



The HSSL is a collaborative space that hosts organizations across the nuclear industry, as well as university partners, for human-centered control room research.

Human System Simulation Laboratory

Enabling peak control room operation by optimizing human interactions with technological systems

The Human System Simulation Laboratory, or HSSL, at Idaho National Laboratory is a virtual nuclear control room that safely tests new technologies before they are implemented at commercial reactors. The lab interactively simulates digital, analog and hybrid systems with touch-screen versions of physical controls like switches, gauges, keyboards and other interfaces. This one-of-a-kind simulator is highly configurable and supports a variety of real control room formats to test emerging technologies such as digital upgrades on nuclear power plants based on the training simulators used at actual plants. The touch-screen displays can be rearranged to represent

overview displays and paired with desktop-based workstations to represent new operational concepts and scenarios for advanced reactors.

HUMAN FACTORS TEST BED

The goal of human factors is to design systems that are intuitive, efficient and safe. INL human factors researchers are experts at evaluating the interaction between human performance and new systems that are tested in the HSSL to ensure they meet requirements and standards for human operability. Systems include advanced alarm systems, automated controls, prognostic and predictive maintenance systems, advanced operational visualizations, and computerized procedure systems.

INL researchers work with industry counterparts, regulatory bodies and university collaborators to prototype new control room design concepts and evaluate their performance and usability with operating crews under normal and emergency conditions. They can then mitigate human error traps posed by the system before it is deployed.

CONTROL ROOM MODERNIZATION

The HSSL supports the mission of the U.S. Department of Energy's Light Water Reactor Sustainability Program to extend the life of nuclear power plants. This effort includes control room modernization, which focuses on addressing aging and long-term reliability issues



of legacy instrumentation, information and control (II&C) systems used in the current commercial reactor fleet. The primary benefits of modernization are to:

- Reduce the technical, financial and regulatory risk of upgrading the aging II&C systems to support long-term operation up to and beyond 60 years.
- Provide the technological foundation for a transformed nuclear power plant operating model that improves performance and maintains high safety standards.
- Address the opportunities of the future business environment, such as integrated energy systems in which nuclear energy complements renewable energy sources.

ADVANCED CONTROL ROOMS

Advanced reactors such as microreactors and small modular reactors bring considerable changes to how nuclear power plants will be operated. The HSSL supports human factors research needed for the next generation of control rooms. Topics of research include:

- Key emerging technologies such as AI-based monitoring and control systems that enhance plant efficiency through automation.
- Automation and the potential shift from concept of operations to concept of monitoring.
- Regulatory considerations for the human uses of emerging technology.



HSSL saves time and money by allowing users to test new control room design concepts, observe performance, perform analysis, and mitigate risk prior to implementation.

- The impact of new technologies on operator communication and coordination under different operational conditions such as reduced staffing or remote operations.
- New human error modalities and ways to mitigate risk.
- Cybersecurity implications of digital, highly automated plants.

HSSL CAPABILITIES

Human factors researchers provide scientifically robust methods to validate operational concepts for application in the nuclear industry. Research capabilities include:

Control room configuration – The HSSL can be reconfigured to represent any existing U.S. commercial nuclear power plants. Simulator and control system vendors can interface in the HSSL to create functional control room simulators.

Control system prototyping – A suite of human-machine interface software tools mimic current control system interfaces or provide advanced II&C mock-ups for

demonstration and testing. These tools can be used on their own for static mock-ups or interfaced with simulators as functional prototypes.

Advanced simulator development – Simplified simulators demonstrate advanced reactor concepts before the full-scope training or engineering simulators have been deployed. This capability allows early design work on the control room of a new reactor.

Human factors evaluation – INL researchers have extensive experience performing regulatory-required testing to support licensing of new control room concepts. Human factors researchers have developed and published many innovative ways of evaluating crew performance to support the unique needs of design verification and use validation.

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy.

FOR MORE INFORMATION

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