IChemE Webinar
Instructions for Attendees

- Only the presenters can be heard – unless they pass speaking privileges to an attendee

- When no one is speaking, you may experience absolute silence; Do not be alarmed

- Please use the “Emotives” to indicate whether you have a question or other request
  - “Put your hand up” to catch the moderator’s eye – just like you would in a face-to-face meeting

- There is a Queue to speak; We will acknowledge each request as they come in but please be patient as you wait your turn
  - Please remember to “Unmute” yourself when it is your turn to speak

- Today’s webinar will be recorded
Agenda

- Who We Are
- Introduction to Human Factors
- Major Pitfalls / Weaknesses in Control Room Design
- Considerations for Control Room Design
- Control Building Development Methodology
- Questions & Discussion
Our Company

✦ Vision
  ➢ **Transform** the nature of plant operations
  ➢ **Improve** the effectiveness of the business
  ➢ **Enhance** the quality of life of the people who staff it

✦ Approach
  ➢ **Apply** human factors **principles** & human-centered design **methodologies** to enhance **performance**
  ➢ **Pioneer advances** in design & operations practices
  ➢ **Transition** these **innovations** into the plant
Our Service Offerings
Visioning, Assessments, Design, Evaluations and Education

- Staffing and Work Process Design
- Operator Interface Design
- Procedure System Design
- Alarm Management System Design
- Workplace Design
- Training System Design

We facilitate vision development, assess gaps in existing practices, collaborate on solution development, evaluate effectiveness of implementations and educate clients on the key factors contributing to operational excellence.
Abnormal Situation Management®

A Joint Research and Development Consortium

Founded in 1994

Creating a new paradigm for the operation of complex industrial plants, with solution concepts that improve Operations’ ability to prevent and respond to abnormal situations.

www.asmconsortium.org

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Human Centered Solutions
Helping People Perform
What is Human Factors?

- **Human Factors** (Chapanis, 1985)
  - Discovery and application of information about human behavior
    - abilities, limitations, and other characteristics
  - To the design of:
    - tools, machines, systems, tasks, jobs and environments
  - For productive, safe, comfortable, and effective human use

- **Multi-disciplinary Science**
  - Emphasis:
    - Understanding the **people**
    - Understanding the **work domain**
    - Understanding the **design space**
Aspects of Human Factors

- Various aspects – all focusing on Human Capabilities, Limitations, & Preferences in the context of System Design & the use of Technology
  - Perception
  - Attention
  - Memory
  - Decision Making
  - Learning
  - Expertise
  - Individual Differences
  - Physical ergonomics
  - Social dynamics
Human Capabilities and Limitations

- Basic Human Capabilities are Fixed
  - People rely on innate perceptual and cognitive capacities that evolved centuries ago
  - People read at the same speed today as 100 years ago
  - Many 1980’s concepts are still applied today
    - User interfaces
    - Control room design
    - Roles and responsibilities

- Human factors strives to design technology in the context of human strengths and weaknesses
  - Instead of forcing humans to conform to technology
  - Technology is more adaptable than are humans
  - The goal is overall human-machine system performance
Major Pitfalls in Control Room Design

🔹 Centralized vs. Distributed Control Rooms

🔹 Wall-mounted large screens in Control Rooms

🔹 Designing from the outside to in rather than from the inside to out
Weaknesses in Control Room Design

- **Console Design** for
  - the console operator’s roles & responsibilities

- **Console Adjacencies** for
  - required communication & collaboration

- **Control Room Layout** for
  - properly managed traffic flow, distraction, & congestion

- **Environmental Design** for
  - proper lighting, acoustics, and climate
Control Room Design Requirements

“Designing a control room effectively is an extremely complex task because of the multifunctional nature of control buildings:

- It’s a communication center
- It is the distribution, coordination and control center for plant work
- It’s a centralized local control focus for plant operation
- It must be suitable for 24-hour operation in 12-hour shift system
- It may be the main training facility for operators
- It’s an emergency response center
- It may be a control application development center, used in the definition, design, testing and maintenance of software applications
- It may be an office facility for day-time operations, maintenance and technical support staff”  

Centralized vs. Distributed Control Rooms

- Potential trade-offs for this decision point

- Centralizing console operations when console-field collaboration is actually more critical than console-console collaboration
  - Which operational collaborations need to be ‘optimized’?

- Distributing control rooms in hazardous locations vs. locating critical control functions outside of blast zones

Use of Wall-mounted Large Screens

- Effective use *or* a fascination with the technology?

- From the Nuclear Power Industry, system designers have *proposed* the following benefits:
  - Support *Situation Awareness* of the individual operator and Operations team
  - Support a console operator’s monitoring to get the “big picture”
  - Support a “common frame-of-reference” for team collaboration
  - Support an individual’s and team’s “accurate” mental model of the plant
  - Provide individual’s entering the control room (e.g., supervision or engineering) with ability to see the “state of the world” without interrupting the operator

What is Meant to be Achieved with Wall-mounted Large Screens?

Emily Roth, personal communication, 19 May 2006:

- The study did not find clear evidence that the ‘large’ wall panel display was superior to ‘small’ local displays.
- It appeared to be the content of the ‘overview display’ that mattered.
- In general, I have not come across a case where, large wall-mounted displays were terribly effectively used.

At least three questions need to be answered

- What role is the wall-mounted large screen meant to serve? (For whom is the screen really there?)
- What will be displayed on the wall-mounted large screen?
- Is the wall-mounted large screen going into a brownfield or greenfield control room?

You need to develop an overall design approach that examines the needs of:

- On-console operator HMI requirements
- Off-console functional and collaboration needs
- Control room layout and ergonomics
Console Design

✧ Console size / foot-print should be driven by the
  ✧ Operator interface design, Additional equipment requirements &
    Expected number of users

✧ Number & types of users
  - Primary operator
  - Secondary operator / trainee
  - Engineer or Technician

✧ Ergonomics
  - Viewing angles
  - Reach envelopes
  - Adjustability
  - Sit-stand surfaces
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Console Adjacencies

- Identifying process interactions between console positions
- Support lines-of-sight & verbal communication opportunities (side-to-side vs. facing vs. back-to-back)
  - Impacts the control room layout
Control Room Layout

✧ **Primary Support Adjacencies**
  - Locate (building decisions) and arrange (layout decisions) support staff and resources to improve situation awareness, promote collaboration and minimize noise/distractions

✧ **Traffic Patterns**
  - Minimize distractions from traffic without limiting legitimate interactions with field operators and supervisors
  - Provide information resources such as unit overviews and alarm summaries at field operator stations and supervisor offices
  - Avoid “surprising” visitors (i.e., when one’s back is to the traffic)

✧ **Physical space considerations**
  - Entrances/exits, space provisions, and windows
  - Off-workstation and shared equipment arrangements such as storage, printers, and message boards

✧ **Non-operational considerations**
  - Visitors, maintenance and cleaning
Control Room Layout

- Room Size should be determined by functional requirements (e.g., console size, additional work areas)
  - Design “inside-out” rather than “outside-in”

- Physical Spaces required
  - Each console workspace must be > 9 m² (10-15 m²)
  - General walkways must be > 140 cm
  - Maintenance access must be > 123 cm

- Console Layout strategy
  - Horseshoe vs. Theater vs. Functional
# Control Room Layout Strategy

<table>
<thead>
<tr>
<th></th>
<th><strong>Theatre</strong></th>
<th><strong>Functional</strong></th>
<th><strong>Horseshoe</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lighting</strong></td>
<td>Negative—Big screens complicate lighting</td>
<td>Positive—Provides good space in center “island”</td>
<td>Negative—Almost forces light sources to come from behind operators</td>
</tr>
<tr>
<td><strong>Noise</strong></td>
<td>Negative—noise from front row washes over back row</td>
<td>Positive—Console noise focused behind operator</td>
<td>Very Negative—concentrates noise in the center</td>
</tr>
<tr>
<td><strong>Traffic/Congestion</strong></td>
<td>Negative—concentrates traffic between console rows</td>
<td>Neutral—concentrates traffic behind operators for discussions</td>
<td>Very Negative—concentrates traffic and discussions in the center</td>
</tr>
<tr>
<td><strong>Operations Communication</strong></td>
<td>Neutral—most relevant communication is side-by-side</td>
<td>Positive—relevant communication is side-by-side and face-to-face</td>
<td>Neutral—most relevant communication is side-by-side</td>
</tr>
<tr>
<td><strong>Social Communication</strong></td>
<td>Neutral—requires looking away from screens</td>
<td>Positive—communication is side-by-side and face-to-face while keeping screens in front</td>
<td>Neutral—requires looking away from screens</td>
</tr>
<tr>
<td><strong>Control Room Size</strong></td>
<td>Neutral</td>
<td>Positive—Smallest</td>
<td>Negative—Largest</td>
</tr>
</tbody>
</table>
Environmental Design – Lighting

- **Ambient Light levels should be 400-1000 lux to support visual acuity**
  - Task lighting required when levels are below ~300-400 lux

- **Reduce sources of glare**
  - Ambient light sources should generate an even distribution of lighting across the ceiling
  - Windows should not cause glare or reflections

- **Periods of bright blue light (~1000 lux) to support alertness**
  - Promotes circadian adaption for 24/7 shift work
    - Several continuous hours early in the Day shift
    - Short, periodic periods through the Night shift
    - Based on research at the US Naval Submarine Medical Research Lab and the Lighting Research Center at Rensselaer Polytechnic Institute

- **Challenge to Ambient Light Levels with Black Background Displays**
  - Luminance Contrast causes eye strain & fatigue
  - Occurs when ambient light is high and background illumination is low or vice versa
Environmental Design – Acoustics

- Ambient noise levels should be ~50-55 dB
  - The three largest sources of ambient noise are typically
    - HVAC vibrations propagating through ductwork
    - Control room equipment fans
    - Plant equipment noise

- ‘High activity’ noise levels should be < 60 dB

- Abatement strategies
  - Sound-absorbing materials on surfaces
  - Remoting CPUs outside of the control room (also helps with Climate!)
  - Directional speakers for electronic ‘noise’
  - Effective arrangement of Consoles

- Console-specific alarm tones
Environmental Design – Climate

- As a guide, ‘comfortable’ means—
  - Temperature should be between 18.0°C and 22.0°C
  - Relative humidity from 40 percent to 65 percent
  - Airflow between 0.10 and 0.15 m/s

- Workplace environment controls should be adjustable at each console
  - Personal heaters, vented air, ...

- Ensure HVAC diffusers are not located directly above operator sitting positions
  - i.e., avoid uncomfortable drafts

- Control room and equipment rooms should be on separately controlled zones
Recommended Control Building Development Methodology

- Phase 1: Problem Definition & Shared Vision
- Phase 2: System Description & Task Analysis
- Phase 3: Task Allocation & Job Design
- Phase 4: Functional Conceptualization
- Phase 5: Control Building Detailed Design
- Phase 6: Operational Feedback

- This approach is consistent with the ISO 11064 standard
Questions / Feedback?

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