NEUP Nuclear Energy University Programs

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Project Title

Meta-Level Design Guidance and Operator Performance Measures for Hybrid Control Rooms

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Program: Reactor Concepts

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ABSTRACT:

The nuclear power plant (NPP) operator is not only responsible for the health of the plant, but for maintaining critical safety functions that protect the facility, its workers and the public. The displays and controls within the nuclear main control room are effectively the sensors and actuators of the operator enabling him to monitor, diagnose and manipulate plant conditions. Traditional analog human-system interfaces (HSIs) are distributed throughout the control room, usually based on subsystem and function. However, because of display salience, an experienced operator can often scan the entire control room and gain a holistic understanding (i.e., situation awareness or SA) of plant status.

As US utilities build new reactors and modernize plant infrastructure within their existing fleets, new opportunities and imperatives emerge for upgrading HSIs, increasingly using digital control-display technology. As a result, today NPP operators may encounter a purely analog control room, a fully digital control room, or most often a hybrid of both digital and analog controls and displays. Regardless of the configuration, the HSIs of the NPP control room must support operator SA and decision-making to safely, effectively and efficiently manage plant performance at a tolerable cognitive load.

We propose to refine and test methods to evaluate the introduction of digital HSI to support the work of operators of existing largely analog NPP control rooms. Over the next 10 years, existing NPP control rooms will have "hybrid" (i.e., a mixture of analog and digital) controls and displays, which present unique challenges to both designers of the HSIs and for the end-users, the NPP control room operator and supervisors. *We propose that operator performance in hybrid NPP control rooms will be improved if future digital HSI components are designed based on: 1) more robust design guidelines for operator SA and decision-making; 2) enhanced operator performance metrics during HSI evaluation; 3) an ontology for selecting simulation scenarios to evaluate specific digital HSI; and 4) a model that provides predictions of optimal HSI design attributes given operator performance level objectives.*

This project will use a human factors engineering approach to address four **Specific Aims**: **1)** Develop and validate meta-level design guidance (MDG) for NPP operator SA and decision-making relevant to the design of digital HSI components intended for hybrid control rooms; **2)** Identify, refine and validate additional human performance measures for SA and decision-making relevant to new digital HSI designs; **3)** Create and evaluate a simulation Scenario Ontology for the selection of scenarios to evaluate new digital HSI designs; and **4)** Create a data fusion model that supports heuristic evaluation of digital HSI designs whereby the design attributes are model inputs, the MDG and other design guidance are model operators, and performance measures are model outputs.

The study aims to advance the mission of the Department of Energy and the Office of Nuclear Energy by developing technologies and other solutions that can improve the reliability and sustain the safety of current reactors. We propose to integrate and apply knowledge and expertise from the healthcare and nuclear power industries, and diverse engineering disciplines (e.g., human factors, nuclear, information sciences, and civil and environmental) to develop and validate new tools to evaluate digital HSIs designs for hybrid control rooms. Our multidisciplinary team will use cognitive engineering, usability analysis, simulation, and probabilistic modeling to accomplish the aims set forth in this proposal.