Purpose of the Research

- Understand Human Errors under imperfect, unexpected, or extreme conditions
- Improve human reliability analysis (HRA) methods and process
- Gain insights from doing HRA

What causes well-trained, experienced operators to make errors?

Ideal world:
- Tasks
  - Training, procedures, interfaces, tools, work process
  - "Mission completed"

Reality:
- Tasks in given context
  - Task demands (e.g., multitasking, unpredictable dynamics)
  - Cognitive capacity limits
  - Performance influencing factors (e.g., fatigue, mismatched procedures, unreliable indicators)

Errors!
HRA Research and development

Lessons learn from events
Crew performance from Halden simulation
Operational experience and data
Cognitive science

HRA methods and guidance
Support risk-informed regulatory and licensing activities

learning from Halden Crew performance - examples

Learned:
Complex cognitive activities in extreme conditions
Important crew aspects
Multitasking challenges performance

Incorporated in HRA:
Built-in cognitive models
Identification of crew failure modes
Task analysis identifying multitasking

HRA process - An Integrated Human Event Analysis System (IDHEAS)

Analyze scenario context and develop operational narrative
Identify and analyze critical human actions
Identify crew failure modes for critical actions
Analyze performance influencing factors that affect the failure modes
Calculate the human error probabilities

PRA scenario
Action 1
Action 2
Action 3

Applicable crew failure modes (CFM), e.g.,
- Key alarm not attended to
- Misinterpret procedures
- Critical data misperceived

Distraction

Mental fatigue

P_a

P_d

P_b

Yes

No

Yes

No

Yes

No
Using IDHEAS to analyze the Electrical Fire Event
Example context challenging personnel performance

<table>
<thead>
<tr>
<th>Context</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant status</td>
<td>Electrical fire, multiple failures (e.g., CCW cooling to Rx coolant pumps)</td>
</tr>
<tr>
<td>Critical actions</td>
<td>Timely restoration of CCW cooling to the RCPs</td>
</tr>
<tr>
<td>Procedures</td>
<td>Mismatched procedures, open to interpretation</td>
</tr>
<tr>
<td>Unfamiliar scenario</td>
<td>Crew responded to fire alarms and loss of CCW</td>
</tr>
<tr>
<td>Distraction</td>
<td>Crew was distracted by the electrical fire</td>
</tr>
<tr>
<td>Time urgency</td>
<td>Restore CCW within 13 minutes of indications</td>
</tr>
</tbody>
</table>

Examples of applicable crew failure modes
- Key alarm not attended to
- Critical data dismissed
- Critical data misperceived
- Misinterpret procedures
- Choose inappropriate strategies
- Delayed implementation
- Action executed incorrectly
- Critical data not communicated

Electrical Fire Event (cont.)
Example of analyzing the likelihood of human errors

**Key Alarm Not Attended To**

<table>
<thead>
<tr>
<th>Cognitive Workload/Distraction</th>
<th>HSI</th>
<th>Perceived Urgency</th>
<th>Crew Failure Scenarios</th>
<th>HEP</th>
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<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>1</td>
<td>2.5E-1</td>
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<tr>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>2</td>
<td>9.8E-2</td>
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<td>High</td>
<td>3</td>
<td>5.8E-2</td>
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<td>7.3E-3</td>
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<tr>
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<td>Low</td>
<td>Low</td>
<td>7</td>
<td>2.4E-5</td>
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</tbody>
</table>

**Misinterpret Procedure**

<table>
<thead>
<tr>
<th>Procedure mismatches</th>
<th>Workload (multitasking)</th>
<th>Training/Experience</th>
<th>Recovery potential</th>
<th>Crew failure scenarios</th>
<th>HEP</th>
</tr>
</thead>
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<td>1.6E-0</td>
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</table>
**Database for HRA**

- SACADA (Scenario Authoring, Characterization, and Debriefing Application)

- A human performance data collection system for operator simulator exercises to
  - Provide data support to HRA
  - Help identify the what's and how's to improve human performance

**A sample screenshot of SACADA**

**SACADA can be used for...**

- **Authoring:**
  - Design simulation scenarios

- **Characterizations:**
  - Characterize the human performance challenges of the tasks in the scenarios

- **Debriefing:**
  - Guide post-simulation performance evaluation and document the results
    - Include task performance results, performance deficiencies, causes of deficiencies, team error recovery, impact on scenario, remediation, and the corresponding INPO performance fundamental classification

- **Reporting:**
  - Post simulation reports, training cycle report, and annual reports
    - Output data for statistical analyses
    - Custom output, e.g., output for crew notebook

**Insights an HRA can provide**

- Operative narrative of imperfect, unexpected, and non-typical conditions that challenge human performance
- Identification of human actions that may lead to undesired or unsafe plant status
- Potential ways that crews may fail required actions
- Performance influencing factors that impact crew performance
- Likelihood of personnel performing the actions
Conclusions

- HRA is a meaningful tool supporting safety regulation – for imperfect, unexpected, or extreme conditions
- The outcomes and process of doing HRA provide systematic understanding of personnel performance
- HRA research and development incorporate lessons learned from events, crew performance simulation, operational data, and cognitive science.