DCS Console Operator Issues In Related Industries

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Center for Operator Performance
Distributed control systems (DCS) have enabled wider spans of control for console operators.

Design of the operator–process system has become increasingly critical to safe and efficient operation:
- Alarms
- Displays
- Procedures
- Decision Making/Training
Current Span of Control

Number of Positions per Number of Control Loops

Mean: 172.5
St. Dev: 74.7
Median: 170.0
# of Positions: 77
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Overview

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- Design of the operator-process system has become increasingly critical to safe and efficient operation:
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Overview of Study

- Approximately 30 operators will run the experiment.
- Two kinds of alarm display’s will be used (Chronological and Categorical).
- All treatment simulations are 1 hour and the alarm rates used as below:

<table>
<thead>
<tr>
<th>Alarms/10 minutes</th>
<th>Chronological</th>
<th>Categorical</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>25</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

- Also running 10-minute simulation similar to student experiments.

<table>
<thead>
<tr>
<th>Alarms/10 minutes</th>
<th>Chronological</th>
<th>Categorical</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>20</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Students and Operators reaction time for solving an alarm can not be distinguished from one another except at the alarm rate of 20 alarms per 10 minutes.

- Students performed significantly slower than operators at 20 alarms per 10 minutes.

### RT – Alarm Rates v. Student/Operator

<table>
<thead>
<tr>
<th>Level</th>
<th>Least Sq Mean (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student, 20</td>
<td>93.016354</td>
</tr>
<tr>
<td>Operator, 20</td>
<td>47.676607</td>
</tr>
<tr>
<td>Student, 10</td>
<td>31.785469</td>
</tr>
<tr>
<td>Operator, 10</td>
<td>24.217462</td>
</tr>
</tbody>
</table>
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Design of the operator–process system has become increasingly critical to safe and efficient operation:

- Alarms
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Simulation interface: virtual plant
Eye fixations when everything is calm
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Procedure Assessment

- Issues
  - Same steps in multiple procedures
  - Different levels/types of information (task versus training)
  - Different users

- Improvement option
  - Break procedures into chunks that can be recombined

- Problems
  - Volume
  - Style/format
Phase 2 - Heuristic 7

Conjunctions and Conditions

if (∀ k ∈ Si, ∃ conj ∈ ConjuntionList | k == conj,
    and ∀ j ∈ Si | cond ∈ ConditionList | j == cond)
    {conjunction(Si) = k; Condition(Si) = j;}

Procedure Chunking

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Action</th>
<th>Target</th>
<th>Step-Break</th>
<th>Conjunction</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continue circulating hydrogen until reactor temperature is below 500°F, continue hydrogen</td>
<td>until True</td>
<td>until temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shut down compressors 503 and 504.</td>
<td>shut down compressors 503</td>
<td>until True</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vent system to flare if necessary.</td>
<td>vent system</td>
<td>until True</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continue circulating through heater</td>
<td>continue stripper bottom</td>
<td>until True</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Characteristics of Expertise</th>
<th>Crude Unit Operator</th>
<th>Fluid Catalytic Cracker</th>
<th>Pipeline Analyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Form expectancies</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>2. Monitor cues</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3. Anticipate team member needs and limitations</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>4. Know where equipment and human resources can mislead you</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>5. Seek information to spot opportunities</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>6. Adapt the way they perform</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>7. Describe how events came about and will play out</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>8. Utilize time horizons</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>9. Use recall processes to overcome memory limitations</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>10. Construct mental simulations</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>11. Decenter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Engage in deliberate practice</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>13. More recognitionial decisions than option comparisons</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
</tbody>
</table>
Good decision making requires practice
Adapt military training exercises
Scenario based
Time pressure
Ambiguous
Low cost
Easy to apply (< 1 hour before shift)
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