'Future proofing' the Fleet

LWRS Program supports nuclear plant modernization efforts

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Plant Modernization Pathway

The nation's existing nuclear power plants fleet produced more than 800 million kilowatt hours of electricity in 2021. This clean energy is indispensable to curbing greenhouse gas emissions.

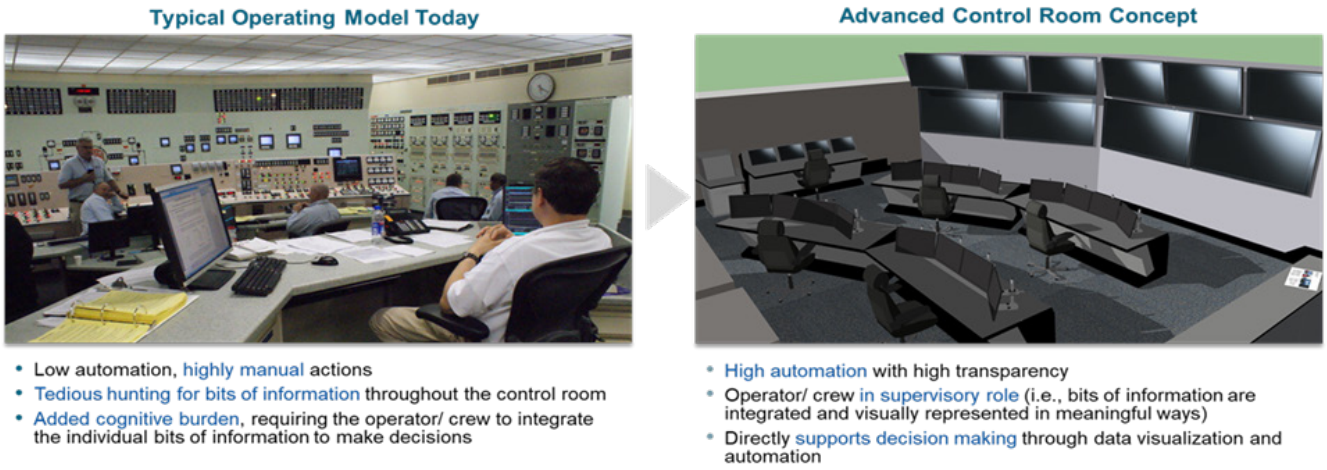
Updating aging infrastructure is a major and continuing challenge. The oldest operating nuclear plant in the U.S. is New York's Nine Mile Point Unit 1 which is 54 years old, and many more are approaching the half-century mark. Parts for some plant components are, or will become unavailable and operating systems will become obsolete. Utilities have long recognized the need for modern advanced digital systems. Automation can eliminate tedious, error-prone tasks, provide near-instant integrated plant data, and reduce training burdens.

Engineering challenges - Most of the light water reactors that make up the U.S. fleet were originally designed and constructed with analog instrumentation and control systems. Digitalization offers huge advantages (Figure 6), but poses new engineering challenges for plant owners and operators. The LWRS Program is a source of solutions for modernizing, digitalizing, and streamlining operations at U.S. nuclear power plants.

LWRS Program researchers have developed methodologies and tools that can help the nuclear industry identify and implement the need for advanced digital technologies. The goal is "obsolescence management." With some plant owners applying for license extensions that could extend operations as long as 80 years, the LWRS Program aims to "future proof" the process as it looks ahead at new capabilities and automation.

Human and Technology Integration (HTI) - For continued safe and reliable operations, it is essential to understand how people will use the new technology, identify situations in which operators would be likely to make

Figure 6. Comparison of existing control rooms to advanced control room.



mistakes and developing approaches for their mitigation. HTI applies human factors engineering (HFE) methods and tools while focusing on the application of technology to reduce operation costs. The methodology extends from known standards and guidelines and is based on original LWRS Program research in advanced alarm systems, computer-based procedures, model-informed decision support and advanced human-system interface displays.

Viewed more widely, HTI ensures safe, reliable use of advanced digital technology by leveraging the capabilities of people and technology. The new digital technologies minimize training demands, eliminate human error, reduce workload, enable automation transparency, and provide meaningful information to support organizational effectiveness and decision-making. These benefits result in safer, more timely decisions and improve people's trust and adoption of advanced digital technologies.

Industry partners Constellation Energy and Southern Nuclear have taken the lead in partnering with the U.S. DOE's LWRS Program. The Limerick Generating Station in Pennsylvania, has entered a cost-sharing project with DOE, which is providing $50 million toward the first fully digital safety system upgrade at a U.S. nuclear power plant. The main control room will be enhanced with digital instrumentation and control (I&C) systems, digital displays, and alarm systems.

Researchers applied the HTI methodology during the detailed design phase of the Limerick Generating Station project. At INL, the Human Simulation Systems Laboratory (HSSL) offers an environment that can digitally simulate any number of control rooms. To address information and task requirements, they have used advanced HFE tools, methods, and frameworks, including performance-based tests in the HSSL for digital human modeling (Figure 7) and cognitive task analysis. INL collaborated with Constellation, Westinghouse and CORYS to prepare a near-full scope simulator and coordinated the execution of preliminary validation. To integrate the three key components of any modernization -- hardware, software, and people -- and to determine whether performance and safety requirements are met during the upgrade, researchers will continue to use performance-based tests.

Southern Nuclear, researchers applied the HTI methodology in the initial scoping phase of Southern Nuclear's fleet-wide modernization project by developing the vision and new concept of operations for the Farley plant.

Southern Nuclear collaborated with Sargent & Lundy to develop new control room requirements and the conceptual layout of a new control room. This was done using the HSSL and the Advanced Visualization Laboratory at the Center for Advanced Energy Studies, at INL. The demonstrations led to human factors considerations for large overview displays, computer-based procedures, advanced alarms, and compact workstations providing complete, transparent, and usable information. Continued HTI methodology demonstration will expand into defining fleet-wide requirements for Southern Nuclear.

The lessons learned from both projects will offer industry guidance on HTI, reducing the technical, financial, and regulatory risk of upgrading the aging I&C systems. Ultimately, this should support extended plant life up to and beyond 60 years. The work will expand the vision scope and concept of operations across other utility plant sites to ensure that they are safe, reliable and include state-of-the-art digital technology that ensures economic viability.

Figure 7. Use of digital human modeling to perform human factors analysis.