Automation and HSI Complexity in Advanced Reactors

Halden Research Group Briefing

Dr. Kristopher Thornburg

Humans and Automation Laboratory

Massachusetts Institute of Technology

Sponsored by the US Nuclear Regulatory Commission

The Humans and Automation Laboratory - Family Portrait

DIRECTOR

MISSY

RESEARCHERS

SPENCE

KRIS

LUCA

JACKIE

JASON

VISITING FACULTY / RESEARCHERS

AXEL

CHRISTINE

STAFF

SALLY

PING

DOCTORAL STUDENTS

ANDREW

YVES

FARZAN

FEI

MASTERS STUDENTS

JASON

ARMEN

KIM

UNDERGRADUATE STUDENTS

CARINE

MANAL

STEPHEN

PAUL

VICKI

MORRIS

MORRISA

HAL Research

Focus on the interactions of human and computer decision-making in complex socio-technical systems.

- Multi-UAV missions
- Tomahawk mission
- Air traffic control
- Nuclear power plants
- Tactical submarines
- Bus and metro systems
- Lunar base and space vehicles
- Emergency and first response systems

Current projects:

- Tracking operators' cognitive strategies in mission (re-)planning
- Assisting interruption recovery in collaborative time-sensitive targeting
- Supervising heterogeneous unmanned vehicle teams
- Remote collaboration for urban search and rescue
- Collaborative human-computer decision-making
- Mobile advanced command and control station
- Decision-support for lunar and planetary exploration
- Multimodal support of UAV operations

Sponsors: Office of Naval Research, NASA, Boeing, Ford, FAA, Lincoln Labs, AAI, Thales, US Air Force Office of Scientific Research, Charles River Analytics, Perceptronics, Army Aberdeen Proving Grounds, the MITRE Corporation, Nuclear Regulatory Commission…

The Humans and Automation Laboratory - Areas of Expertise

- **Areas of Expertise**
  - Display Design
  - Human Factors Engineering Tools
  - Human-Centered Methodologies
  - Human-Performance Modeling
  - Experimental Design
  - Statistical Modeling

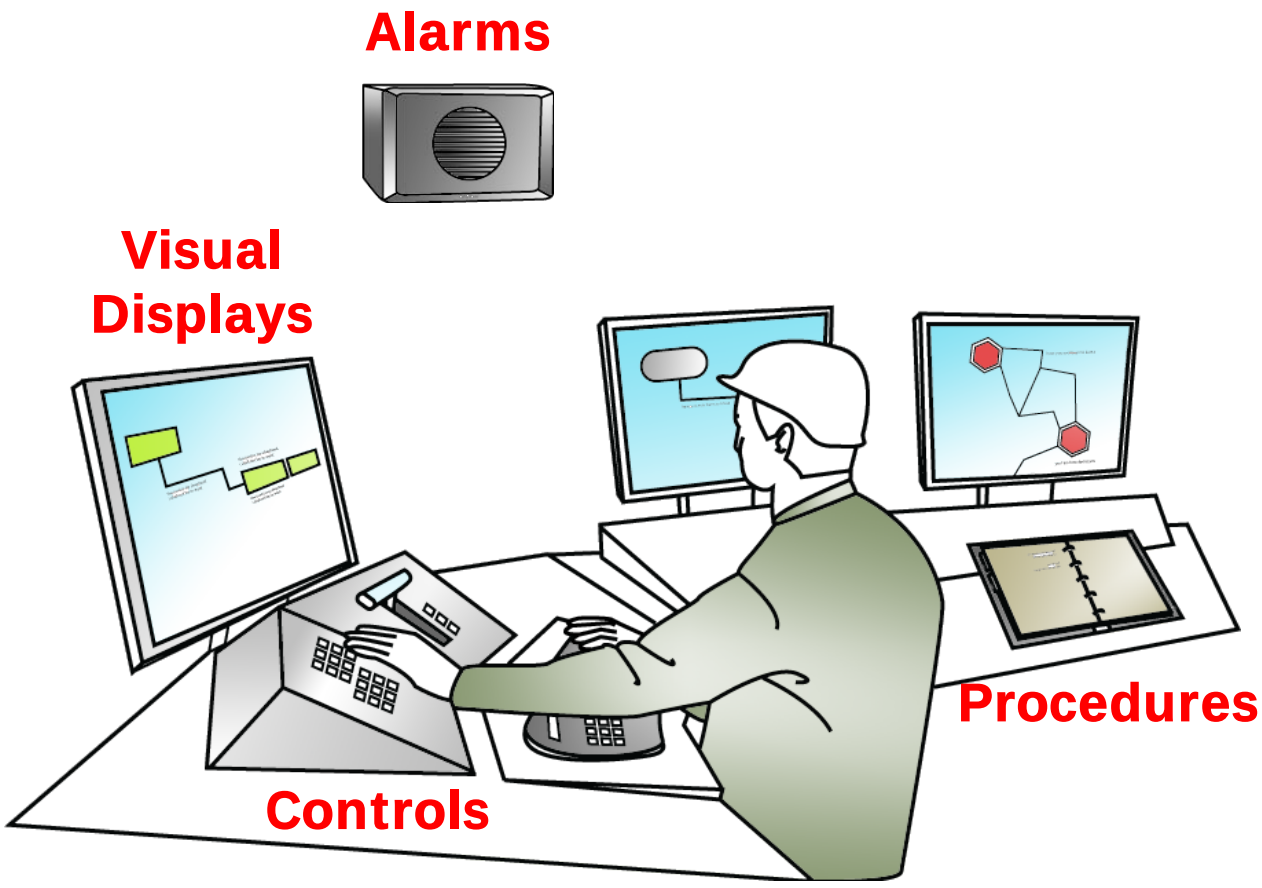
- **Domains of Study Application**
  - Complex Architecture Cost/Benefit Analysis
  - Human-Computer Interaction and Collaboration
  - Single and Multi-Vehicle C2
  - Operator Cognitive Strategies
  - Mission Commander Support



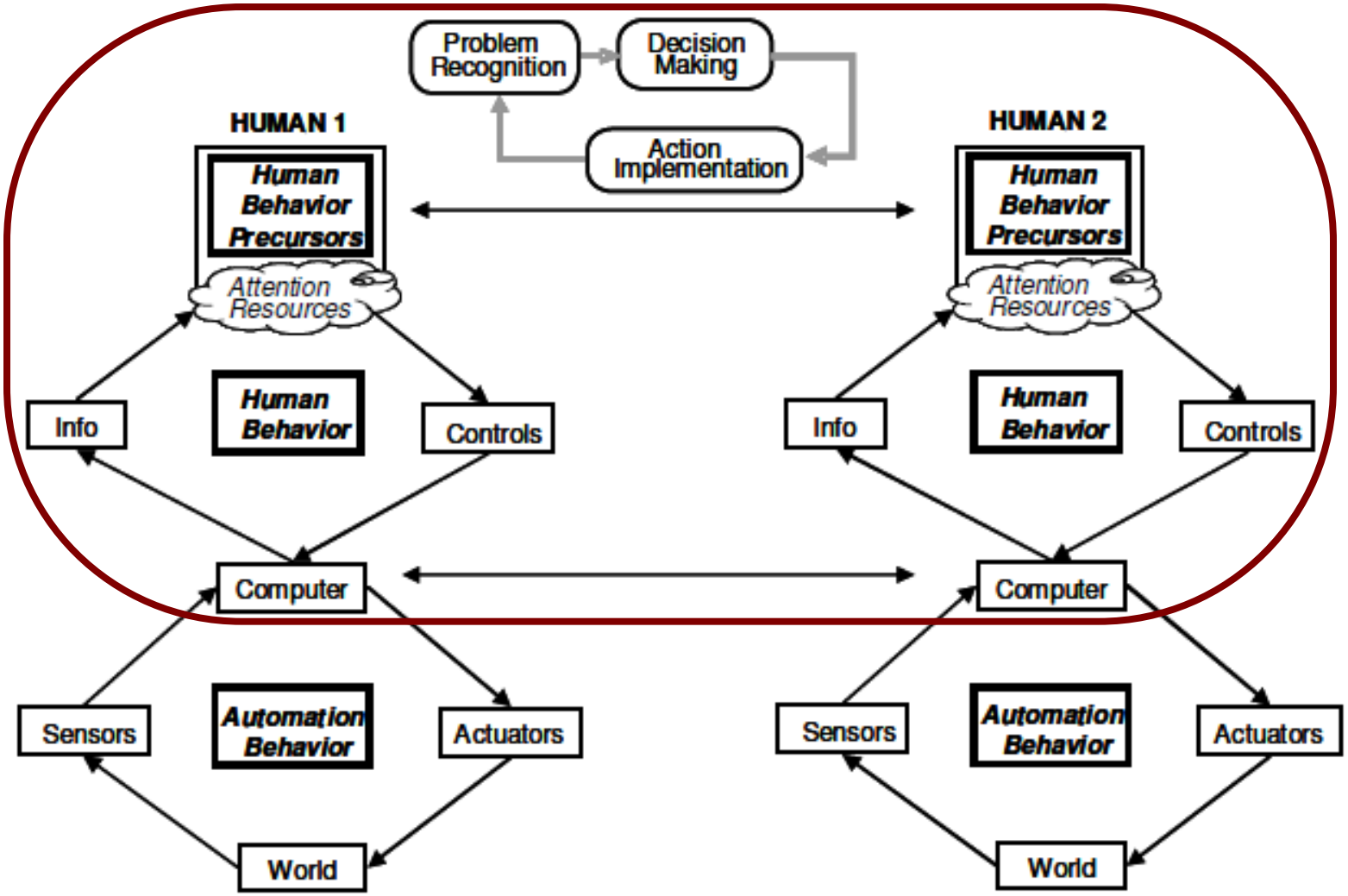





Human-System Interaction

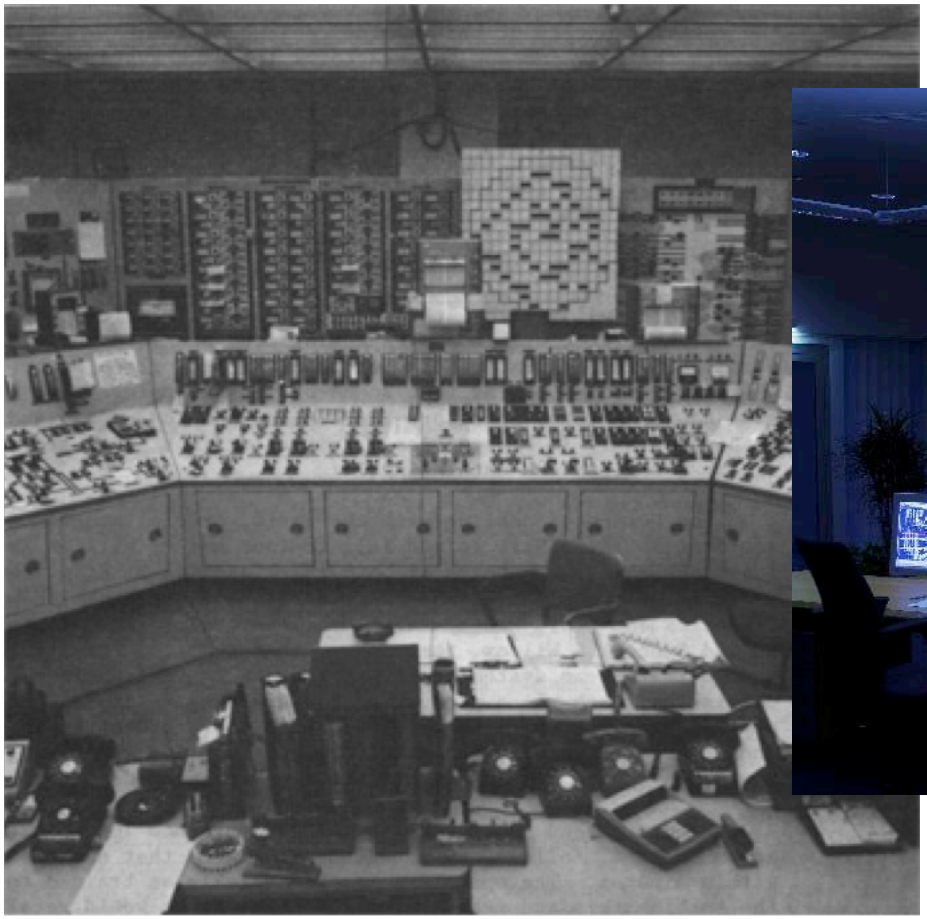


Human Supervisory Control Conceptual Model

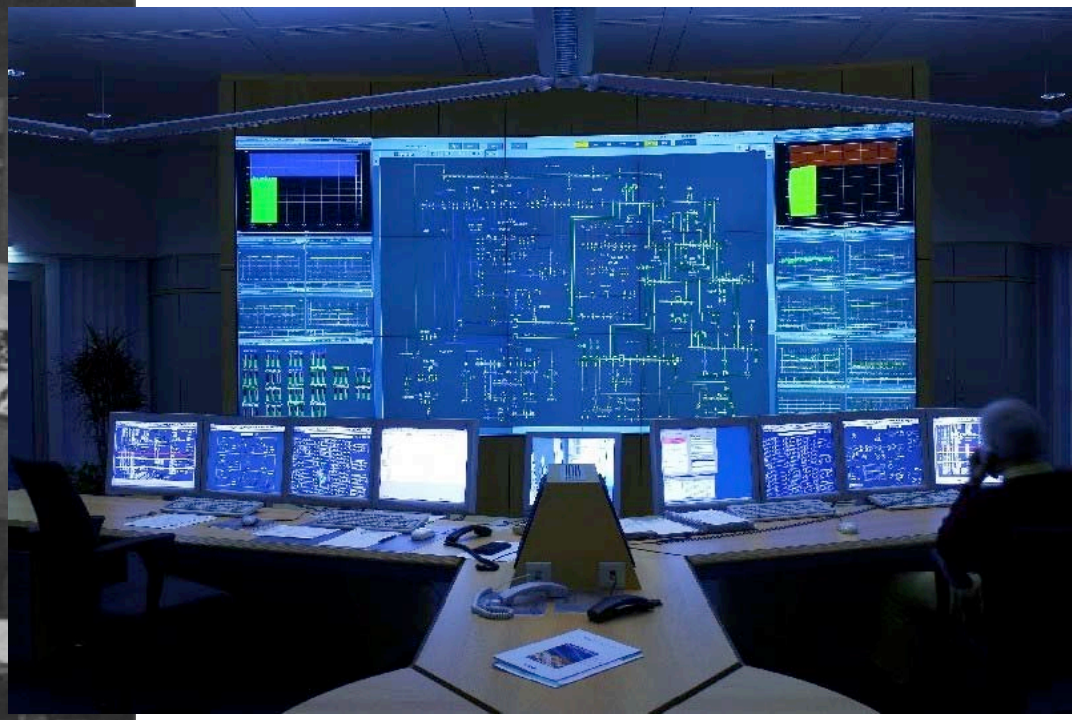


Donmez, B., Pina, P. E., & Cummings, M. L. (2009). Evaluation criteria for human-automation performance metrics. In R. Madhavan, E. Tunstel & E. Messina (Eds.), Performance Evaluation and Benchmarking of Intelligent Systems: Springer.

Motivation



Addressed by regulatory guidance



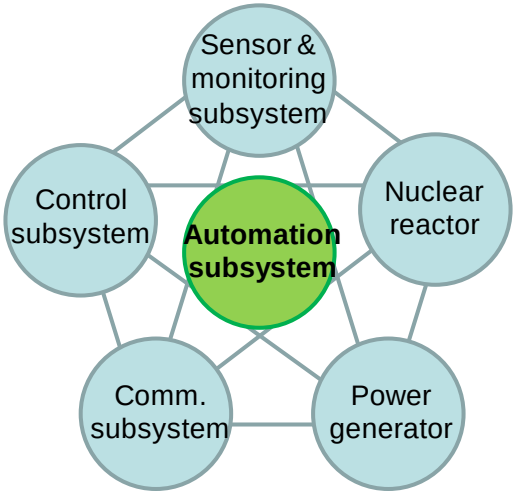
Gain understanding of aspects that may require new or modified regulatory guidance

Automation Focus

- Human element of plant system

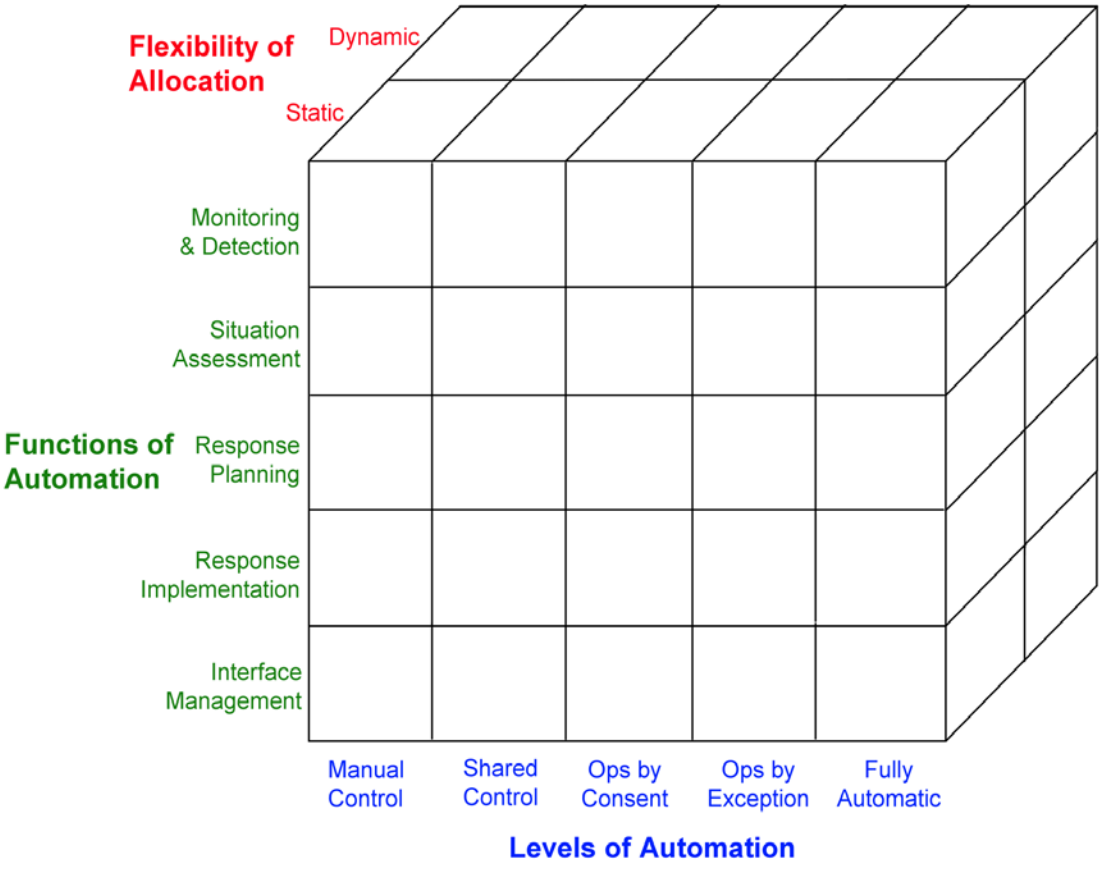
- Automation in Nuclear Power Plants
  - How does control room automation affect operator performance?
  - Automation metrics for control rooms
  - Levels of Automation (LOA) evaluation methods

- Experimental Evaluation of Metrics / Tools



Defining Automation

Automation Dimensions used by the NRC

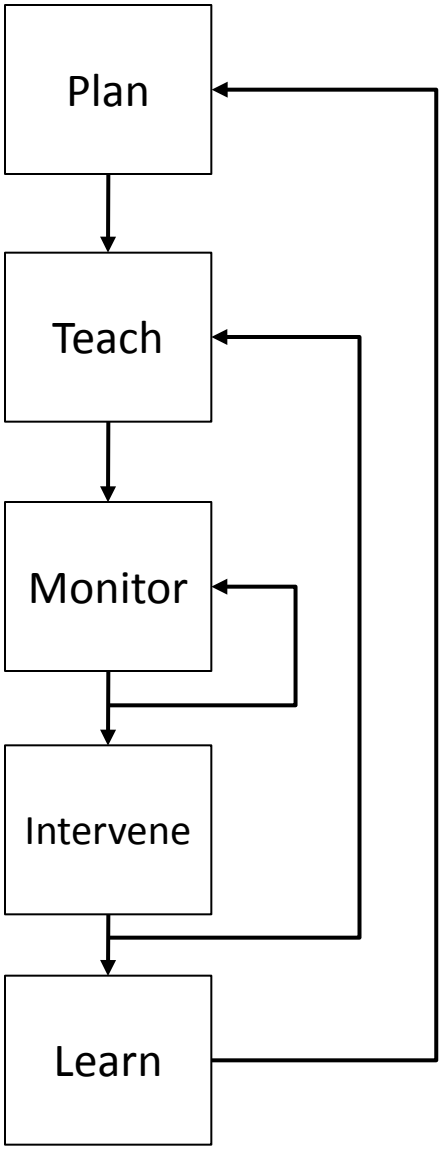


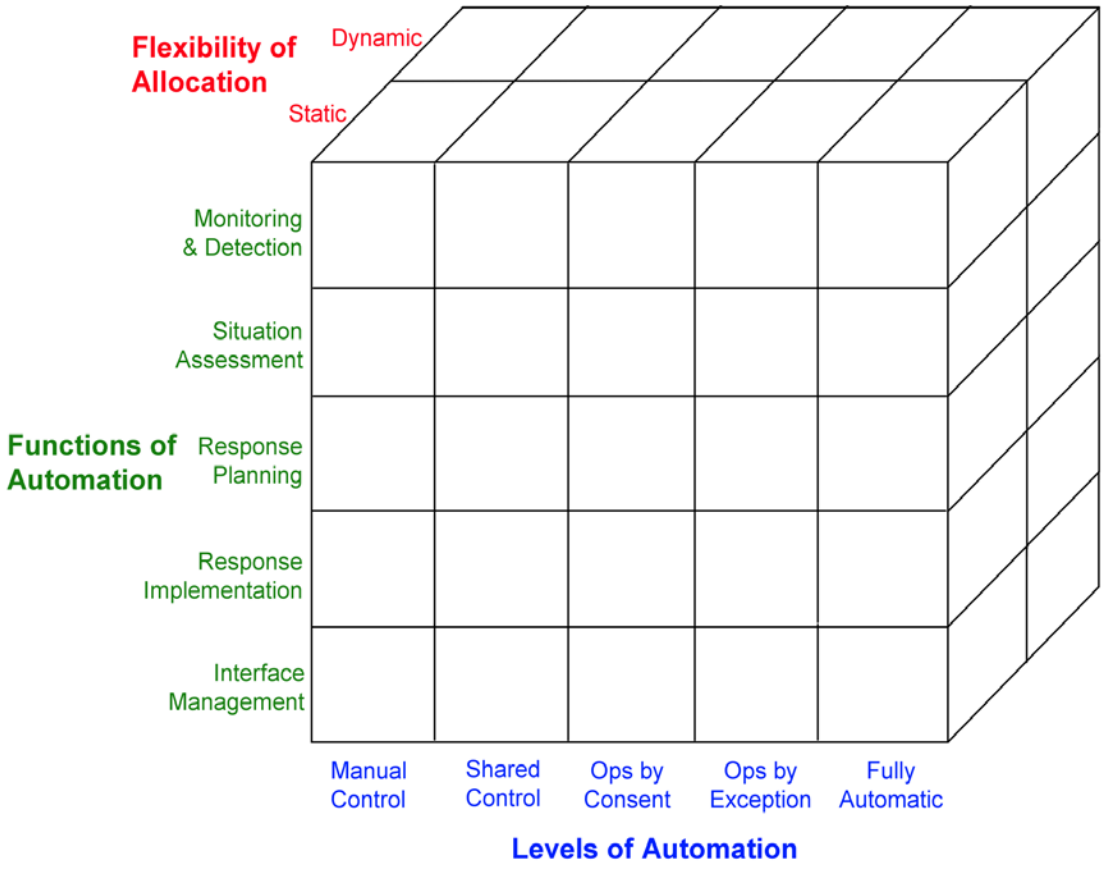
(Note the dimensions of Processes, Modes, and Reliability are not shown)

Automation dimensions:

Flexibility of Allocation
Functions of Automation
Levels of Automation
Processes
Modes
Reliability

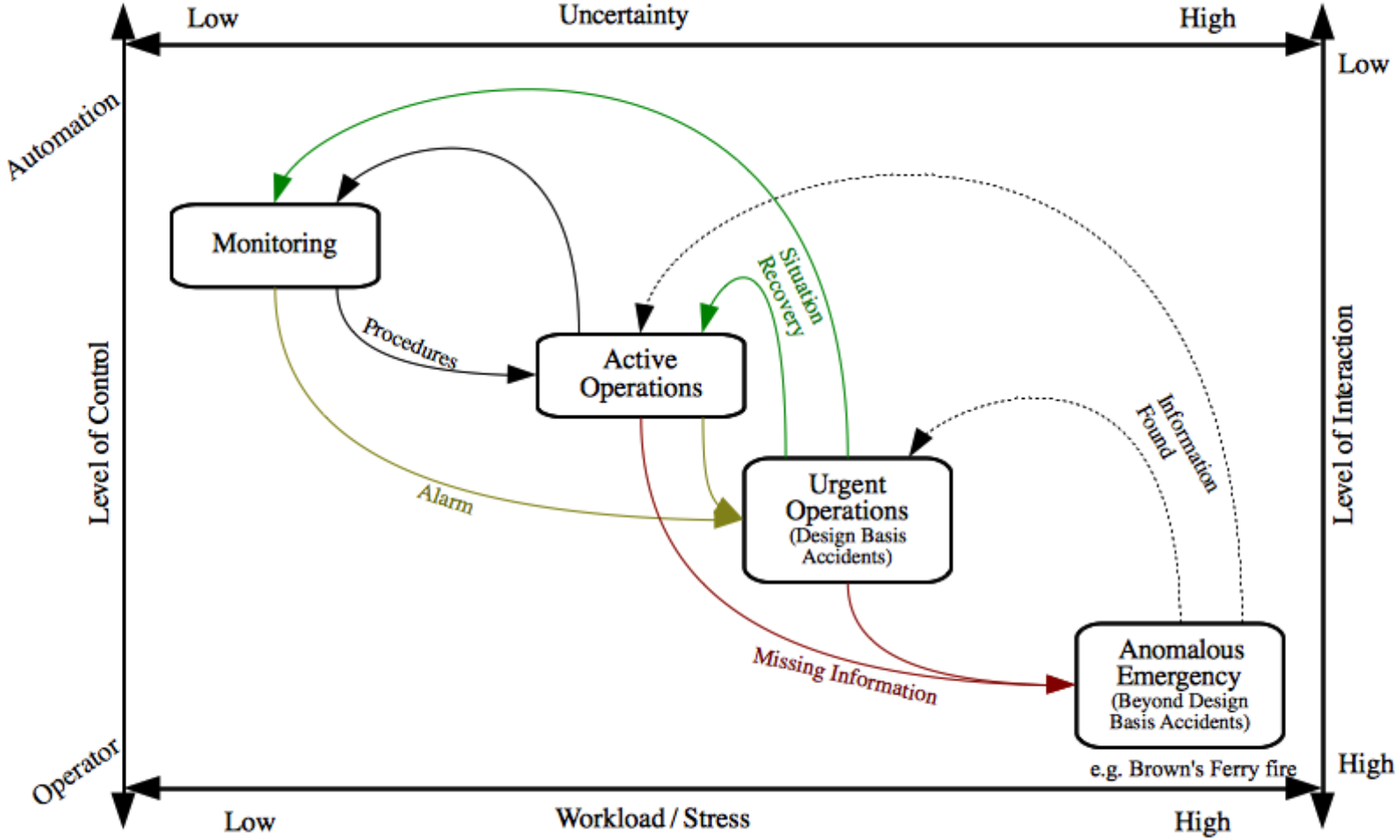
Automation & Supervisory Control Mapping





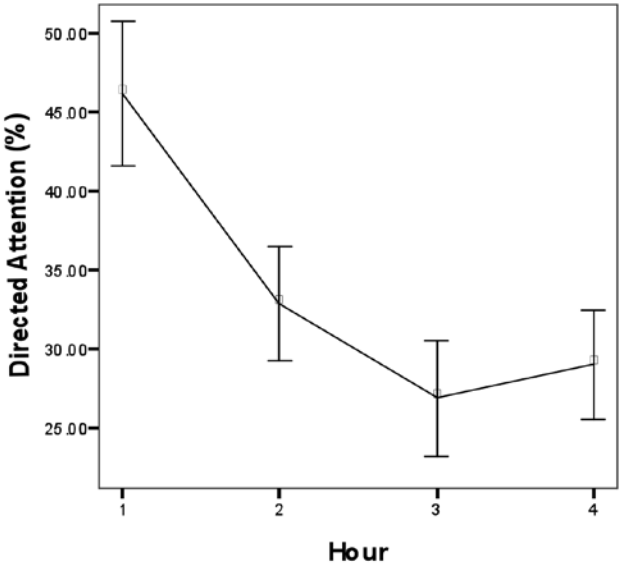
(Note the dimensions of Processes, Modes, and Reliability are not shown)

Possible Role Mapping in Operational States



Research Questions

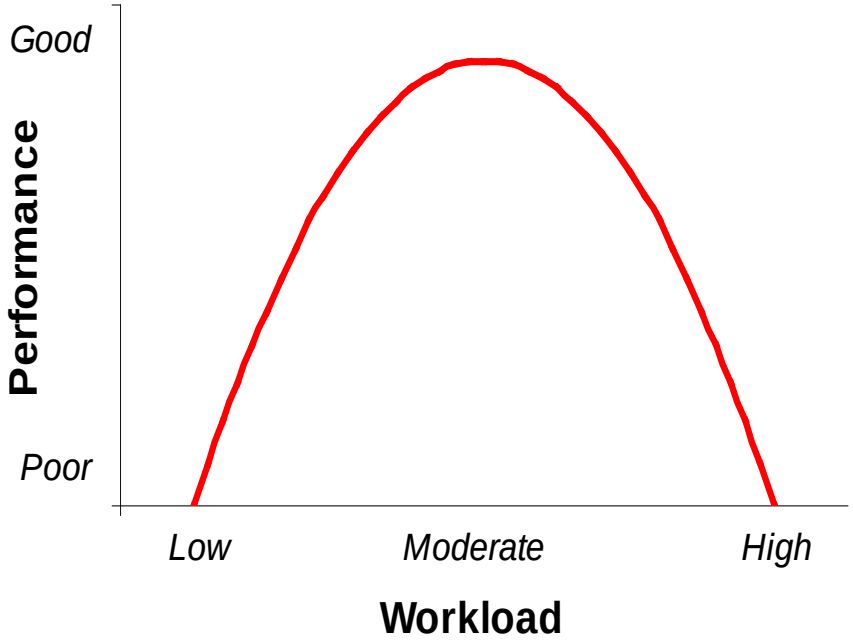
- How does advanced and/or increased automation in control rooms impact operator performance?
  - Shifts (12 hours) can be boring...



- Previous experiments show attention declines, but what does this mean for a supervisory control task?

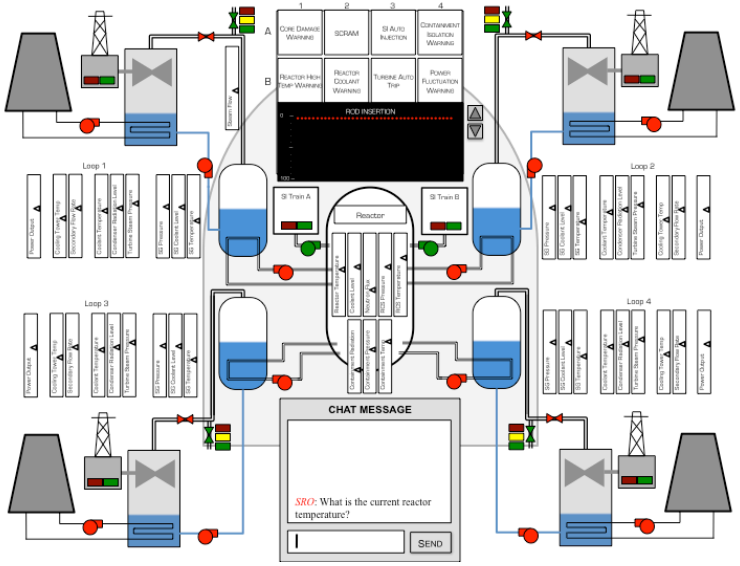
Workload Questions

- In advanced control room settings, workload will (most likely) be re-allocated between the operator and automation.
- How will re-allocation influence operator performance?



Experiment

- Basic nuclear control task
  - 4 hour experiment
  - Highly automated system
  - Critical event occurs
- How does a high level of automation with long periods of inactivity impact operator performance when reacting to a critical event?



Thanks

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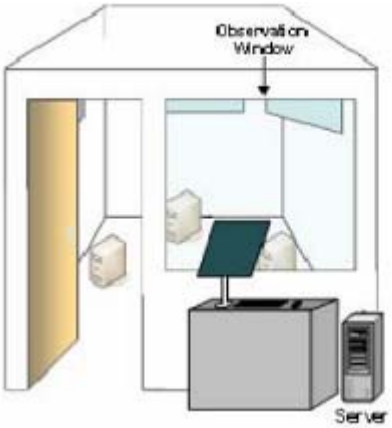
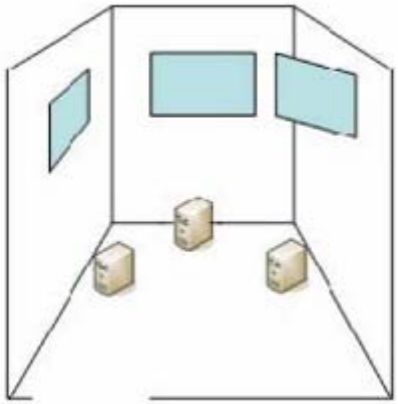
Team Lab

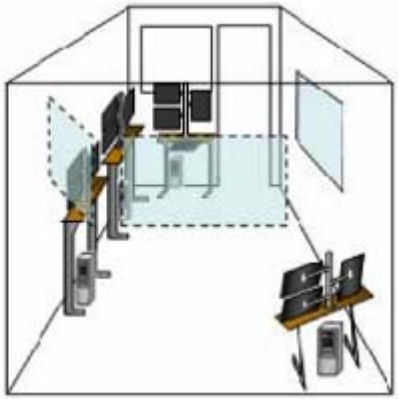
- **Goal**: facility for teaming and mission control experimentation
- Sponsored by Boeing



Collaboration Server



Large-Screen Displays



Operator Consoles