U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Office Of Nuclear Energy Sensors and Instrumentation Annual Review Meeting

Operator Support Technologies for Fault Tolerance and Resilience

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ANL

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INL

NEET-ASI
October 18-19, 2017

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Project Overview

Objectives

- Facilitate more timely response to plant faults and grid disturbances
- Achieve better management of plant upsets and improved operator performance
- Improve plant safety, production, and cost management

Participants

- ANL addressing sensor validation and fault diagnosis
- INL addressing the human factors aspects of assisting operators
- U of Idaho designing operator tests and assessment measures

Schedule

- Three-year project ended September 30, 2017

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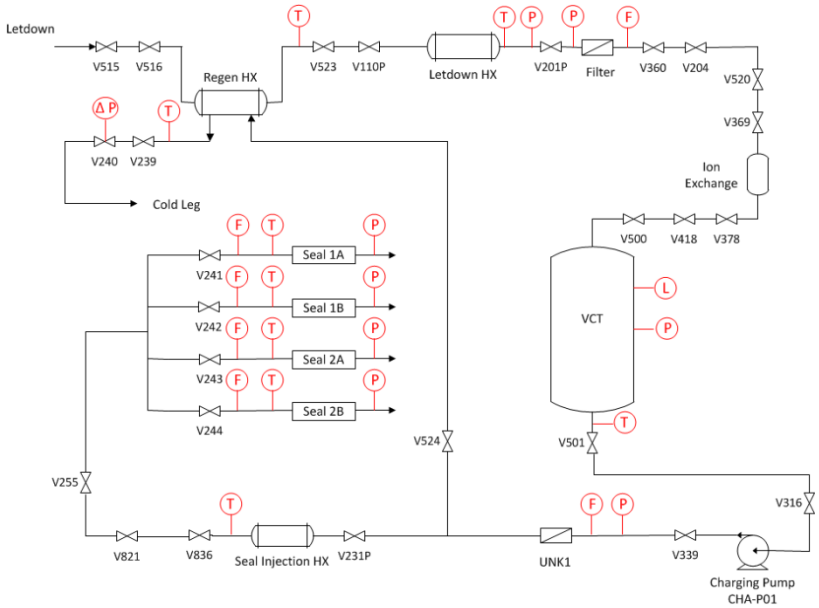
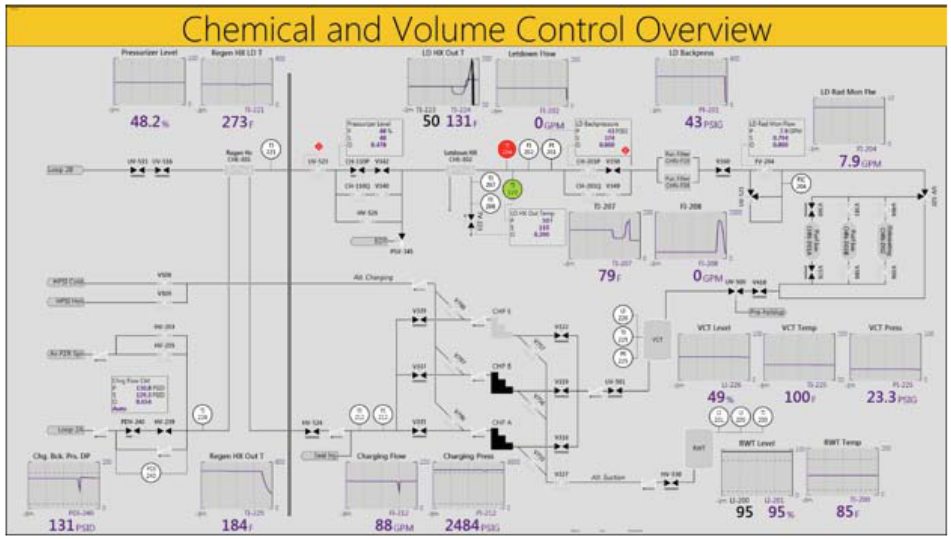
Background

- **Year 3 – Objective was to integrate team members technology and perform human performance tests with NPP operators**



Fault Diagnosis – Localize and identify fault in a plant subsystem

Human Factors – Evaluate different visual modes of presenting plant condition to operator



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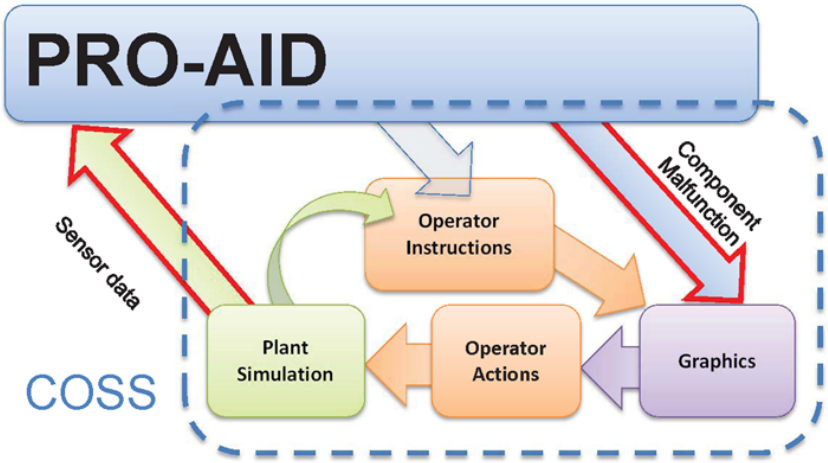
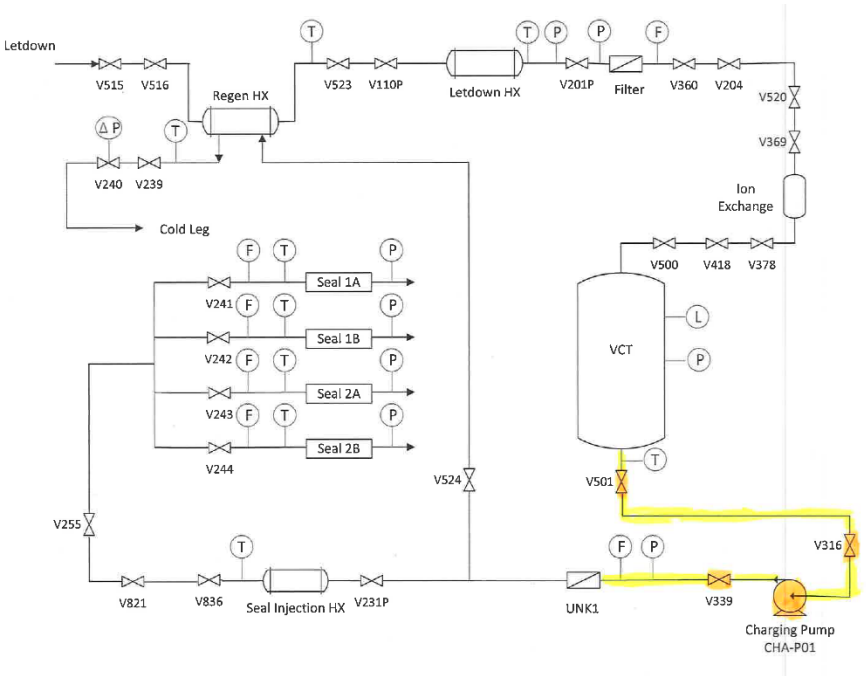
Accomplishments

- **Successfully enabled each team member's technology**



Interfaced PRO-AID fault diagnosis code to NPP full-scope simulator

Performed real time fault diagnosis



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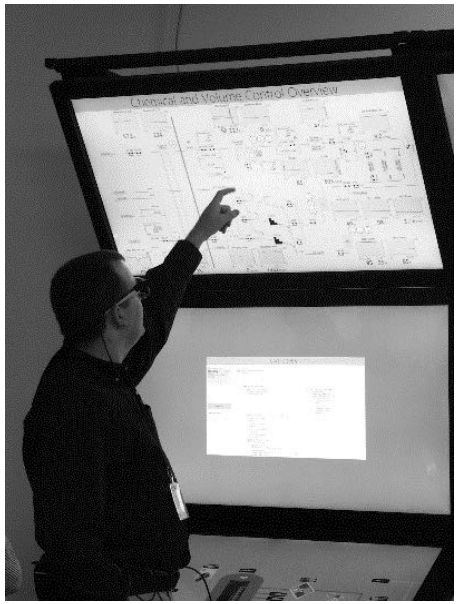
Accomplishments

- **Successfully demonstrated Computerized Operator Support System (COSS) at INL Human System Simulation Laboratory**



Human factors interactive graphics and fault diagnostics algorithms were seamlessly integrated with full-scope simulator providing real-time platform for human performance tests In the control room

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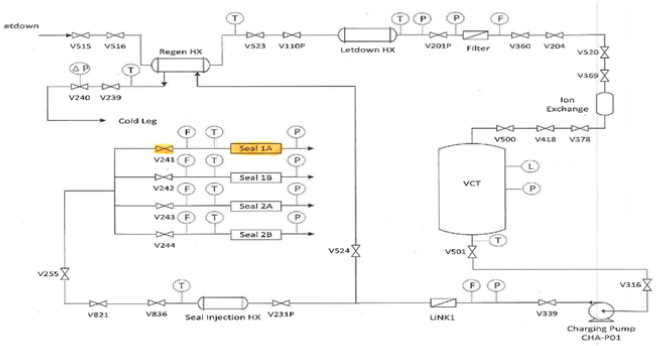
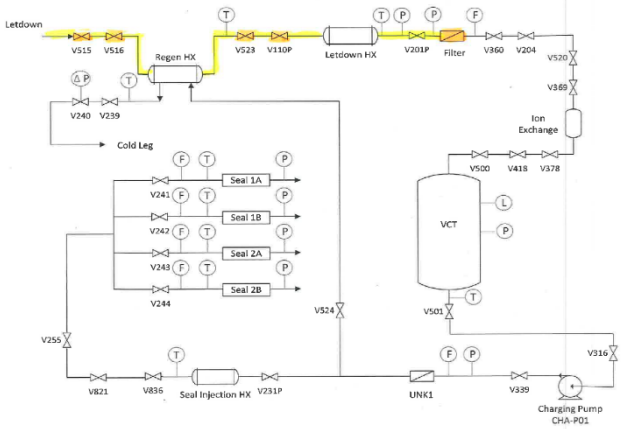
Accomplishments

- **Successfully conducted COSS evaluation tests for two faults**

Reactor Coolant Pump Seal Failure





Leak Outside Containment

Operator in-the-Loop tests at INL Human System Simulation Laboratory

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Accomplishments

Deliverables

- Y. Tang and R. B, Vilim, Technical Requirements for Application of Operator Support Technology across Multiple Plant Systems, ANL/NE-17/27, September 30, 2017.
- T. A. Ulrich, R. Lew, R. L. Boring, K. D. Thomas, B. C. Rice, C. M. Poresky, “Operator-in-the-Loop Study for a Computerized Operator Support System (COSS) – Cross-System and System-Independent Evaluations,” INL/EXT-17-43390, September 2017.

Invited Journal Articles

- R. Vilim, A. Grelle, R. Boring, K. Thomas, T. Ulrich, R. Lew,” Computerized Operator Support System and Human Performance in the Control Room,” submitted, Nuclear Technology, October 2017.

Conference Papers

- Y. S. Park, R. B. Vilim, ”Implementation of New PRODIAG Algorithm and Simulation-Based Acceptance Test,” 10th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human Machine Interface Technologies, San Francisco, CA, June 11-15, 2017.
- R. Vilim, A. Grelle, R. Boring, K. Thomas, T. Ulrich, R. Lew,” Computerized Operator Support System and Human Performance in the Control Room,” 10th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human Machine Interface Technologies,, San Francisco, CA, June 11-15, 2017.
- Lew, R., Ulrich, T. A., & Boring, R. L. (2017, July). Nuclear reactor crew evaluation of a computerized operator support system HMI for chemical and volume control system. In International Conference on Augmented Cognition (pp. 501-513). Springer, Cham.

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Technology Impact

- **Advancing state of the art, supporting mission of NE**
  - Economics - Manpower reduction through automation of surveillance and through fewer forced outages
  - Maintenance and Operations – Check/confirmation on equipment status and plant configuration
  - Safety – Potentially fewer plant protection system challenges through improved situational awareness
- **Impacting the nuclear industry**
  - Control room operations – We are working with Arizona Public Service to demonstrate and conduct human performance tests with Palo Verde NPP operators
  - Operations Support Center – Our capability is cited in the five-year EPRI commercialization roadmap, December 2016.
  - Maintenance and Operations – A $500K proposal submitted to the DOE Technology Commercialization Fund was funded in 2017. Partnering with LPI, Inc. and Dominion Generation in pilot project.

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Conclusion

- Developed innovative technology for improving safety, economics, and maintenance and operations for nuclear energy option
- Based on sound application of engineering first-principles and on human-performance principles
- Cross cuts commercial and advanced reactors
- Working to bring to the nuclear industry technology that rivals that of peer industries such as aviation and oil and gas
- Follow-on pilot project with Dominion Generation