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Operator Training and Human Factors in the EIOC

April 16, 2026

Corey Fallon

U.S. DEPARTMENT of ENERGY BATTELLE

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PNNL-SA-221561

Multidisciplinary Team

- **Eric Andersen**
  - Project Manager
  - PNNL
- **Corey Fallon**
  - Human Factors Team Lead
  - PNNL
- **Mike Cassiadoro**
  - Trainer
  - Total Reliability Solutions
- **Burhan Hyder**
  - Cyber-Physical Security Engineer
  - PNNL
- **Michelle Dowling**
  - Human Factors Researcher
  - PNNL

Improve Operational Efficiencies and Interactions Through Human Factors Studies and Training

- High Level Objective
  - Leverage the Electricity Infrastructure Operations Center (EIOC) to cultivate a highly skilled workforce adept at navigating the complexities of modern utility control room operations.
  - This work will also be leveraged to inform development of human factors design best practices.

- Focus on Training and Human Factors
  - Leverage the EIOC to deliver novel power systems operator training
  - Incorporate Human Factors methods and measures to enhance training
  - Incentivize utility participation by offering NERC Certification credit hours
  - Opportunity to apply human factors methods and measures in a simulated control room environment

Overview

- Previous Work
- Current Effort
- AI Literacy Training

Electricity Infrastructure Operations Center

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Previous Work

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Previous Work: Method

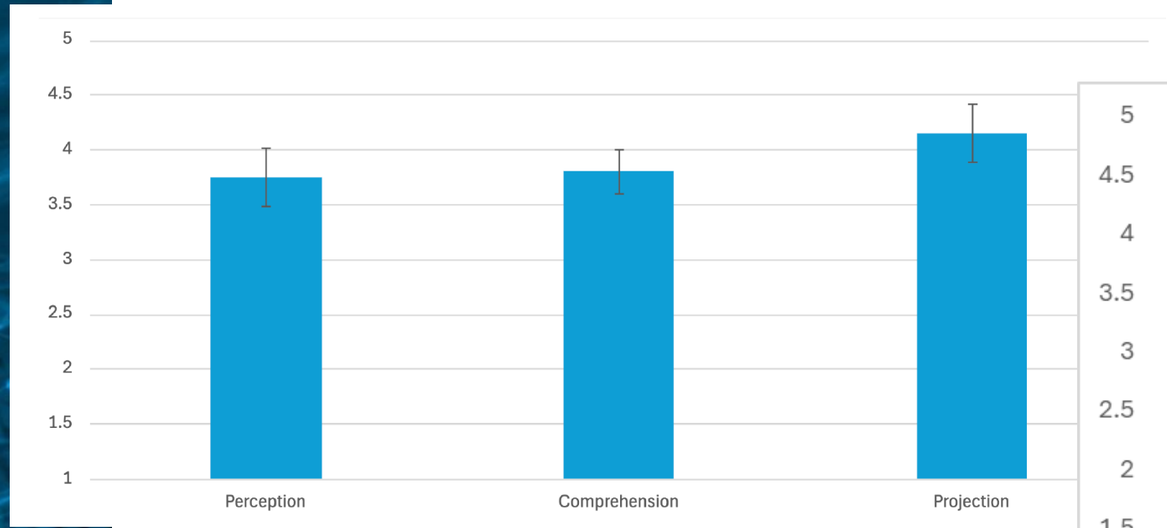
- Four utilities participated in our operator training
- Quantitative Assessment of Operator Situation Awareness
  - Periodically throughout simulation-based training the trainer asked the operators questions designed to assess their level of situation awareness

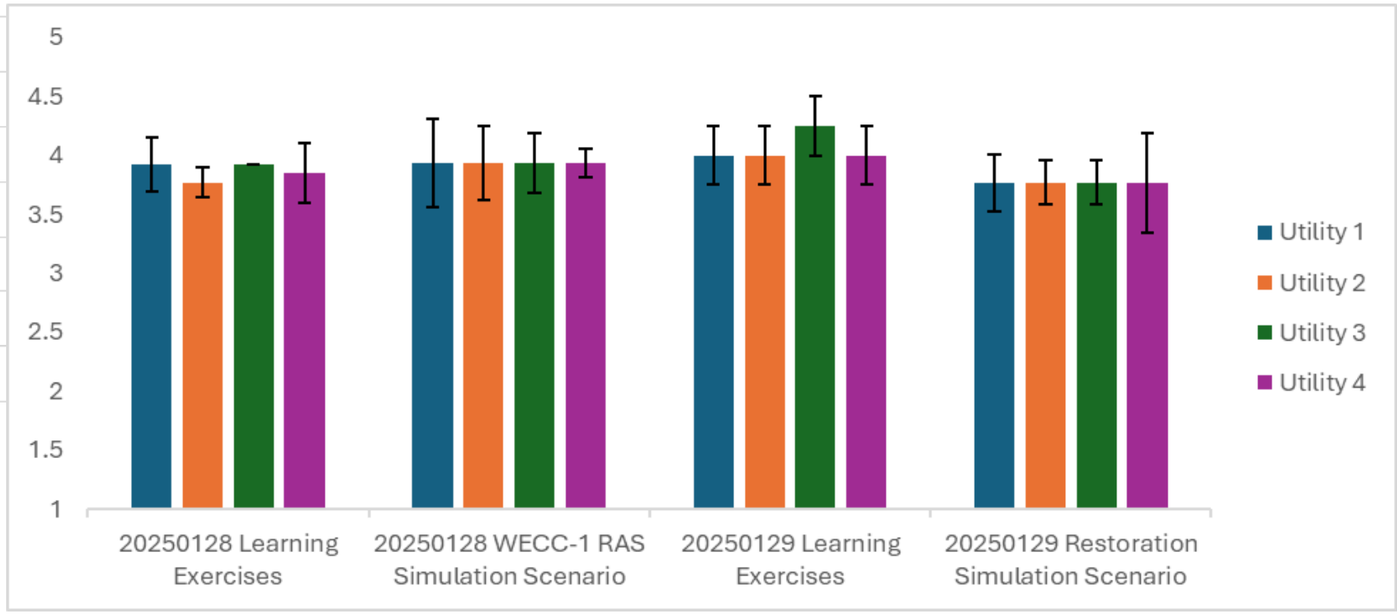
SA Level	Example Questions
Perception (Level 1)	What environmental elements changed and what key events occurred during the simulation?
Comprehension (Level 2)	How would you describe the current state of the power system? Please identify any critical issues that should be addressed in priority order.
Projection (Level 3)	Given the status of the WECC-1 RAS and prevailing system conditions, how do you expect RAS arming levels to change as the day progresses?

- Qualitative Assessment
  - Discussion between Trainer and Operators allowed for qualitative Analysis
  - Knowledge Elicitation

Previous Work: Findings

- Quantitative
  - Operator responses were rated by the trainer on a 5-point scale
    - ✓ 5 = Complete Situation Awareness
    - ✓ 1 = Incomplete Situation Awareness





Previous Work: Findings cont.

- Qualitative
  - Thematic Analysis

Theme	Description	Example
Perception	Describing the status of elements in the operational environment.	'Frequency is settled at 60.2 Hz'
Comprehension	Statements that reflect an integration of elements.	'All of the disconnects are open. That's not normal'
Projection	Prediction of the future status of elements.	'I don't expect them to trip, that is the whole point of a DC tie'
Operating Limits	Mentioning various operating limits that inform SA and strategy development	'We don't like our 230 to go above 241 kV'
Strategy	Descriptions of plans to address challenges with the current and/or future operational environment.	'Shedding load to stabilize is critical to do initially but we need to bring up generation as well.'
Contingency	Consideration of factors that will affect strategy.	'I can do it on my own but if I can get a line from Bonneville that would be a quicker restoration effort.'

- Situation Awareness alone did not capture the full extent of their thought processes
  - Operators were action oriented
  - Situation Awareness → Strategy
- Alarm management challenge
  - Rotating stations exacerbates challenge
  - Mitigations
    - ✓ Uniform terminology
    - ✓ Link help files to alarms

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Current Work

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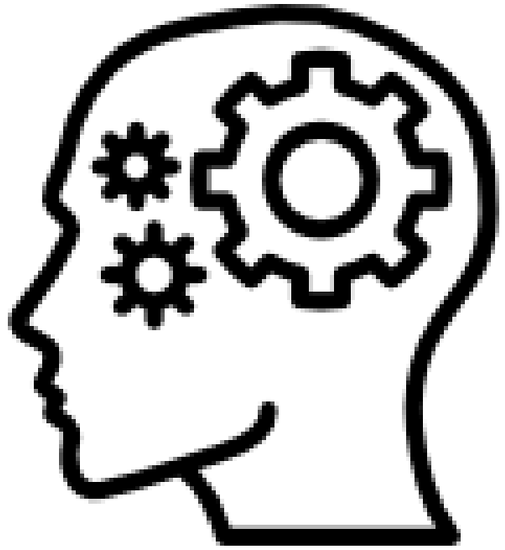
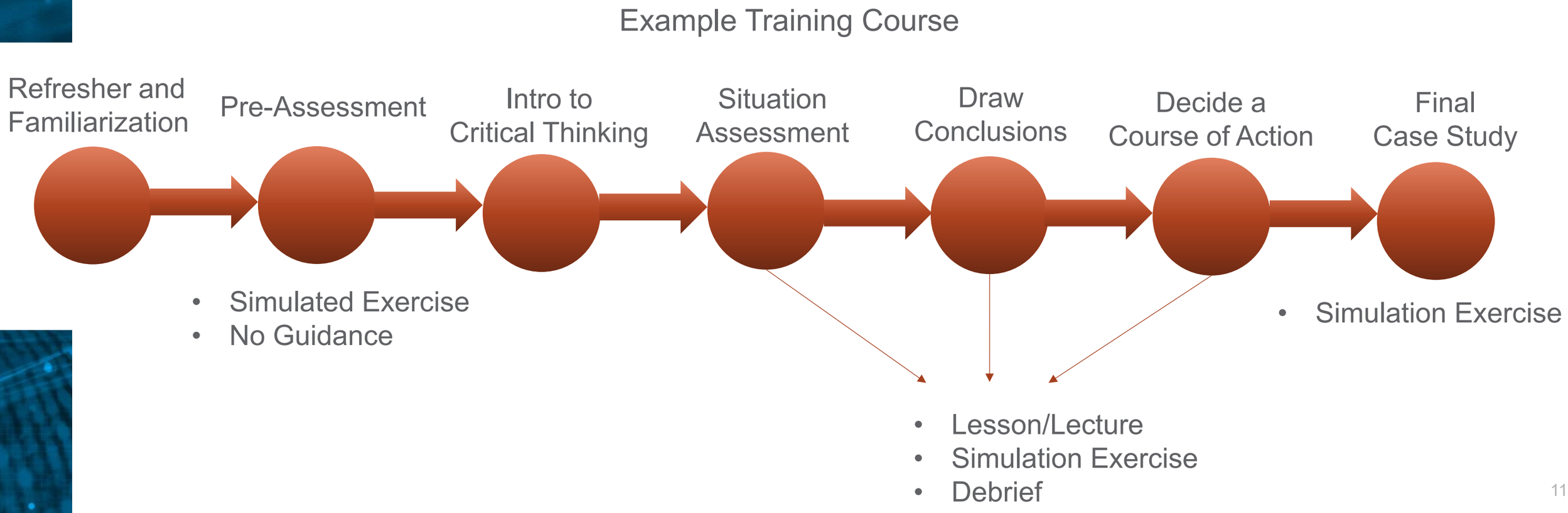
Operator Critical Thinking Training

- Operators will be trained in various critical thinking techniques
- Simulation based exercise employed to evaluate training effectiveness
  - Similar mix of Quantitative and Qualitative Assessment
  - Plan to incorporate interaction logging assessment

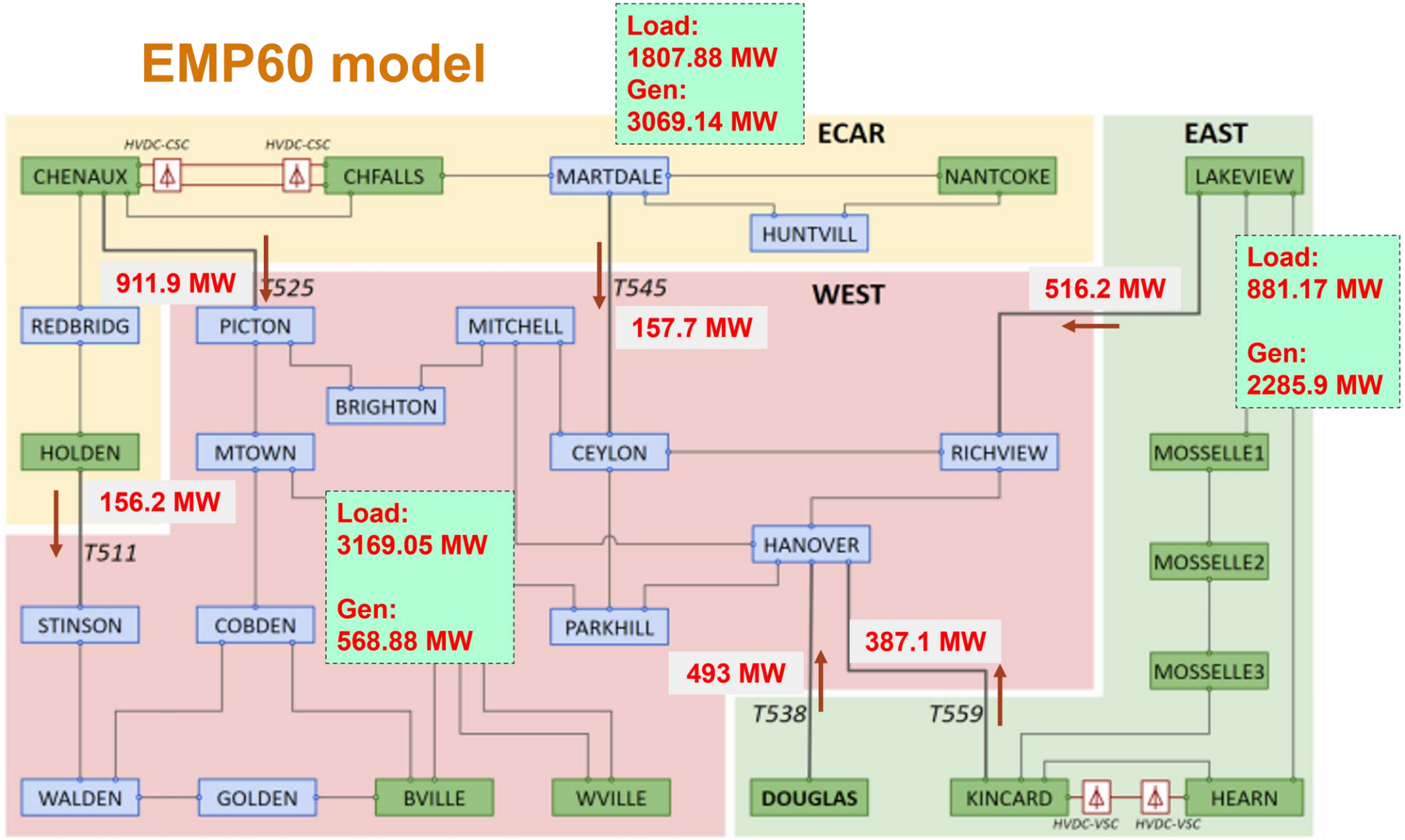


Critical Thinking Training Course

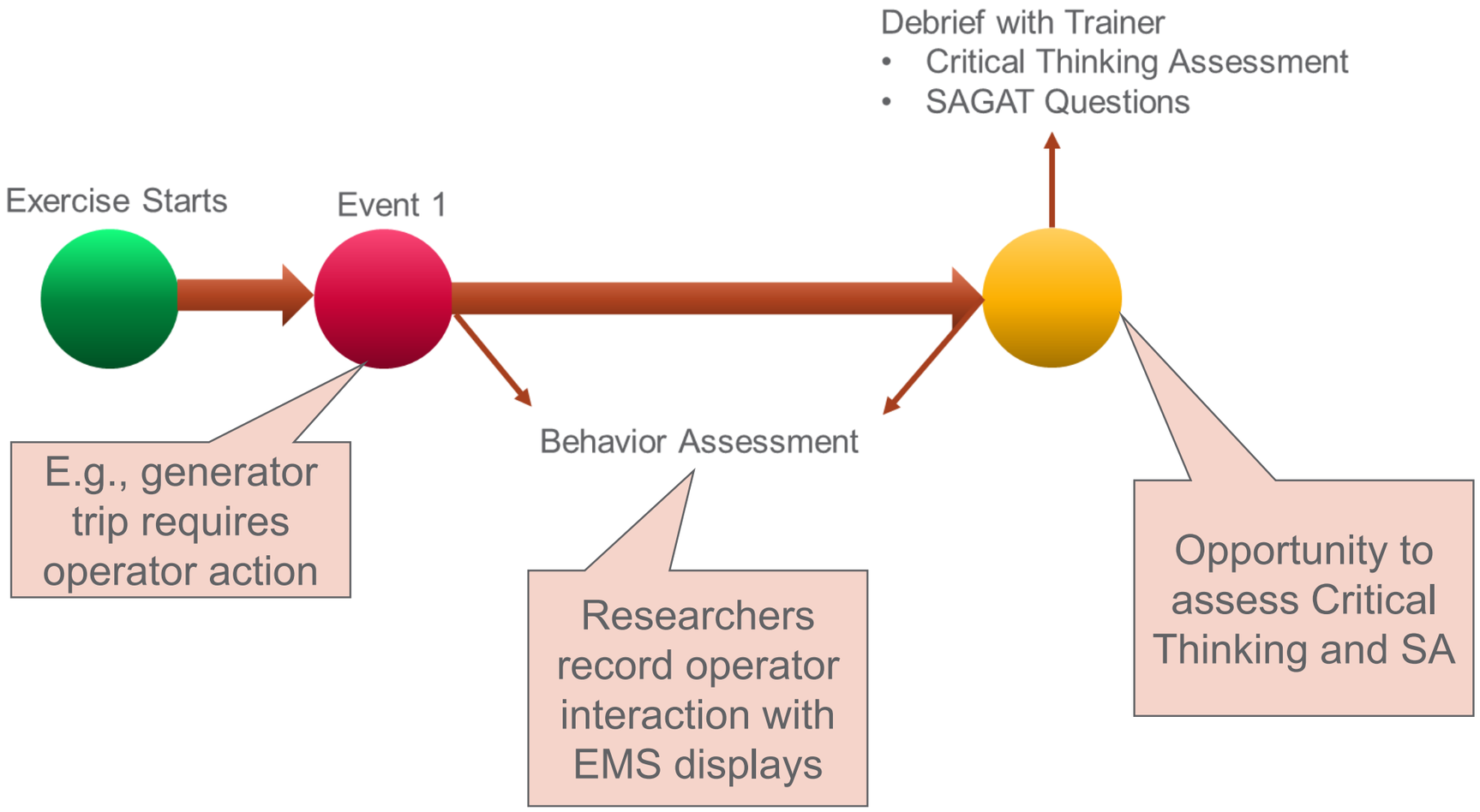
- Multiple operators
- 12 hours of training



Simulation Exercise: One-Line Diagram



Simulation Exercise: Measures



Critical Thinking Assessment

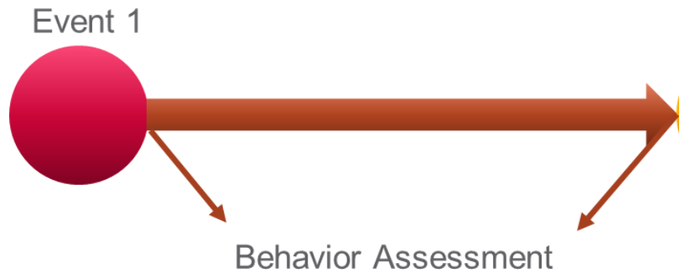
- How operators. . .
  - process information to build SA
  - decide on the correct course of action
- Training course is designed to teach critical thinking techniques
- Critical Thinking measures provide a direct assessment of whether trainees learned various techniques taught in the course.

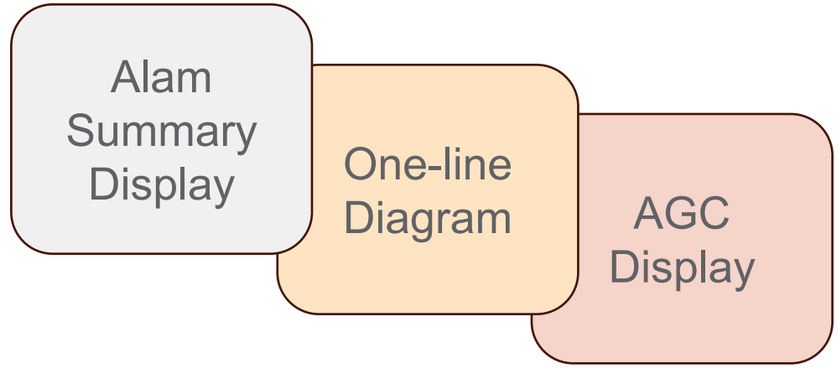
Critical Thinking Assessment examples

- Identify Information
  - Was all of the relevant information identified in the moments following the event?
- Inductive Reasoning
  - Was the correct conclusion drawn from the available evidence?
- Identifying Assumptions
  - Was the operator able to accurately identify the underlying assumptions that led to their conclusions?

Operator Behavior Assessment

- Order of displays accessed post event
  - How does the operator build SA?
  - Which operating characteristics are most important to the operator for handling the event?
    - ✓ Generation output
    - ✓ Voltage
    - ✓ Power flow
    - ✓ Equipment
  - How does the operator's order compare to the optimal workflow
    - ✓ Are there gaps in the workflow?
    - ✓ Are there extra unnecessary steps in the workflow?





Operator Behavior Assessment continued

- Order of displays accessed post event
  - How does the operator's Observed Course of Action (O) compare to the optimal baseline (B)?
    - ✓ True Positives (TP) = Number of steps that appear in both O and B
    - ✓ False Positives (FP) = Number of extra steps in O that are not in B
    - ✓ False Negative (FN) = Number of missing steps in O that are in B
  - Content accuracy = $\frac{TP}{TP+FP+FN}$
  - Order accuracy = $\frac{L}{K}$
    - ✓ K = Number of steps in common between O and B
    - ✓ L = Longest common subsequence between O and B

Training Evaluation and Standards Development

- Evaluate training based on operator situation, awareness and behavior
- Operator-tool interaction data leveraged to inform development of human factors design best practices

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AI Literacy Training

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AI Literacy Training

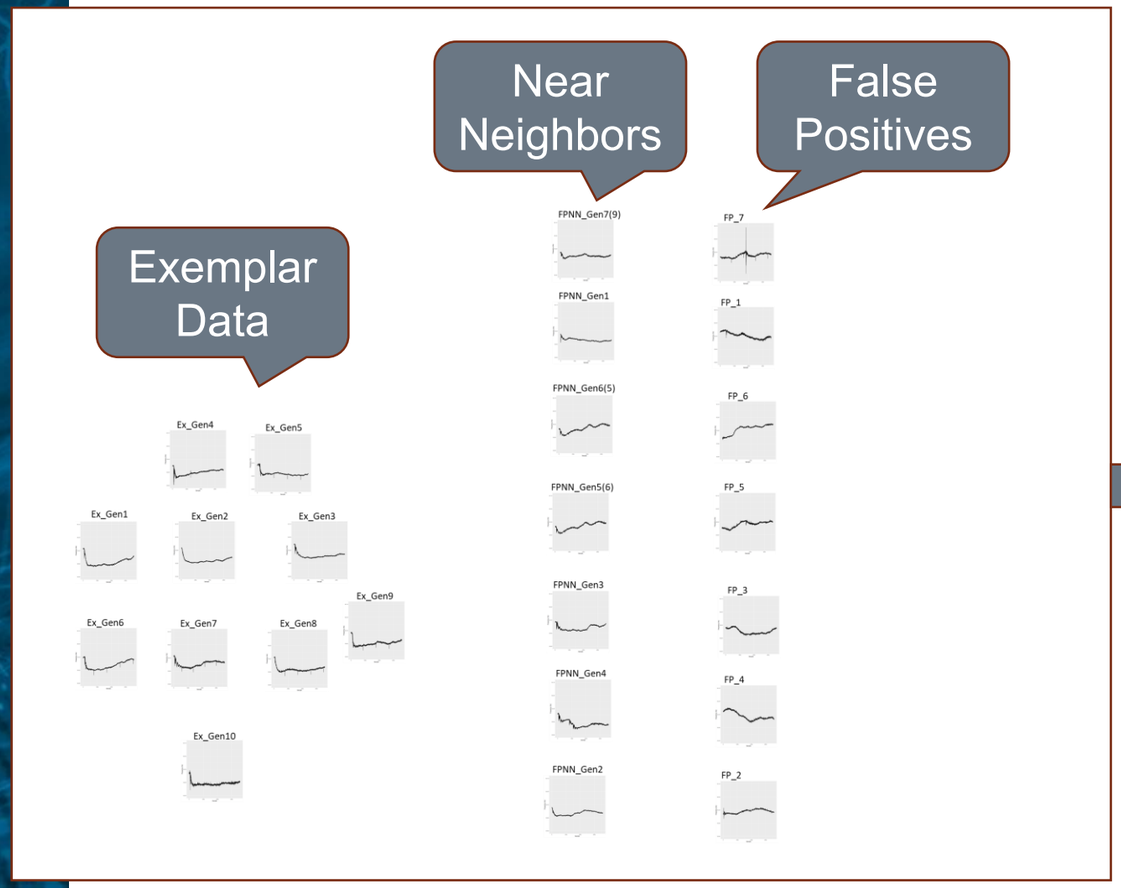
- Training designed to communicate the risks and benefits of AI on a level that a non-technical professional can understand

- Example Training Module Topics
  - AI Fundamentals and Definitions
  - Evaluating AI Performance
  - Evaluating Data Quality
  - Evaluating Model Robustness

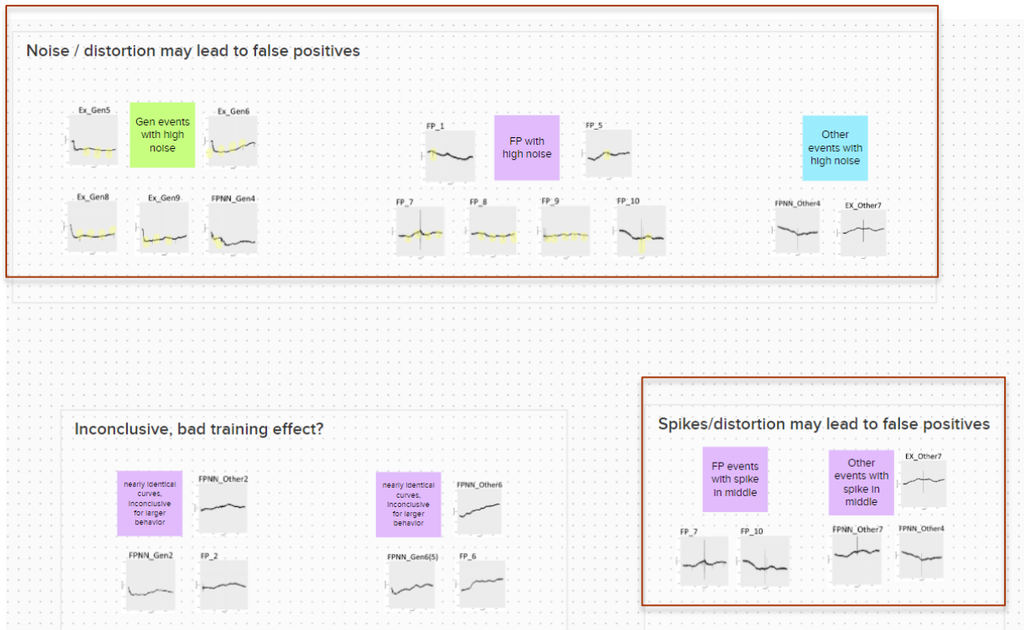
- Training can be tool specific or tool agnostic

AI Literacy Training: Tool Specific Example

Study a Subset of ML Training Data



Contrast, sort and annotate the characteristics of correct and incorrectly classified data to learn model performance



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Thank you