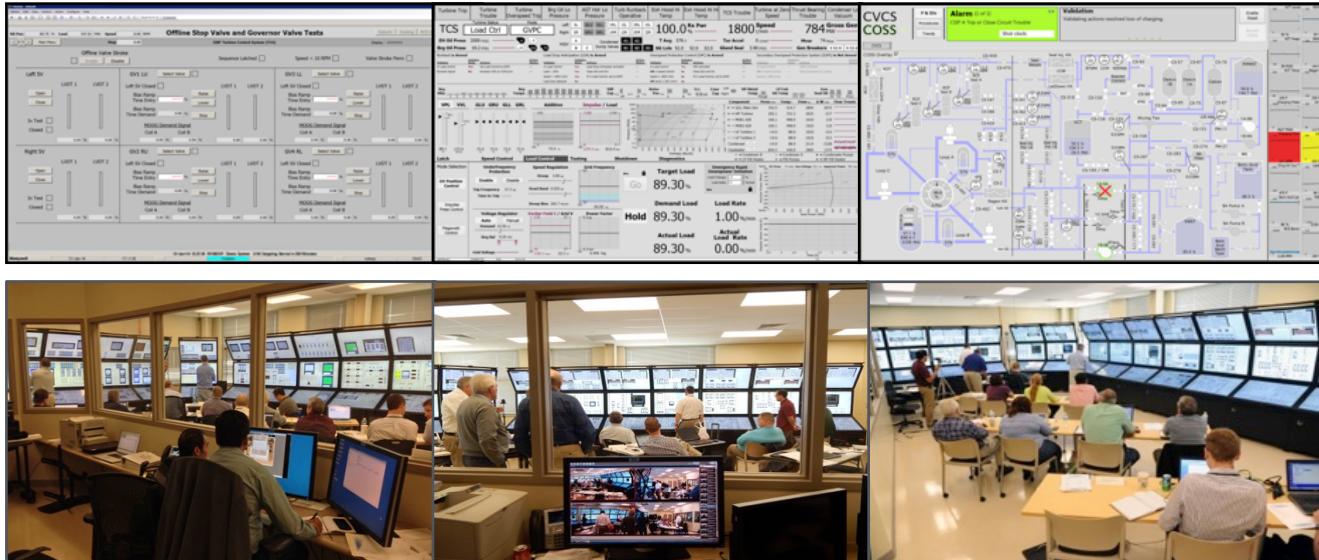
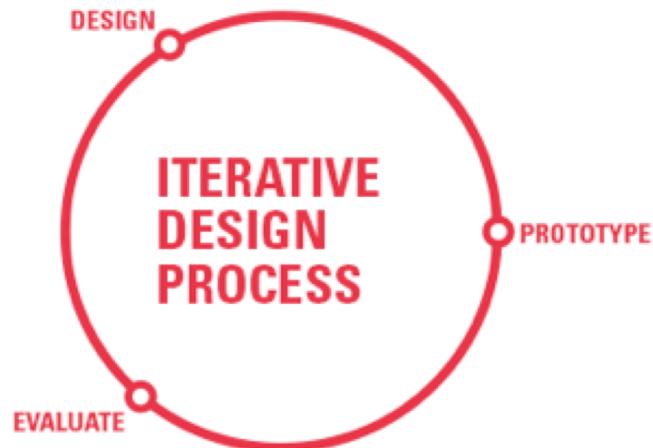
Current Work

*There are many more opportunities
to get the design right through R&D!*



- Full-scope, Full-scale simulator model that includes all functions found in a control room
 - Capable of modeling normal, abnormal, & emergency plant operations
- Reconfigurable
 - Mimics both analog and digital systems and controls virtually
 - Multiple control room configurations possible for both Pressurized and Boiling Water Reactors
- Suite of human performance and risk measurement tools for operator-in-the-loop studies

Current Work



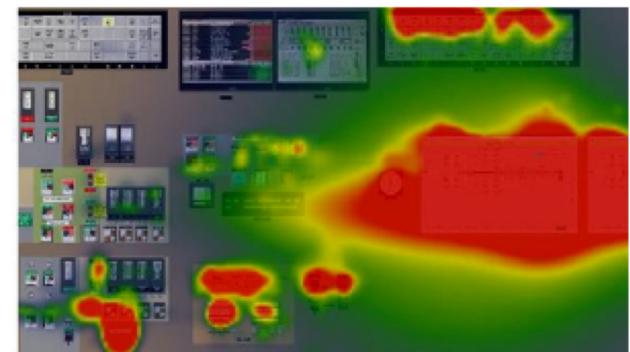
Current Work

- Researchers use a suite of human performance and risk measurement tools for operator-in-the-loop studies

With the system in the current configuration what would be the result on level of E 01 if we open LV 208B more?

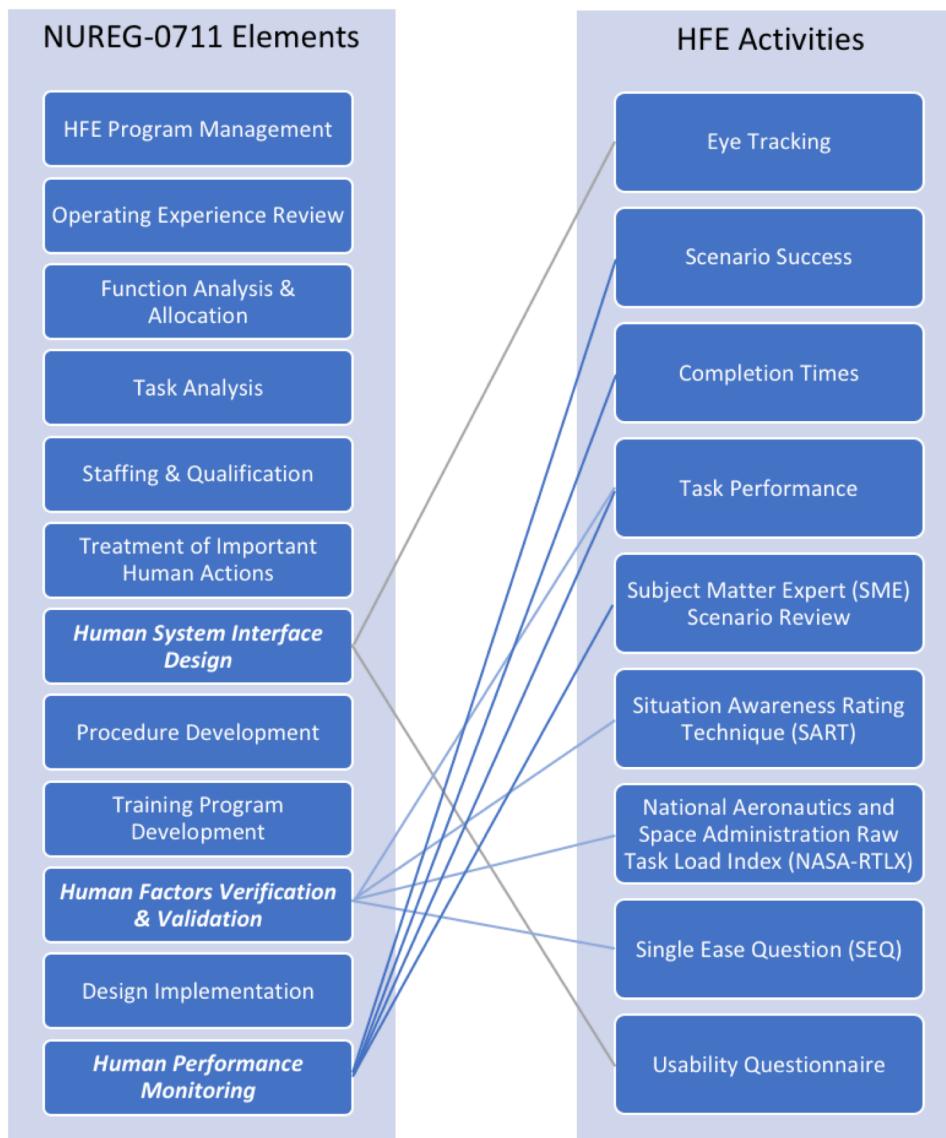


Human factors study using eye tracking metrics and heat maps to evaluate display design.



Heat maps used in full-scale simulator study.

A Crosswalk Between NUREG-0711 and HFE



Because LWRS program researchers are doing so much scientific R&D on CRM, we need to also show the connections between the R&D performed and the Regulatory HF Program Review Model (NUREG-0711)

Summary of Current Work

- Work with the new instrumentation and control systems at scale to see how they will integrate with other plant control systems before modifying the plant.
- Early learning provides the opportunity to modify the design and further improve plant safety and efficiency prior to implementation.

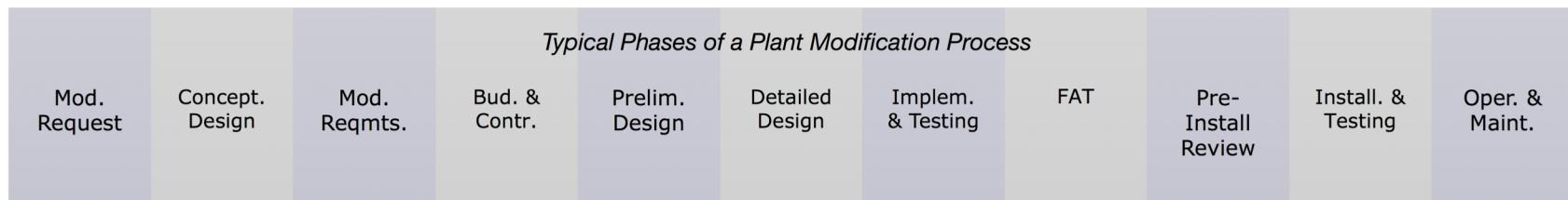


Desired Outcomes

- Apply human factors principles to the design philosophy to achieve measurable improvements in human performance
- Perform original research to investigate design concept tradeoffs to provide quantifiable evidence for decision making
- Utilize evaluation techniques to provide technical basis for design decisions
- Develop principles and create state-of-the-art guidance on control room modernization
- Better integration of HF and Plant Modification Activities

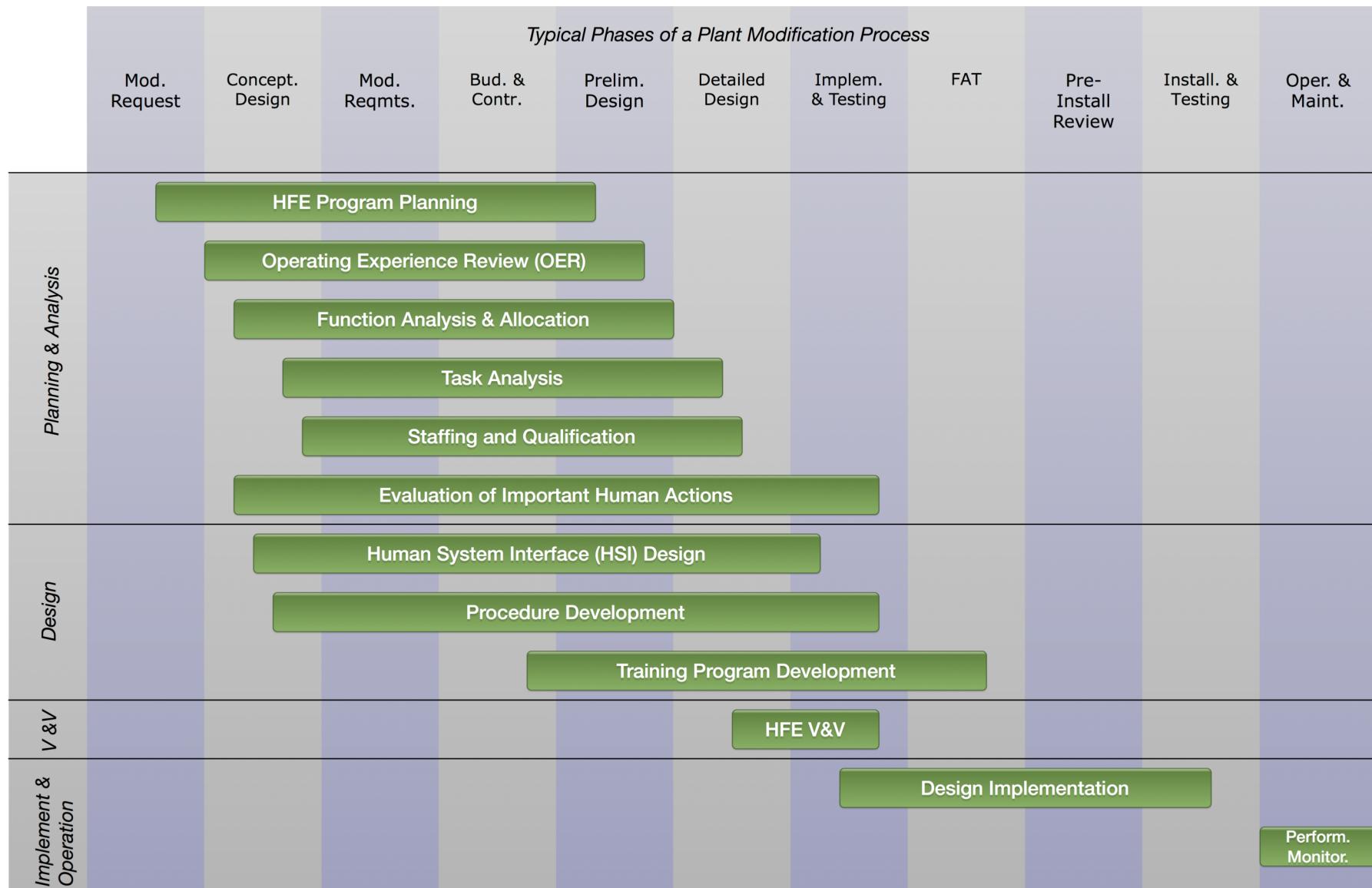


Integration of HF and Plant Modification Phases



- Typical phases of a plant modification process
 - Modification request
 - Conceptual design and planning
 - Development and specification of requirements
 - Budgeting and contracting
 - Preliminary design
 - Detailed design
 - Implementation and integration testing
 - Factory Acceptance Test
 - Pre-installation review and testing
 - Installation and post-installation testing
 - Operation and maintenance

Integration of HF and Plant Modification Phases

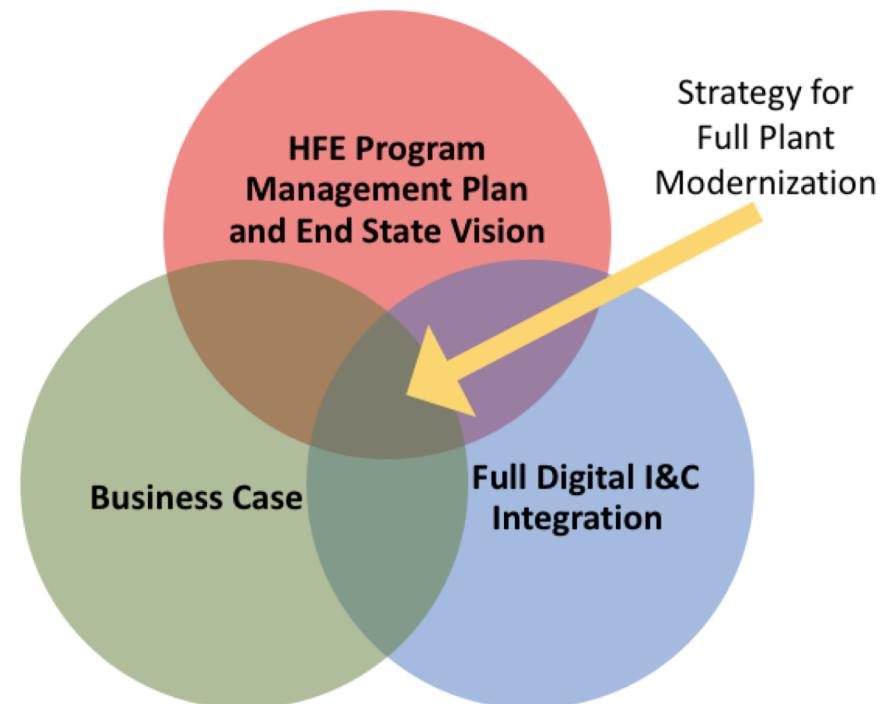


Desired Outcomes

- Seamless integration with Full Plant Modernization



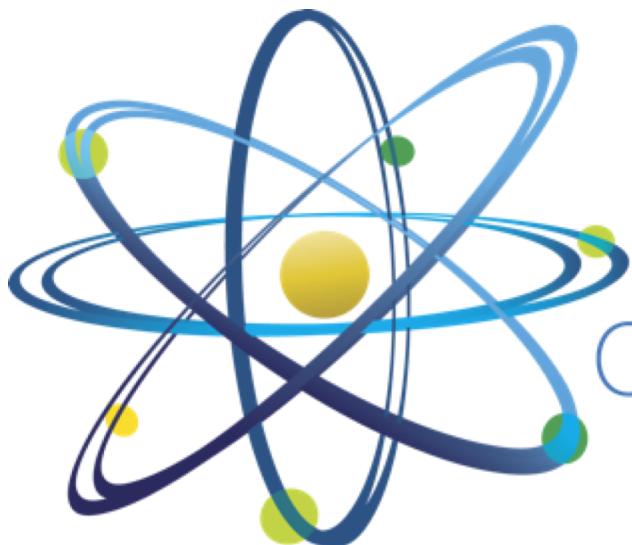
Seamless information architecture



Seamless integration via a Strategy for Full Nuclear Plant Modernization

Challenges

1. Lack of an end-state vision and strategy.
2. Insufficient process expertise and operational experience with digital upgrades.
3. Overcoming the inertia of status quo solutions developed by I&C and other digital solutions vendors.
4. Licensing and regulatory processes for digital upgrades.
 - Cyber-security for digital upgrades.
5. Cost to implement relative to the expected value or anticipated benefits.
 - Limited time windows in which to install the upgrades.



Clean. **Reliable. Nuclear.**