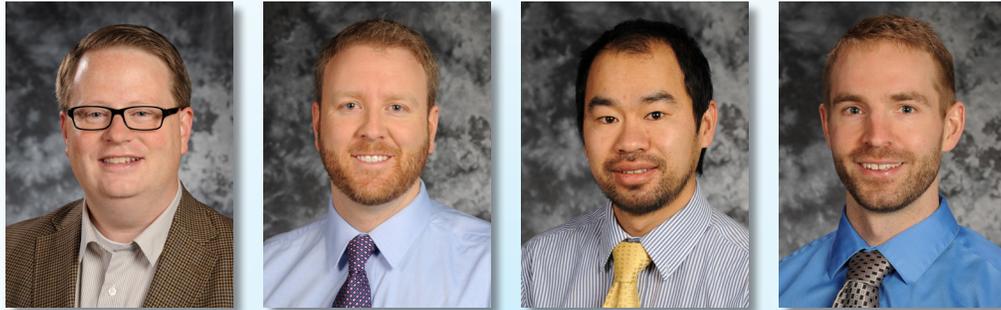


Operator Studies on Overview Screens



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Plant Modernization Pathway

As the main control rooms in nuclear power plants are upgraded from analog to digital technologies, there remain questions regarding the optimal content of digital displays. In a series of operator-in-the-loop studies conducted with nuclear utility research partners, LWRS Program researchers investigated the role of overview screens as an enhancement to control room operations. The Operator Studies of System Overviews (OSSO) focused on upgrades to Turbine Control Systems (TCSs).

Upgrades to TCSs are among the most frequently implemented in nuclear power plants. The digital control technology is already well established from non-nuclear applications like fossil-fuel-generating stations. It is often possible to achieve additional electricity production and increased plant revenue through upgraded turbine components, including the control system. Further, there is—in some cases—the opportunity to take advantage of underused features like flexible power operations (i.e., adjusting the total electrical output of the plant to complement the output of fluctuating energy sources like renewables), which might strain the capabilities of existing control systems.

As a part of this research, we studied crew performance with existing control room systems, used that information to benchmark the performance of new vendor-proposed systems, and considered other enhancements to these proposed systems. The objectives of the study that used operators were threefold: (1) determine any human factors challenges with the currently installed analog TCS and identify any features and functions that operators would like to retain in the new system; (2) study the suitability of the vendor-proposed digital TCS upgrade; and (3) evaluate the value of adding system overview screens or dashboards to the vendor TCS upgrade. To obtain data that support these objectives, the full-scope training simulator from the nuclear power plant was installed in the Department of Energy's Human Systems Simulation Laboratory. Scenarios were developed to represent a range of activities associated

with the operations of the TCS. Prototypes of the digital TCS upgrade and overview screen were developed. A full suite of operator performance measures was gathered during data collection, and here we present eye-tracking results to illustrate findings from the study.

Heat maps were generated for the three interfaces for the turbine startup scenarios, as shown in Figure 1. The heat maps were produced using eye-tracking systems that monitor eye movements for scans and dwell times while an operator is performing a simulated task with the turbine control system and candidate overview display in the HSSL. The heat map for the analog control board (top figure) reveals fixations primarily on key indicators and controls, that are associated with specific monitoring and control tasks associated with the turbine startup procedure that was being used. For the digital TCS prototype (middle figure), much of the dwell time data is centered on the two side-by-side TCS screens, with some additional focus on supporting controls. For the digital TCS with the overview screen (bottom figure), attention is divided more evenly between the control and overview screens, although some areas of the main digital TCS are used less, presumably since they are somewhat redundant to the overview screen. The heat map for the digital TCS with the overview screen also features a scan pattern that more closely mimics the analog boards. The broader scan patterns of the operator while using the overview screen suggest that the operator is using the overview screen to maintain awareness of the system beyond just the information provided on the main TCS screens and verifying specific values on the control boards needed for their specific procedural tasks. That is, in addition to obtaining task-specific information needed to accomplish procedural activities, the operators use the overview displays to monitor the overall system and the effects that their tasks and inputs to the system are having on the system.

The study demonstrated that operators are able to successfully complete a variety of operations with all of the turbine control systems. There were some reported



Figure 1: Heat map of eye tracking for analog (top) vs. digital TCS (middle) vs. digital TCS with overview display (bottom).