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

Advanced Sensors and Instrumentation
Annual Webinar

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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.
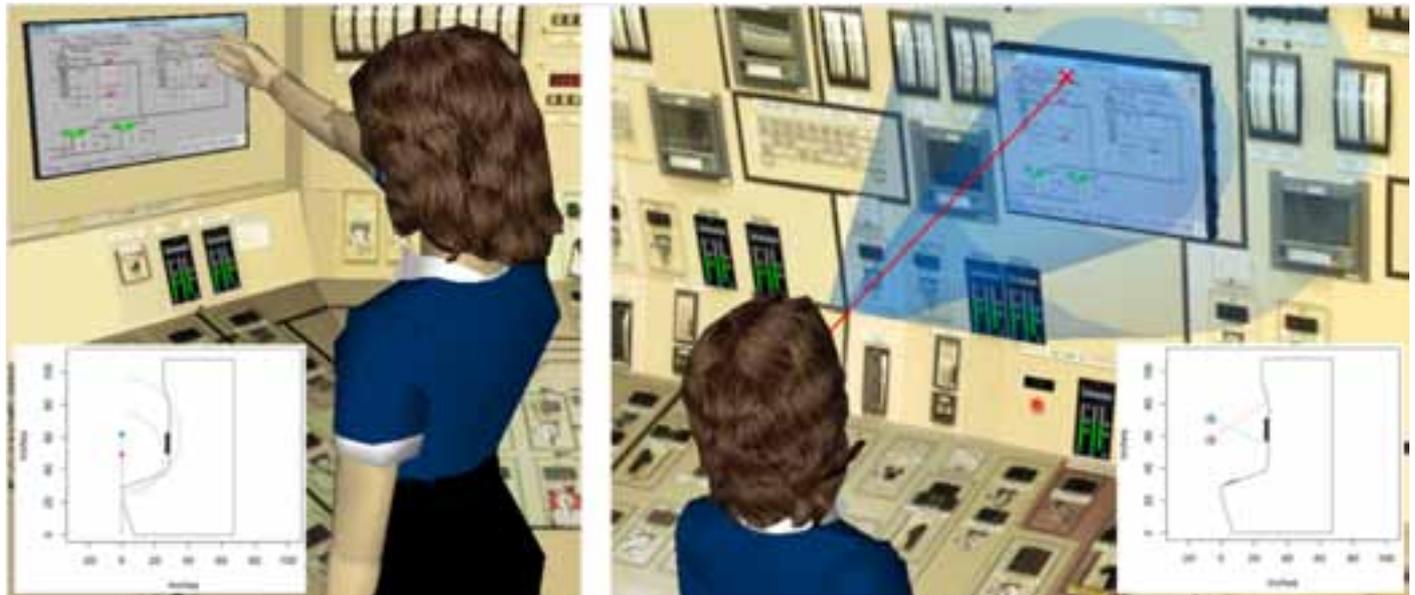
Current Work

Typical utility/regulatory approach is to perform:

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

to Minimize Risk

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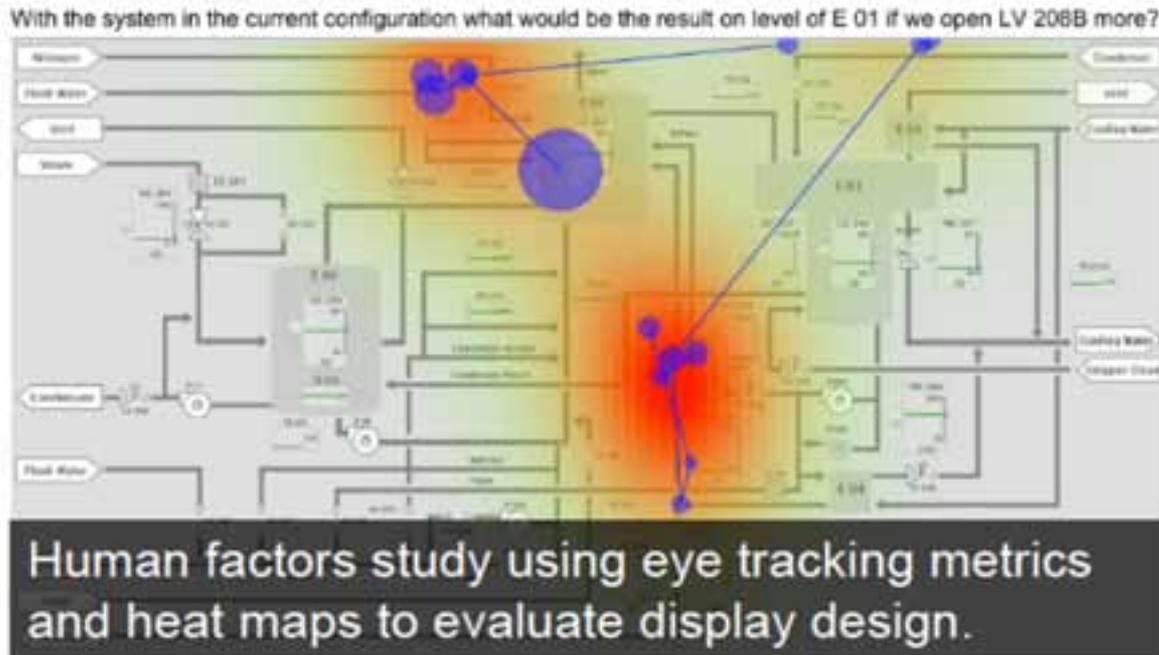- HFE Analyses Using NUREG-0700

- 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
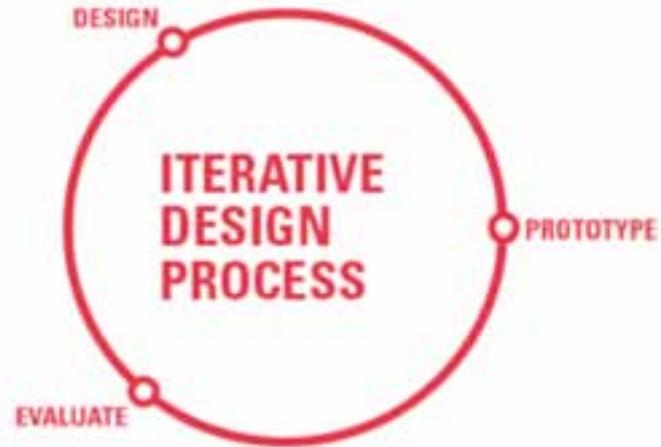
Current Work

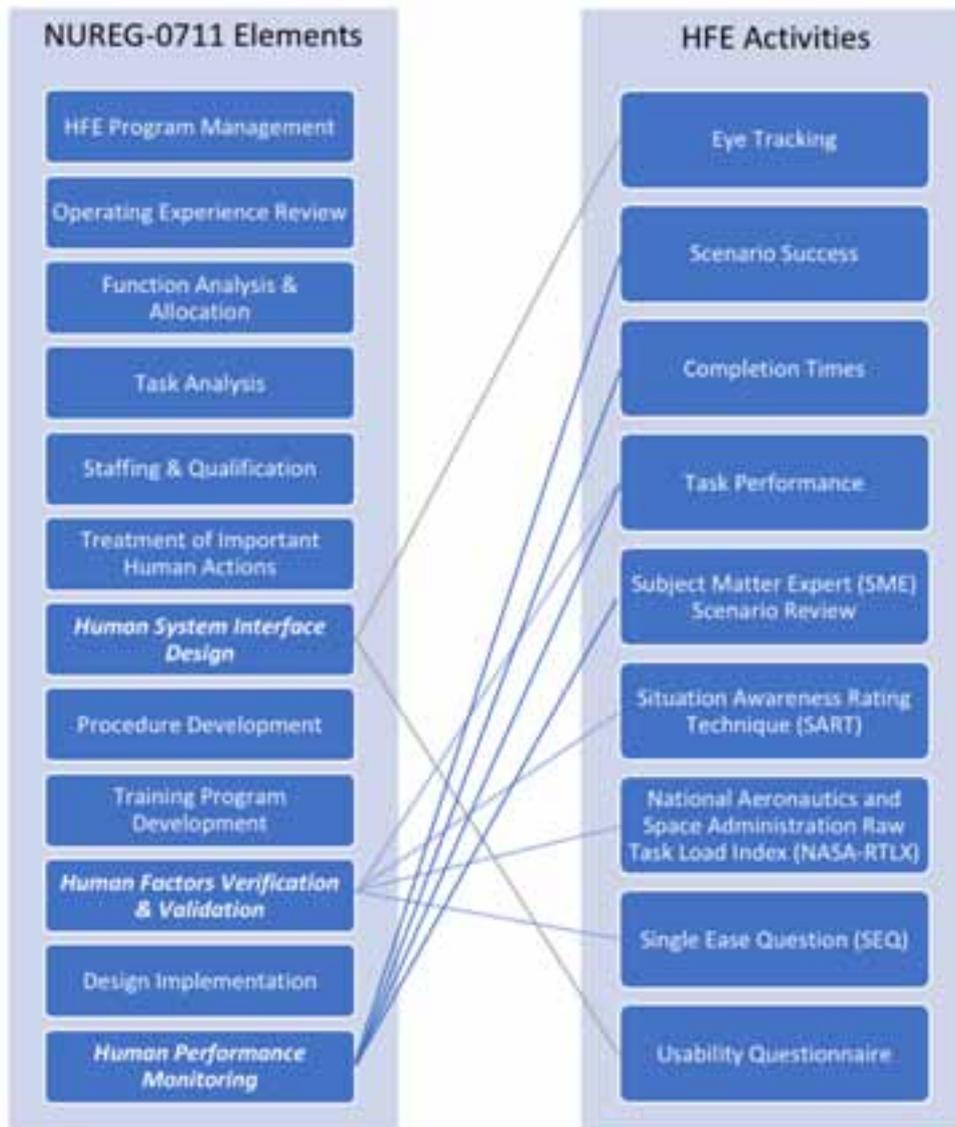- Researchers use a suite of human performance and risk measurement tools for operator-in-the-loop studies

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

Heat maps used in full-scale simulator study.

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

Mod. Request	Concept. Design	Mod. Reqmts.	Bud. & Contr.	Prelim. Design	Detailed Design	Implem. & Testing	FAT	Pre-Install Review	Install. & Testing	Oper. & Maint.

- 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

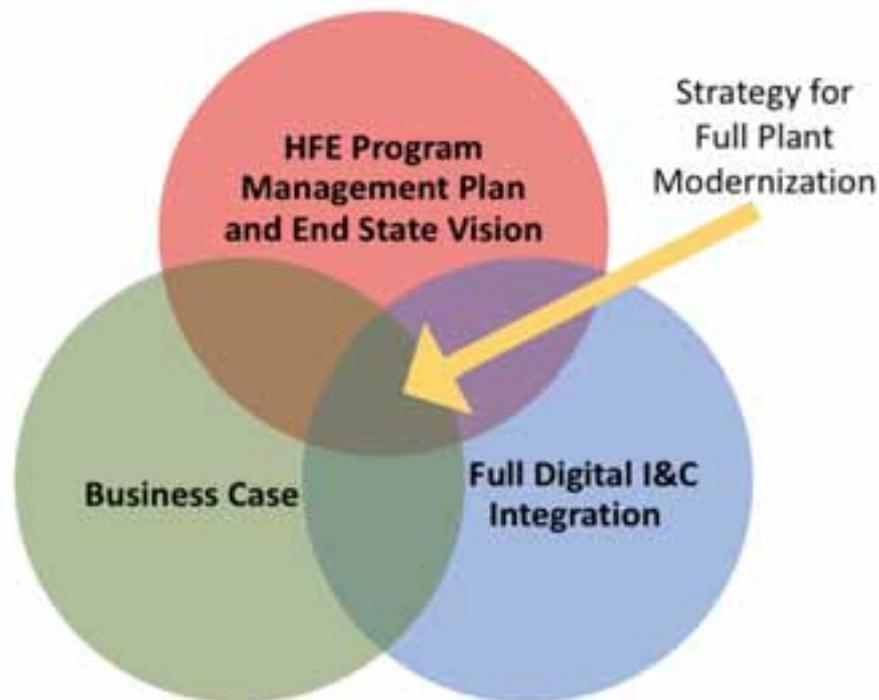Typical Phases of a Plant Modification Process
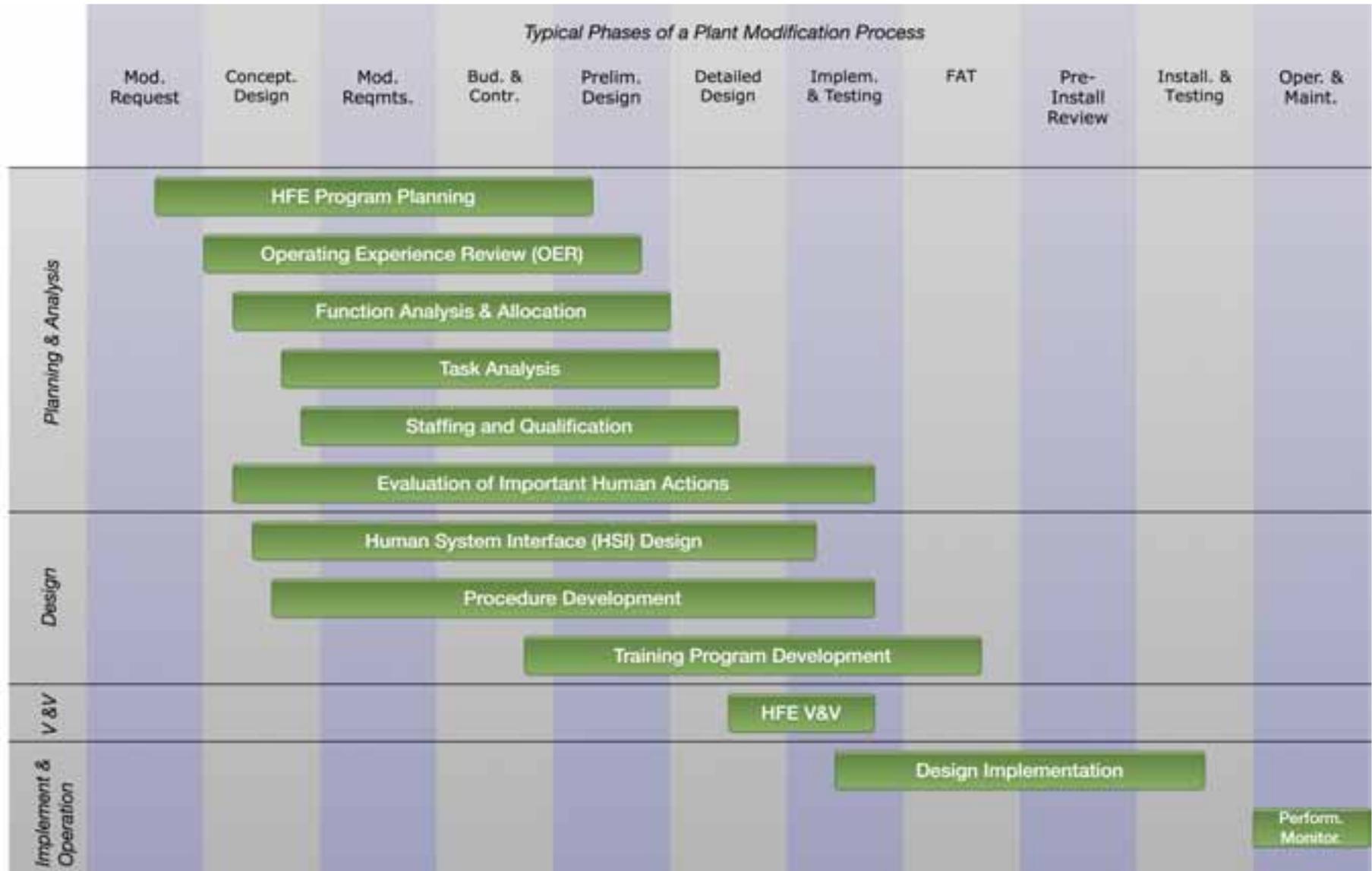
Desired Outcomes

- Seamless integration with Full Plant Modernization
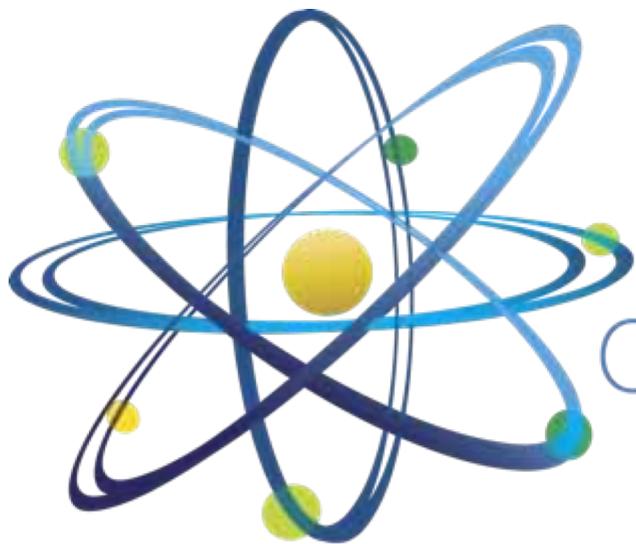

Seamless information architecture

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.

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