Development of an End-State Vision for Incorporating Digital Controls and Operator Interface Design into Control Room Modernization

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LWRS Charter

- Assist utilities with safely extending the life of currently operating plants

Our Framework

- Work with utilities to help them upgrade main control rooms

The State of Control Room Upgrades at Plants

- None of 104 current reactors in US has upgraded main control room yet
- Obsolete analog-only technology with some digital islands
- Regulations make upgrades challenging
- Vendors providing mainly like-for-like replacements
- Piecemeal replacements instead of systematic upgrades
- Limited current human factors experience to leverage for upgrade process
modernization ≠ new control room
different control room upgrade paths

INL conducted a survey of 11 US utilities and 10 nuclear institutions in March 2012.
Help Utilities Develop End-State Vision

- Vision should realistically address constraints but also move forward
- Bridge utilities, researchers, regulator, and vendors

Pilot Project on Main Control Room Upgrades

- Focus on HSI
- Provide stepping stones to achieve vision
  - Human factors engineering program plan
  - Digital style guide
  - Operator-in-the-loop testing of candidate digital HSIs
- Champion research where needed
  - Provide proof-of-concept prototypes for eventual implementation by utilities and vendors
- Disseminate results to industry and regulator
San Onofre Nuclear Generating Station (SONGS)

- 2-unit Combustion Engineering plant (2,350MWe combined output)
- Engaged in multi-year main control room modernization effort
- Provided plant simulator to allow us to help with control room modernization
  - We are not deploying upgrades, only helping them create a viable end-state vision
  - Prototyping and validating interface modernizations beyond like-for-like replacements
  - Assisting plant develop a systematic upgrade path
  - Providing appropriate guidance and specifications to allow SONGS to work with vendors on implementation
Step 1
- Translate analog control room to digital representation
- Marry plant control room to INL simulator

Step 2
- Upgrade select non-safety systems in control room
- Develop style guides for replacement HSI
- Provide human factors support to SONGS

Step 3
- Create innovative controls and displays that improve human performance
  - Develop intelligent alarm system replacement
  - Develop operator support systems including overview displays
Orchid® Touch Interface
Classroom Simulation
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- simulator environment
- Offload full scope simulator by using a device that fits the need of young learners
full scope
full scale
fully glass panel
a systematic human factors design process for replacing analog panels with digital I&C
creating future HMIs: research for advanced controls and displays
step 3

Hybrid Control Systems:
- Merge of PLC and DCS attributes
- Windows Explorer
- Miniaturizing footprint
- Open Networks
- Windows-based Operating Interfaces

Other Migrations:
- PLCs Taking on Analog Control Attributes
- Interconnection of IT and control systems
- Migration from proprietary networks
- Migration from UNIX and VMS interfaces

Distributed Control Systems:
- Multiple Analog Control Loops for Plants
- Supervisory Control and Data Acquisition Systems (SCADA):
  - Wide Area Monitoring

Enterprise-wide Control Systems:
- Digital Fieldbus
- OPC
- Web-based Interfaces
- Asset Management Systems
- Condition Based Maintenance

Resilient Control Systems:
- Integrated Cyber Security
- Information Quality Analytics
- Tailored Automation
- Global Control/Effciency

Decentralization

Open Systems

Centralized Control

Programmable Logic Controllers (PLC):
- Relay Replacement

Era
1970s 1980s 1990s 2000s
Current Alarm Systems in Nuclear Power Plants

- Analog systems beyond service lifetimes
  - Fundamental alarm technology developed in the 1960s
  - Replacement parts difficult to obtain
  - Alarm systems very complex to maintain
- Overabundance of binary state alarm annunciator tiles
- Typical plant features over 1000 individual alarm tiles in main control room
- Ineffective filtering of alarms leads to nuisance alarms that can overload operators

example: need for improved alarm systems
digital replacement systems have tended to be like-for-like

New Technologies: Digital Alarm Displays
- Beyond alarm tiles
- Prioritized alarm lists
- Single-screen displays for all alarms
- State dependent alarms

New Technologies: Alarm Intelligence
- Automation of key plant functions to prevent nuisance alarms
- Filtering alarms to most important information for operator
- Functional grouping of alarms into single alarm
  - More important to know that pump failed than that 25 different flow indications are abnormal
  - Identify root cause rather than cascade of effects

example: need for improved alarm systems
New Research on Smarter Operator-Alarm Interaction

- Humans have finite ability to perceive and make sense of information and take appropriate action.

Typical Current Systems: Alarms provide operator bottlenecks by overloading operators.

Improved Systems: Alarms match what the operator is doing, from monitoring to planning.

example: need for improved alarm systems
bridging human factors process expertise and cutting-edge research to meet practical plant needs for modernization
I/C TESTING IN PROGRESS