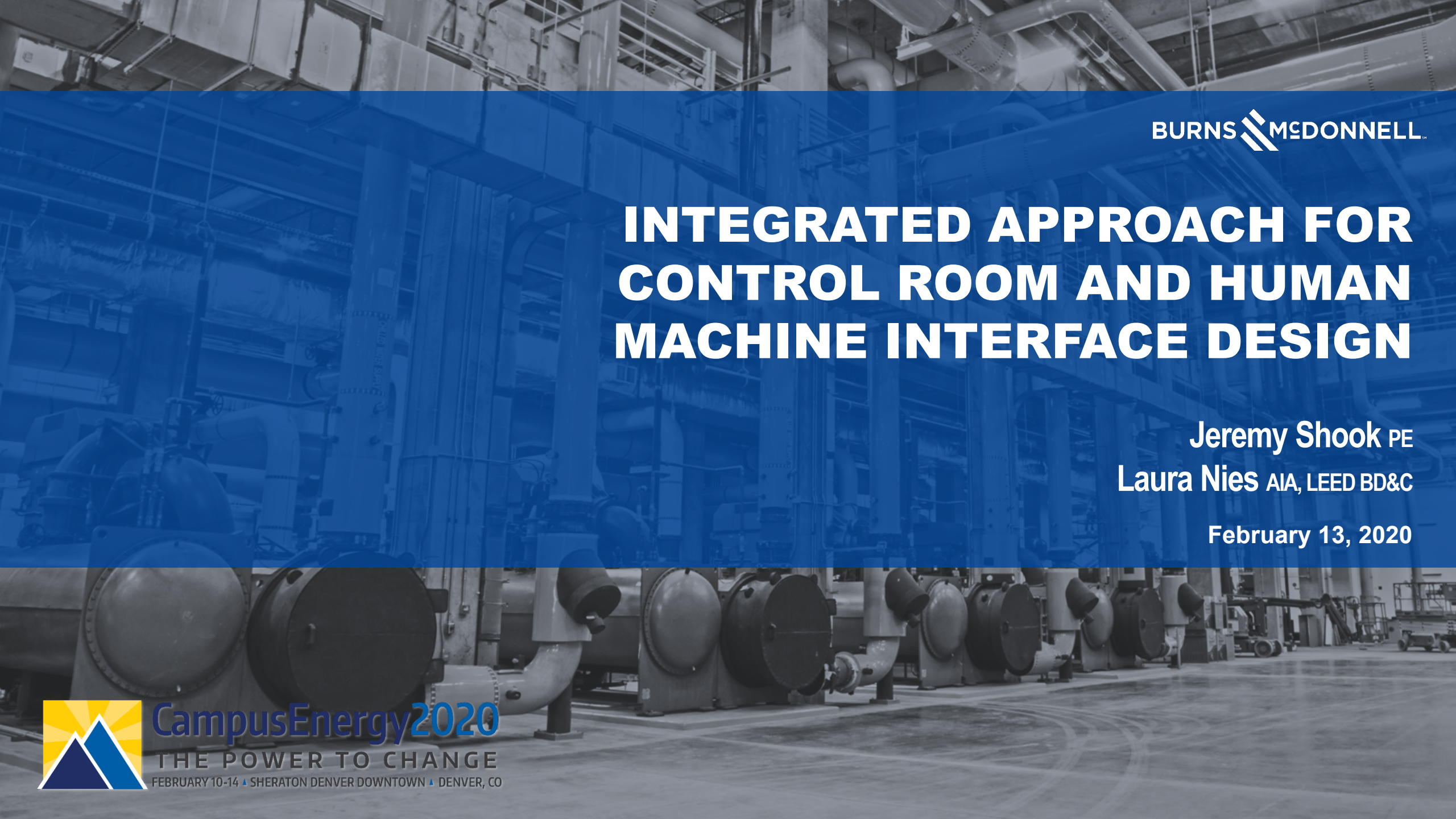


BURNS McDONNELL

INTEGRATED APPROACH FOR CONTROL ROOM AND HUMAN MACHINE INTERFACE DESIGN

Jeremy Shook PE
Laura Nies AIA, LEED BD&C

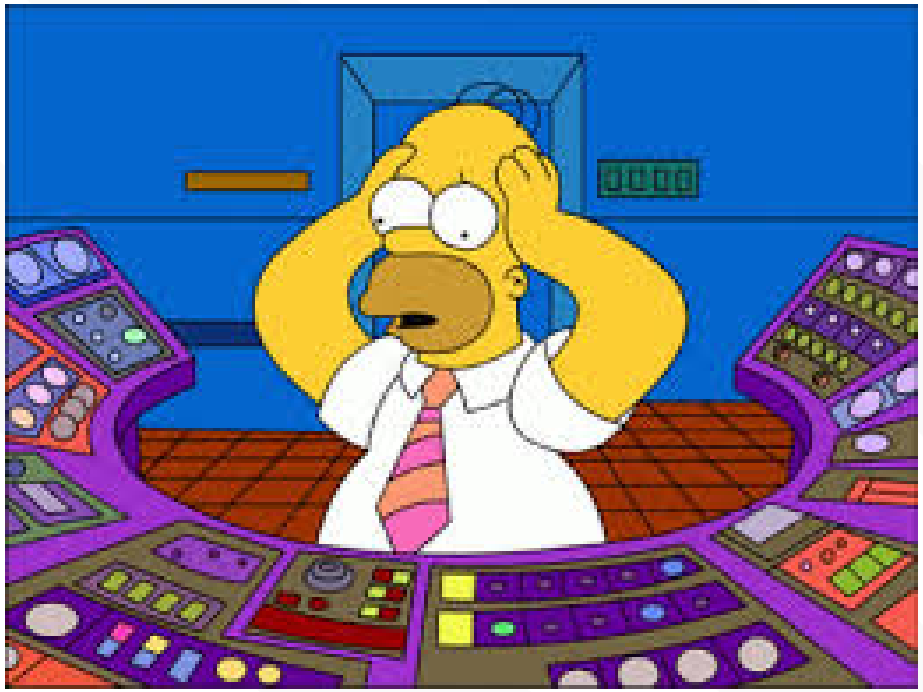
February 13, 2020

CampusEnergy2020
THE POWER TO CHANGE
FEBRUARY 10-14 ▲ SHERATON DENVER DOWNTOWN ▲ DENVER, CO

Agenda

- Why is Control Room Design Important?
- Control Room Requirements
- Control Room Key Design Considerations
  - Human Machine Interface (HMI)
  - Layout
  - Consoles
  - Architectural
  - Other
- Case Studies
- Summary

Why Is Control Room Design Important?



- Reduces chance of human error
  - Improves plant safety
  - Improves plant availability
  - Reduces risk of equipment damage
- Improves the health of your operators

CONTROL ROOM REQUIREMENTS

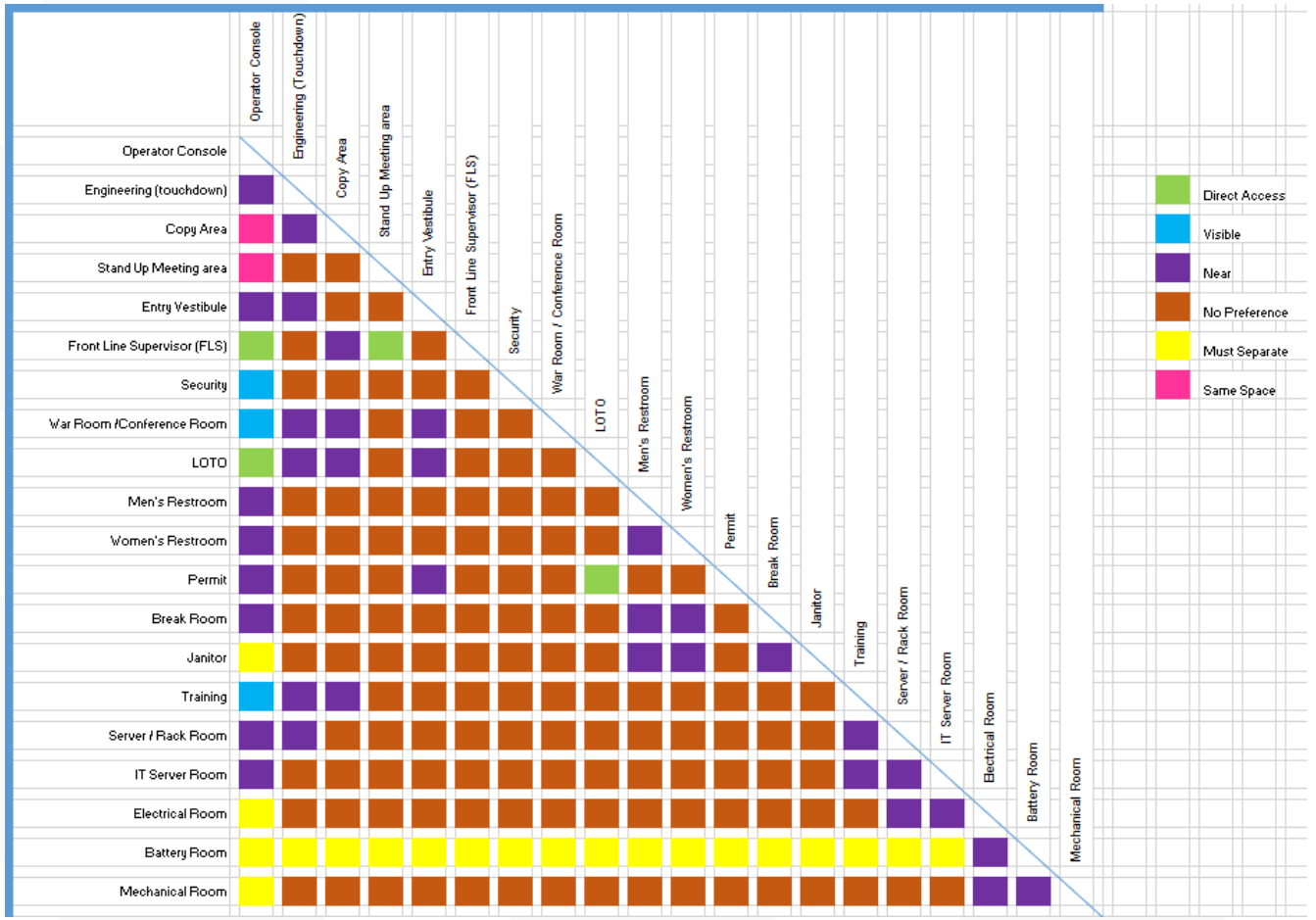
Types of Requirements

- Functional Requirements
- Client Requirements
- Codes and Standards
- Other Constraints

Functional Requirements Derived by Analysis

Task	Frequency	Importance	Total Score	Equipment
Normal Operations	5	5	25	Operator Workstation
Performance Monitoring	5	4	20	Operator Workstation
Equipment Condition Monitoring	5	4	20	Operator Workstation
Shift Log	5	4	20	Business Computer
Monitor External Perimeter	5	4	20	Security System (Monitor with Joystick/Keypad)
Visitor Access Control	5	4	20	Security System (Monitor with Joystick/Keypad)
Ongoing Training	3	4	12	Business Computer
Simulator Training	3	4	12	Business Computer
Time Reporting	3	3	9	Business Computer
Initial Training	2	4	8	Business Computer
Email	4	2	8	Business Computer
Event Reporting	2	4	8	Business Computer
Startup Plant	1	5	5	Operator Workstation
Abnormal/Emergency Operations	1	5	5	Operator Workstation
Shutdown Plant	1	5	5	Operator Workstation
Lockout/Tagout - Normal Ops	1	5	5	Business Computer/LOTO Printer
Lockout/Tagout - Outage	1	5	5	Business Computer/LOTO Printer
DCS Configuration Changes	1	4	4	Engineering Workstation
Shutdown Operations	1	3	3	Operator Workstation

Task Criticality and Adjacency Drives Layout Constraints

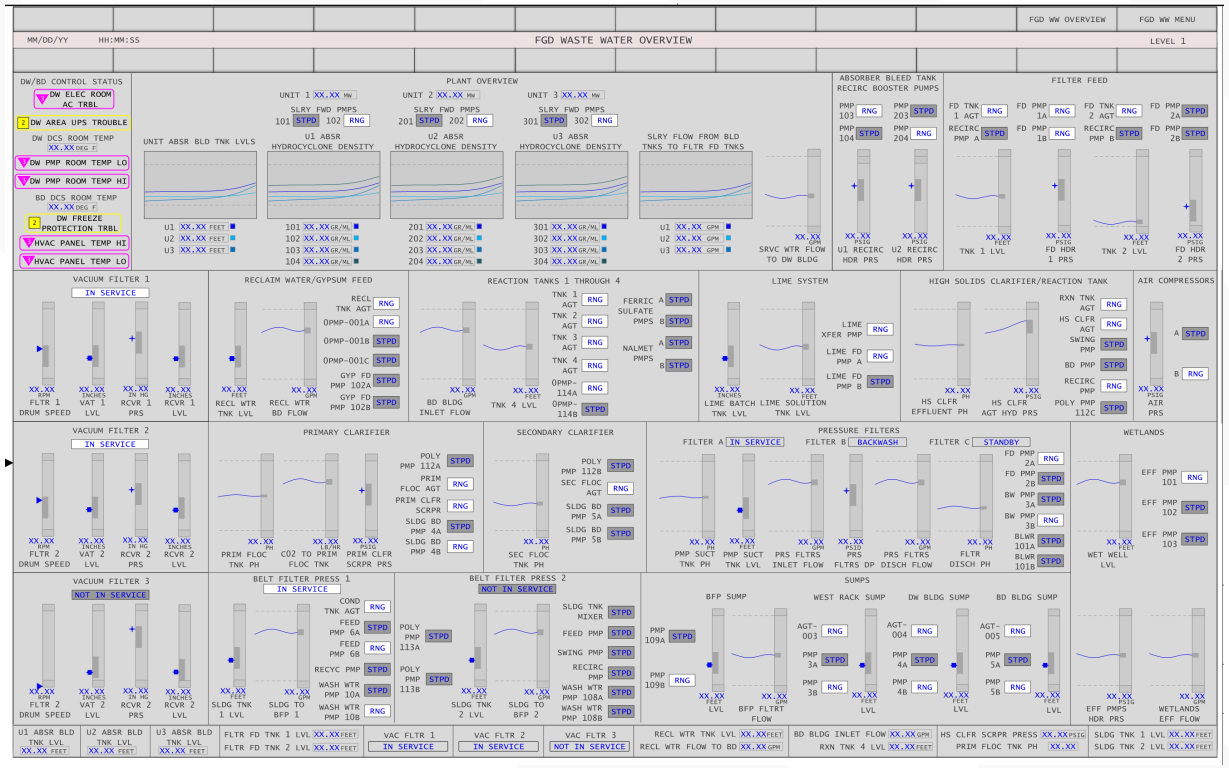


CONTROL ROOM KEY DESIGN CONSIDERATIONS

Human Machine Interface: Hardware Considerations

- **Types**
  - Task Based
    - Normal
    - Time Critical
  - Situational Awareness
- **Monitor Sizes**
  - Workstation 24”-27” Typ.
  - Overview 40”-75” Typ.
- **Computer Options**
  - Thick client
    - Console mount
    - Rack mount
  - Thin client

Human Machine Interface: Software Considerations



- Display navigation & hierarchy
- Task inventory
- Amount of information per display
- Trends & bar graphs for analog points
- Alarm concept
- Consistency

Layout

- Console Orientation
- Communication
- Access to all task areas
- Emergency stop locations
- Overview monitor placement

Supervisor locations	Linear or arc, two-sided (2 G)	Linear or arc, two-sided (2 H)	Linear or arc, two-sided (2 I)	Linear or arc, two-sided (2 J)	Linear or arc, two-sided (2 K)	Linear or arc, two-sided (2 L)
Linear examples						
Arc: operators inside						
Arc: operators outside						
Key User Off-workstation display						

ISO 11064

Tresco

Design Guidance

INTERNATIONAL STANDARD

ISO 11064-3

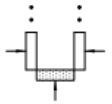
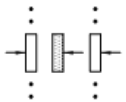
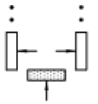
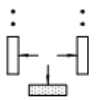
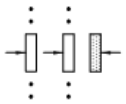
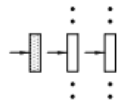
First edition
1999-12-15

Ergonomic design of control centres —

Part 3:
Control room layout

Conception ergonomique des centres de commande —

Partie 3: Agencement de la salle de commande

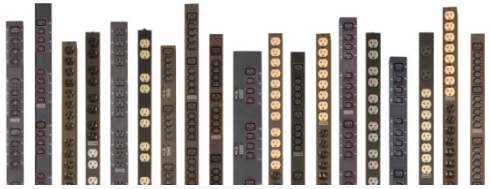
Supervisor locations	Linear or arc, two-sided (2 G)	Linear or arc, two-sided (2 H)	Linear or arc, two-sided (2 I)	Linear or arc, two-sided (2 J)	Linear or arc, two-sided (2 K)	Linear or arc, two-sided (2 L)
Key Control workstation: Supervisor workstation: Continuation:						
Features	**Between supervisors and operators**					
Sharing workstation equipment	–	–	–	+	–	–
Sharing off-workstation displays	–	–	–[a]	–	–[a]	+[a]
Direct eye contact	+[b]	0[b]	–	–	[b]	–
Verbal communication	+[d]	0[c]	0[c, d]	–	+	–[c]
Low noise interference	–	–	0	+	–	+
Message passing	+	0	+	+	0	–[c]
Collection and delivery of paperwork	+	0	–	0	–	–
Standing in for supervisor	0[d]	–	+[d]	0[d]	0	–
Operator training by supervisor	0[d]	–	–[d]	+[d]	–	0
Equipment accesss for maintenance	–[b]	–[b]	0	+	0	0
Key Better + Average 0 Worse –	[a] Careful positioning of workstations required to view or share off-workstation displays. [b] Depends on precise layout; better for arcs with operators outside; worse for arcs with operators inside. [c] Operators or supervisor shall turn around or move. [d] Better for operators adjacent to supervisor.					

Consoles: Features

Tresco

Slat Wall

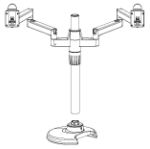
Cable Management



Integrated Power Distribution

Task Lighting

Environmental Controls



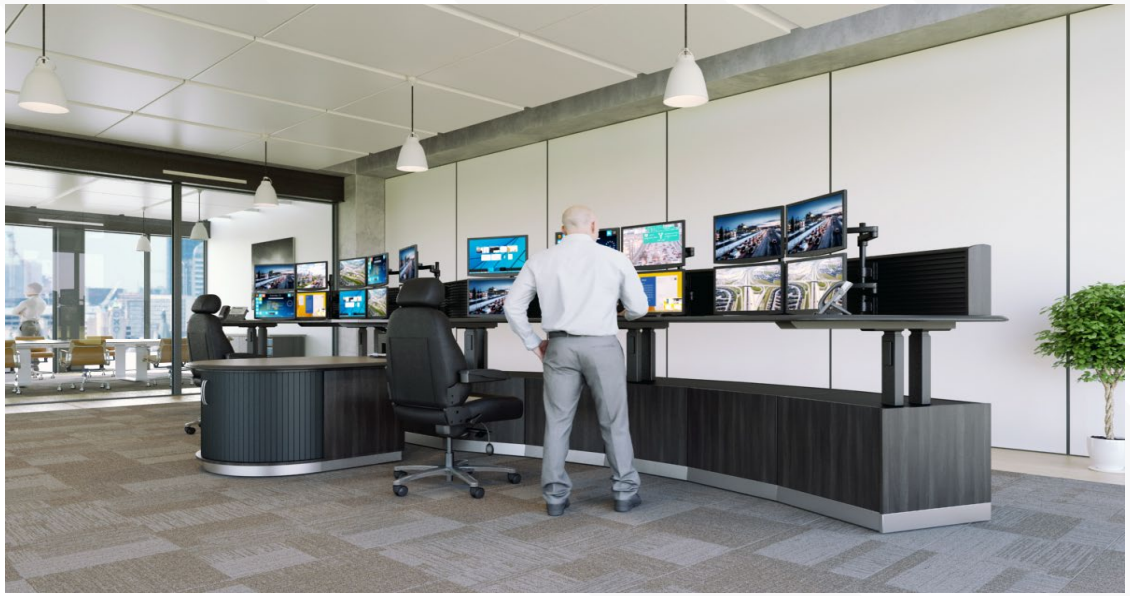
Swivel/Tilt Monitor Arms

Articulating Monitor Arms

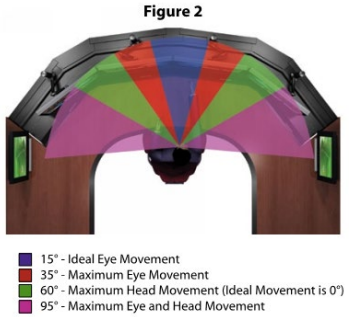
Monitor Mounts

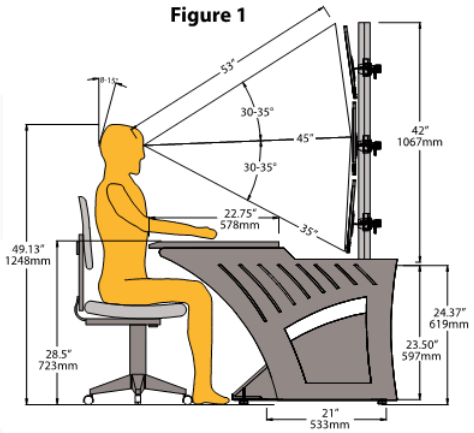
Consoles: Ergonomics & Adjustability

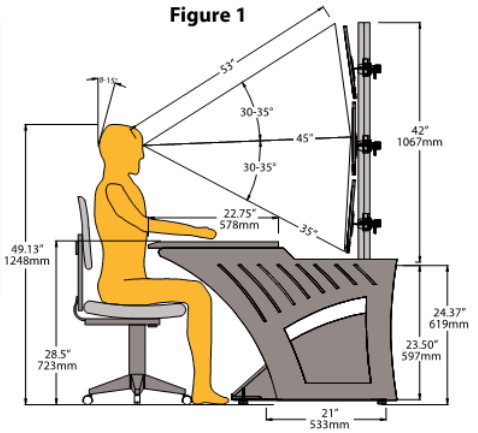
- Seat selection
- Console Furniture: Sit / Stand
- Fatigue



Tresco



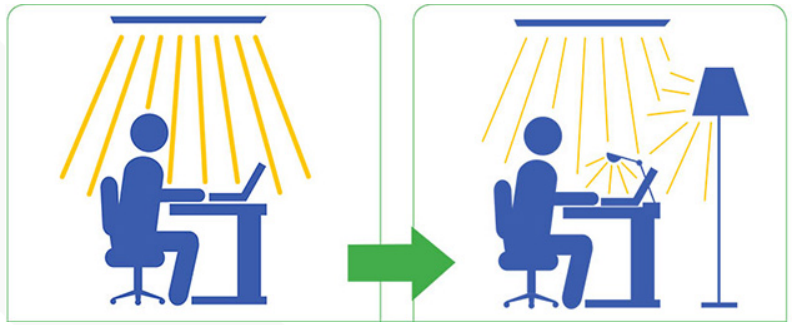


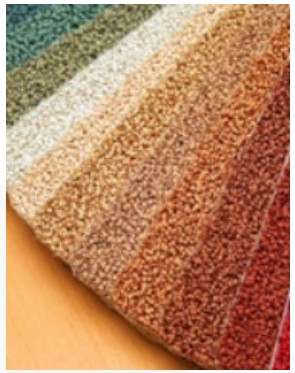


Winsted – Human Factors: Planning & Design of a Control Room

Architectural Considerations

- Acoustics
  - Wall, floor, and ceiling material selection
  - Sound masking
- Light Levels
- Wall & Floor Color
- Materials / Durability
  - 24/7/365
  - High Traffic /
  - Anti-static





Research on Environmental Factors

6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015

Situation awareness and automation in the electric grid control room

Susan Stevens-Adams*, Kerstan Cole, Michael Haass, Christy Warrender,Robert Jeffers, Laurie Burnham and Chris Forsythe

Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM, USA

4. Conclusions and Future Steps

Vermont control room operators were interviewed to determine factors that are important to successful control room operations and, in turn, grid stability and resilience. Situation awareness, via communication with the field crews, was found to be a major contributor to successful operations. The operators explained that,in the control room,they only have an abstract view of the current situation – the ...rew, who witness what is actually happening in the real world, are the eyes and ears of the operator. Thus, the operators' situ... highly reliant on the field crew. Grid mod... ...nologies that are intended to give the operators more data - but how will this relate t...

Lighting up the office: The effect of wall luminance on room appearance, workers' performance, and subjective alertness

Adrie de Vries[a,b,*], Jan L. Souman[a], Boris de Ruyter[c,d], Ingrid Heynderickx[b], Yvonne A.W. de Kort[b]

[a] *Signify N.V. (Department Lighting Applications), High Tech Campus 7, 5656, AE Eindhoven, The Netherlands*
[b] *Eindhoven University of Technology (Human-Technology Interaction, School of Innovation Sciences), Eindhoven, The Netherlands*
[c] *Philips Research (Department Brain, Behavior & Cognition), Eindhoven, The Netherlands*
[d] *Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, Nijmegen, The Netherlands*

5. Conclusion

The findings of our experiment suggest that an increased wall luminance may have a positive effect on maintaining the level of subjective alertness of office workers. However, uncertainty remains with regard to the underlying mechanism. The results strongly suggest a psychological rather than a biological mechanism, for instance linked to motivational

13th International Scientific Conference on Sustainable, Modern and Safe Transport (TRANSCOM 2019), High Tatras, Novy Smokovec – Grand Hotel Bellevue, Slovak Republic, May 29-31, 2019

The Effects of back lit Aircraft Instrument Displays on Pilots Fatigue and Performance

Andrea Brezonakova[a]*, Iveta Skvarekova[a], Pavol Pecho[a], Robin Davies[b], Martin Bugaj[a], Branislav Kandera[a]

[a] *Air Transport Department, University of Zilina, 010 26, Zilina, Slovakia*
[b] *Flight Safety Volunteer, British Airline Pilots Association, Heathrow, UK*

4. Conclusion and future recommendations

Vision is undisputedly the most important of a pilot's sensory inputs, especially in providing information to maintain a safe flight. Although the human eye is optimised for daytime vision, it is also able to see in environments with very low illumination.

The correct illumination settings of instrument display panels e.g. backlight intensity, together with audiovisual comfort and piloting comfort as a whole, effects crew performance and stress. The stress environment can have a negative impact on the decision-making process. (Novák A., Mrázová M., 2015) Incorrect interpretation of aircraft information caused by poor illumination settings can be a source of many mistakes.

This article experimentally verifies the influence and importance of the instrument panel backlighting intensity settings during flights and its direct relationship between the eye monitoring parameters. The results of the measurements are graphs depicting the adaptation of the pilot eye(s), which adapt to the current lighting conditions with a transition between different light intensity. By analysing the observed eye parameters such as saccadic eye movements, blinking, eye fixation and dwell time, under different light conditions, the authors concluded that there was a direct influence with the intensity of the instrument panel backlight, especially during night flight conditions. The results of this eye monitoring analysis supports the hypothesis that visual fatigue depends on backlight intensity levels. Moreover, the backlighting of the instrument display panels, during a flight influence the pilot via visual fatigue. A higher visual fatigue can therefore be expected as a consequence of the factors mentioned above. Additionally, visual fatigue can be linked to sleep deprivation, circadian rhythm synchronisation factors and general fatigue inducing conditions. (Caldwell J.A., 2005).

Other Considerations

- Fire Alarm & Protection
- Access Controls
- Communications Equipment
- Cable Routing
- HVAC

CLEAN AGENT SYSTEM

CAS

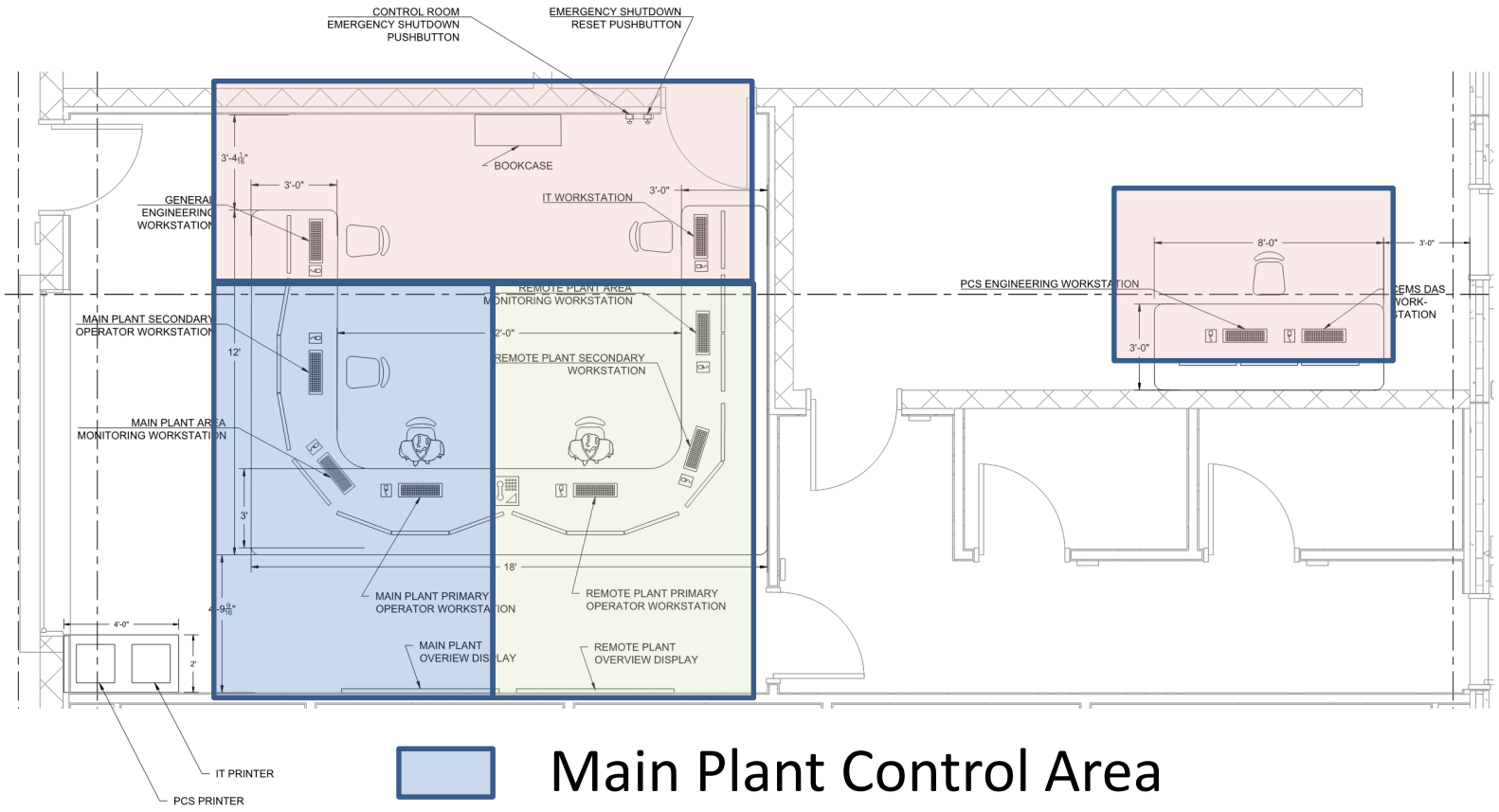
PRODUCT QUALIFICATIONS:

Note: Installation per manufacturer's requirements.

Description:	NOVEC 1230 Fire Suppression Clean Agent
Manufacturer:	3M
Style:	Gaseous
Color/Finish:	N/A

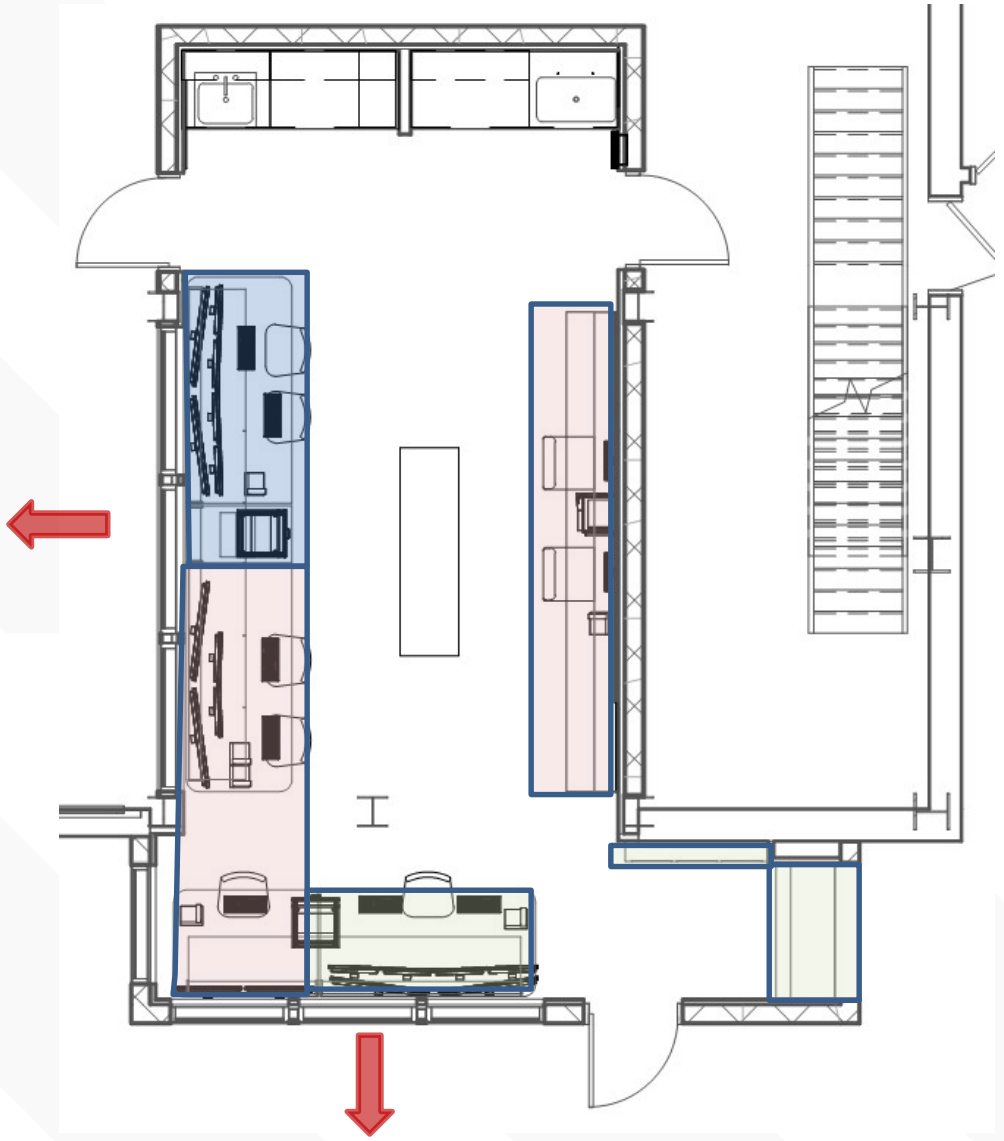
CASE STUDIES

New Plant Control Room Design



- Main Plant Control Area
- Remote Plant Control Area
- Maintenance and Administration Areas

Existing Plant Control Room Modernization



- Boiler Control Area
- Turbine & CHW Control Area
- Support & Security Areas

SUMMARY

Key Takeaways

- Control room design is important!
  - Improves plant safety
  - Improves plant availability
  - Reduces risk of equipment damage
  - Improves the health of your operators
- Use a structured approach to improve your control room design for new and existing facilities

QUESTIONS

THANK YOU

- Jeremy Shook PE

  400 S. Tyron St. Suite 800

  Charlotte, NC 28202

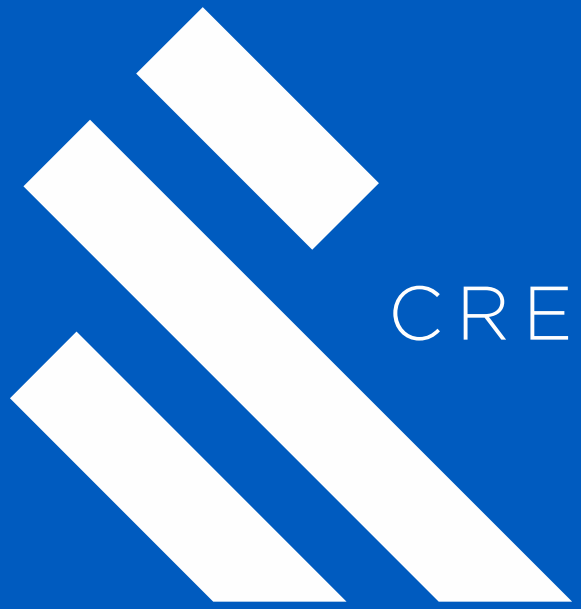
  (704) 450-8924

- Laura Nies AIA, LEED BD&C

  9450 Ward Parkway

  Kansas City, MO 64114

  (816) 333-9400



CREATE AMAZING.