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Insights from Pilot Testing of the IDHEAS HRA Method

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Study Goal and Background

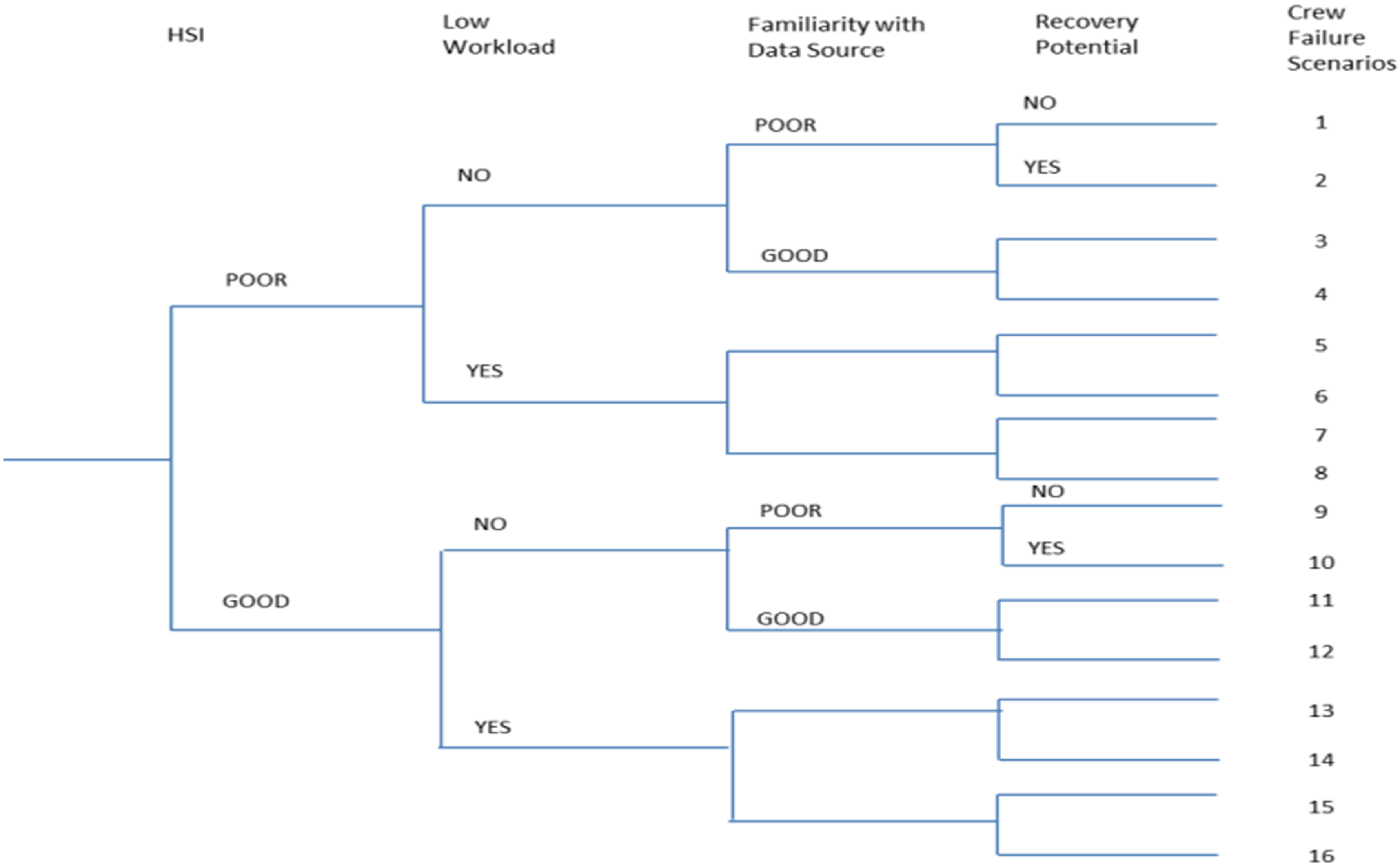
- Study goal
  - Pilot testing of a new HRA method – the IntegrateD Human Event Analysis System (IDHEAS)
- Human reliability analysis (HRA)
  - Used in the context of probabilistic risk assessment (PRA)
  - Use of systems engineering and behavioral science methods to render a description of the human contribution to risk
  - Challenge: variability in HRA results
    - Different assumptions, human performance models, data, method implementation, etc.

IDHEAS

- Motivation
  - To reduce unnecessary and inappropriate variability
- Cause-based quantification model
  - 14 crew failure modes (CFMs)
  - One decision tree (DT) for each CFM
- Strengths
  - Strong theoretical basis in cognitive psychology
  - Good features of existing HRA methods
  - Ability to address errors of commission

<table>
<tr><th>Phase of response</th><th>Plant status assessment</th><th>Response planning</th><th>Execution</th></tr>
<tr><td rowspan="9">Crew failure mode (CFM)</td><td>Key alarm not attended to</td><td>Delay implementation</td><td>Fail to iniate execution</td></tr>
<tr><td>Data misleading or not available</td><td>Misinterpret procedure</td><td>Fail to execute response correctly</td></tr>
<tr><td>Premature termination of critical data collection</td><td>Choose inappropriate strategy</td><td></td></tr>
<tr><td>Critical data misperceived</td><td></td><td></td></tr>
<tr><td>Wrong data source attended to</td><td></td><td></td></tr>
<tr><td>Critical data not checked with appropriate frequency</td><td></td><td></td></tr>
<tr><td>Critical data dismissed/discounted</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Misread or skip step in procedure</td></tr>
<tr><td colspan="3">Critical data miscommunicated</td></tr>
</table>

Wrong Data Source Attended To



IDHEAS Analysis Process

- HFE identification and definition
- Feasibility assessment
- Characterization of the expected success path
- Identification of critical tasks and construction of crew response tree (CRT)
- Development of timeline and operational narrative
- Identification of recovery opportunities
- CFM evaluation and HEP calculation
- Model integration

Testing Scenarios

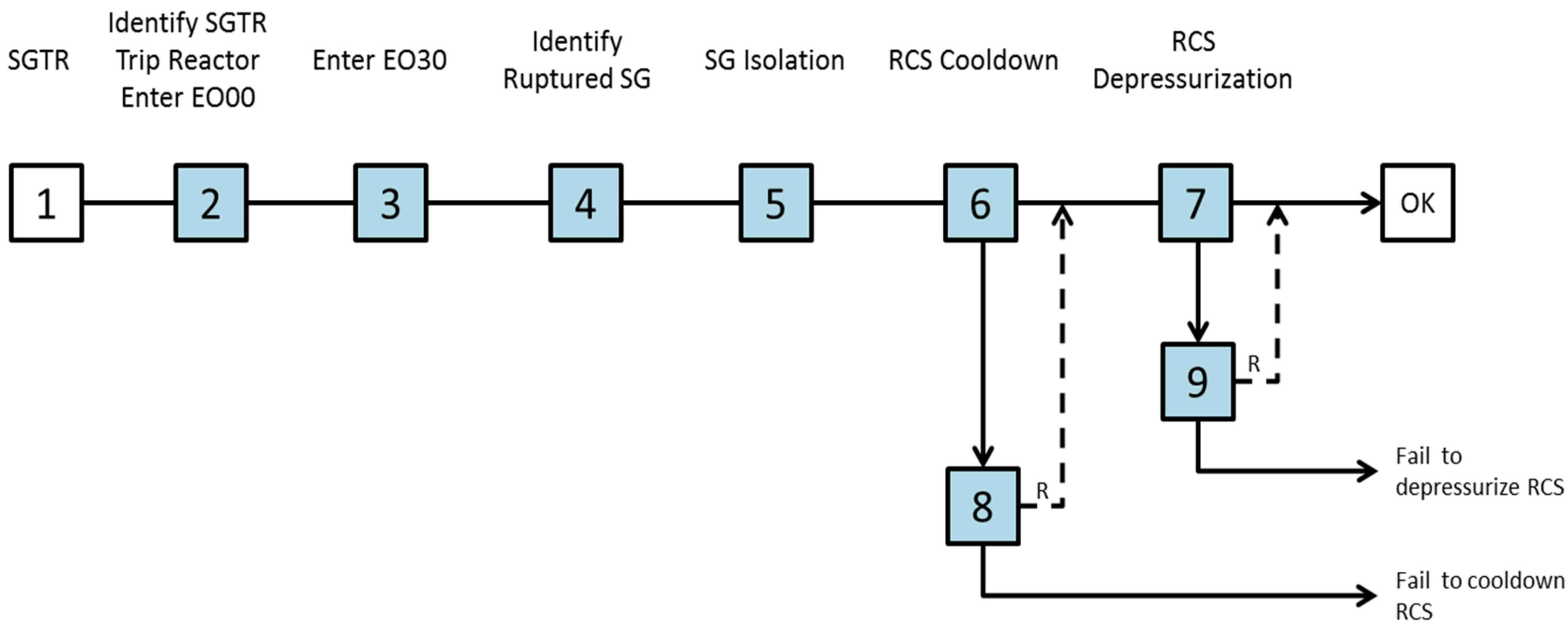
- Total loss of feedwater (LOFW) followed by steam generator tube rupture (SGTR)
- Loss of component cooling water (CCW) and reactor coolant pump (RCP) seal water
- Steam generator tube rupture (SGTR)

Testing Scenarios

- The US HRA Empirical Study

Scenario	HFE
Loss of feedwater (LOFW) followed by steam generator tube rupture (SGTR)	1A, 1B, 1C
Loss of component cooling water (CCW) & reactor coolant pump (RCP) seal water	2A
Standard SGTR	3A

Testing Results of Scenario 3 (1/2)



Testing Results of Scenario 3 (2/2)

CRT node	Crew failure modes	Scenario #
2	Key alarm not attended to	7
3	Misread or skip critical step(s) in procedure	13
4	Fail to execute simple response correctly	15
	Misread or skip critical step(s) in procedure	13
5	Fail to execute complex response correctly	15
	Misread or skip critical step(s) in procedure	13
	Critical data not checked with appropirate frequency	11
6	Fail to execute complex response correctly	15
	Misread or skip critical step(s) in procedure	14
	Critical data not checked with appropirate frequency	11
7	Fail to execute complex response correctly	15
	Misread or skip critical step(s) in procedure	14
	Critical data not checked with appropirate frequency	11

Study Insights

- Strengths
  - Structured qualitative analysis framework
    - CRT – graphical tool to communicate, illustrate, and document qualitative analysis results
  - Consideration of cognitive activities
    - Theoretical foundation in cognition
    - Human failure addressed at the level of underlying cognitive mechanisms
    - Causal relationships between human performance and contextual factors
    - Framework to incorporate contextual factors into quantification process – reduced reliance on analyst experience
  - Development of detailed timelines and operational narratives to treat complexity
    - Understanding of HFEs is developed explicitly in the analysis process
    - Scenario-specific timing and performance issues can be effectively identified

Study Insights (Cont'd)

- Strengths
  - Formal self-consistent quantification approach
    - Use of CFMs and DTs ensures that HEPs are assessed in a well-defined and self-consistent manner.
    - Guidance on DT branch selection – reduced analyst judgment
  - Traceability
    - Use of CRT
    - DT – link between quantification inputs and HEPs
    - Somewhat dependent on documentation
  - Insights for error reduction
    - Cognitive failure mechanisms
    - Plant- and scenario-specific performance issues

Study Insights (Cont'd)

- Weaknesses
  - Fairly extensive resources needed for detailed qualitative analysis
  - Judgment in PIF level evaluation
    - Guidance on DT branch selection involve subjective description
  - Sensitivity of binary DTs
    - Abrupt change in HEPs
    - Unrealistic or simplistic representation of the real world
  - Inadequate guidance for task analysis and CRT construction
    - Task decomposition and identification of critical tasks

Thanks!

Questions and Comments?

Scenarios and HFEs (1/2)

- LOFW followed by SGTR
  - Mis-positioned recirc valve with no indication in the control room
  - Indicated flow from AFW pump on the HSIs masked the fact that no water at all was going to the steam generators
  - HFE 1A: Failure to establish bleed and feed (B&F) within 45 minutes of the reactor trip, given that the crew initiates a manual reactor trip before an automatic reactor trip.
  - HFE 1B: Failure to establish B&F within 13 minutes of the reactor trip, given that the crew does not manually trip the reactor before an automatic reactor trip occurs.
  - HFE 1C: Failure to isolate the ruptured SG and control pressure below the SG PORV setpoint to avoid SG PORV opening. The time window to perform the required actions is estimated to be approximately 40 minutes.

Scenarios and HFEs (2/2)

- Loss of Component Cooling Water (CCW) and Reactor Coolant Pump (RCP) Sealwater
  - Failing distribution panel increased the complexity and masked the status indications
  - Very short time windows
  - HFE 2A: Failure to trip the RCPs and start the Positive Displacement Pump (PDP) to prevent RCP seal LOCA.
- SGTR
  - HFE 3A: Failure to isolate the ruptured SG and control pressure below the SG PORV setpoint before SG PORV opening. The time window to perform the required actions is estimated to be 2 to 3 hours.