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Installation of Computerized Procedure System and Advanced Alarm System in the Human Systems Simulation Laboratory

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Installation of Computerized Procedure System and Advanced Alarm System in the Human Systems Simulation Laboratory

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ABSTRACT

This report describes the installation of two advanced control room technologies, an advanced alarm system and a computerized procedure system, into the Human Systems Simulation Laboratory (HSSL). Installation of these technologies enables future phases of this research by providing a platform to systematically evaluate the effect of these technologies on operator and plant performance.

CONTENTS

ABSTRACT iv

ACRONYMS vii

1. Introduction 1

2. Installation of technologies into the HSSL 2
   2.1 Description of Systems 2
      2.1.1 Advanced Alarm system 2
      2.1.2 Computerized Procedure System 3

3. Impact of Installation of Technologies in HSSL 4

4. References 5

ACRONYMS

API	Application Programming Interface
CPS	Computerized Procedure System
gPWR	Generic Pressurized Water Reactor
HSSL	Human Systems Simulation Laboratory
INL	Idaho National Laboratory
LWRS	Light Water Reactor Sustainability
NPP	Nuclear Power Plant

Installation of Computerized Procedure System and Advanced Alarm System in the Human Systems Simulation Laboratory.

1. Introduction

This research is a part of the United States Department of Energy sponsored Light Water Reactor Sustainability (LWRS) Program conducted at Idaho National Laboratory (INL). The LWRS Program is performed in close collaboration with industry research and development programs, and provides the technical foundations for licensing and managing the long term, safe, and economical operation of current nuclear power plants (NPPs). One of the primary missions of the LWRS Program is to help the U.S. nuclear industry adopt new technologies and engineering solutions that facilitate continued safe operation of NPPs and extension of current operating licenses.

Control room modernization is one way in which existing NPPs can utilize technology to enhance efficiency and safety. The Electric Power Research Institute (EPRI, 2005) describes several potential drivers of control room modernization, which include:

- Addressing obsolescence and lack of spare parts
- Meeting the need for equipment replacement due to high maintenance cost or lack of vendor support for existing equipment
- Implementing new functionality necessary to add beneficial capabilities
- Improving NPP performance, human system interface functionality, and NPP reliability
- Enhancing operator performance and reliability
- Addressing difficulties in finding young professionals with education and experience with older analog technology.

Implementing new technology to support enhanced functionally, improving NPP performance and reliability, improving operator performance, and facilitating recruitment of next-generation operators are certainly valid potential drivers for control room modernization. These drivers might result in control room upgrades that utilize a variety of advanced technologies designed to enhance performance and support operators in the control room. However, the reality is that obsolescence and lack of vendor support for aging systems have been primary drivers for many control room modernization efforts. In response to obsolescence issues, NPPs typically embark on system-by-system upgrades leaving the control room largely analog with disparate digital systems intermixed throughout. While this approach may meet the needs of addressing obsolescence, it will not necessarily result in an end-state that fully exploits modern technologies to support the most efficient operator performance or enhance plant performance. These like-for-like replacements may limit the use of advanced functionality in favor of reducing the perceived technical and regulatory risks involved in such projects.

Modern technology affords the opportunity to visualize information in more intuitive ways, distill a large amount of information to operators in an understandable manner, and provide decision support and automatic aids. These improvements are being incorporated into many newer technologies such as digital displays, advanced alarm systems, computer-based procedures, and NPP automation technologies. Although some of these technologies are currently available, they are not being widely adopted by the nuclear industry.

The Control Room Upgrades Benefits Research Project is under the Advanced Instrumentation, Information, and Control Pathway of the LWRS Program. The objective of the project is to investigate the

benefits of including advanced technologies as part of control room modernization. The specific goals of this research are to:

1. Identify an ideal control room modernization end state

a. Identify advanced control room technologies that provide quantifiable benefits

b. Identify features of those technologies that are most useful

2. Facilitate the transition to an ideal modernization end state

a. Provide evidence for use of key technologies in NPP's business case for modernization

b. Connect research results with meaningful measures of NPP performance (e.g., key performance indicators) and safety.

This report describes the installation of two advanced control room technologies, an advanced alarm system and a computerized procedure system (CPS), into the Human Systems Simulation Laboratory (HSSL). Installation of these technologies enables future phases of this research by providing a platform to systematically evaluate the effect of these technologies on operator and plant performance.

2. Installation of technologies into the HSSL

The technologies were installed in the HSSL and tested for operability on February 15, 2016 and INL researchers received several days of training on how to configure and use the technologies. The capabilities of the technologies are described below.

2.1 Description of Systems

Both the advanced alarm system and the CPS are connected to the Generic Pressurized Water Reactor (gPWR) via an Application Programming Interface (API). Currently, the API and its components simulate a distributed control system inside the HSSL. The API is able to read data points from the GSE gPWR simulator and pass those on to other components, such as the APS or CPS. Using a similar technique, the API can be adapted to read points from other simulator vendors, which makes the CPS and the advanced alarm system reconfigurable and able to connect and function with any plant model.

2.1.1 Advanced Alarm system

The Advanced alarm system was developed both for use in advanced control rooms, and as a back fit solution to overcome some of the challenges with alarms systems currently installed in U.S. NPPs (while still retaining the best features of those legacy systems). The ability to reconfigure and customize the alarm system allows for it to meet existing NPP needs and the needs of the operator.

Using data from the API, the alarm system reads alarm statuses and mimics them in accordingly. The alarm system is configurable, meaning the operator can customize and make changes as it pertains to the current project. For the HSSL, this customization will allow for multiple plant configurations, allowing alarms to be arranged to better reflect each control room more accurately.

The displays for the alarm system can be located in various locations throughout the control room. This adaptability is useful as the HSSL gets reconfigured for the various NPP control room models it can support.

Additional functionality of the alarm system includes alarm prioritization. This allows the NPP's operations organization to determine how alarms can be presented (e.g., customizable colors and shapes) and/or filtered (i.e., suppression schemes for managing nuisance and consequence alarms) depending on their relevance or importance. Other features of the workstation client include navigation menus, tabbed interfaces, alarm history and customizable alarm layouts. Further, pop-up menus also allow for quick access to alarm response procedures, providing the operator quick access to the exact procedure for the annunciating alarm.

Features like alarm prioritization and filtering allow the operators to better focus on the task at hand, rather than being distracted by an "alarm avalanche." For example, manual alarm suppression enables the operator to suppress consequence and nuisance alarms.

2.1.2 Computerized Procedure System

The computerized procedure system (CPS) installed in the HSSL takes the paper procedure system to the next step by utilizing systems networking and computational capabilities. Paper procedures are a tool put in place to guide an operating team's diagnostic and decision making during an event occurring within the NPP. Used to direct operators to check specific indicators, make calculations, and determine specific systems status' paper procedures will provide the next action in step by step format based on the results from the listed checks and calculations. Currently, most operators must physically check and calculate all the plant values and come to a decision on their own, often requiring a peer check as a safety measure before proceeding. CPSs have been developed to improve the procedure process. A CPS leverages technology to simplify the process by making plant information more accessible.

Paper procedures, while providing guidance towards the next step, still require an operator to seek out the new procedure, open it up, and mark the pages which, later, requires removal and storage for archival. The computerized system contains all the procedures and associated documents in a single place for quick access. To speed up access to support documents and other procedures, The CPS monitors for matches in plant status to procedure entry conditions priming the appropriate procedure when one is found. The flexibility afforded in computerized systems allows updates and the following roll out to occur quickly and without the associated work removing previous, outdated, paper procedures. The CPS is a tool to increase support for situation assessment beyond paper-based procedures.

The CPS can be easily adapted to new systems catering to the evolving control room. As control room upgrades are made procedures may require modifications. A computerized procedure can be quickly altered to reflect a new technology integrated into the control room. Additions or modifications can nearly be made on-the-fly. Such adaptability also supports simulated control room work, possibly even more so as many changes could be made rapidly during studies or focus groups.

Leveraging its networking capability a CPS is in constant contact with the plant system allowing it to continually monitor critical safety function status trees and procedure entry conditions in the background while the operator interacts with the present procedural needs. If a particular condition is met the operator is prompted towards the corrective action necessary via alerts, messages, or icons. A system with continuous monitoring capability improves monitoring accuracy and timely implementation of proper actions.

Additionally, the CPS evaluates procedure step logic providing the operator with a suggested step action based on real-time monitoring of the system. Using Boolean logic and numeric operators the CPS supports logic creation wherein information about a system state can be constructed by combining the values of many system pieces. While the responsibility to verify the system values are correct still falls to the operator the CPS has potential to provide an additional check that the procedure condition have been met. Retrieving plant values and processing them through logic gates is expected to reduce operators' mental workload.

Administrative workload is also reduced as the electronic procedures can be easily supplemented by information related to each step such as direct access to graphical displays. Also improved by a CPS is archiving methods. The computerized version can automatically upload to a database preserving every operator action and sequence through a procedure with little additional work. Subsequently, a refreshed version of the procedure is made available.

3. Impact of Installation of Technologies in HSSL

Installation of these technologies into the HSSL makes the HSSL the only facility that is designed to mimic the control room in the existing fleet of light water reactors and also contains a commercially available CPS and advanced alarm system. The HSSL is unique in its capability to evaluate and test advanced control room technologies in the context of hybrid control rooms.

Researchers can now test the effect of computerized procedures and advanced alarm systems in full-scale experiments. The technologies can be reconfigured to work with the major NPP simulator vendors and any plant model, which allows researchers to conduct studies to support a variety of modernization projects that have computerized procedures and advanced alarms as part of their end-state vision.

4. References

EPRI (2005). *Human Factors Guidance for Control Room and Digital Human-System Interface Design and Modification: Guidelines for Planning, Specification, Design, Licensing, Implementation, Training, Operation, and Maintenance, EPRI TR-1010042*. Palo Alto, CA: EPRI.