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Testing the Internal At-Power Application of the IDHEAS HRA Method

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Study Objectives

- Evaluate whether IDHEAS AT-POWER can be practically applied to produce consistent and reasonable HRA results before its deployment.

- Identify strengths and weaknesses of the IDHEAS AT-POWER method to inform future developmental activities

IDHEAS AT-POWER Overview

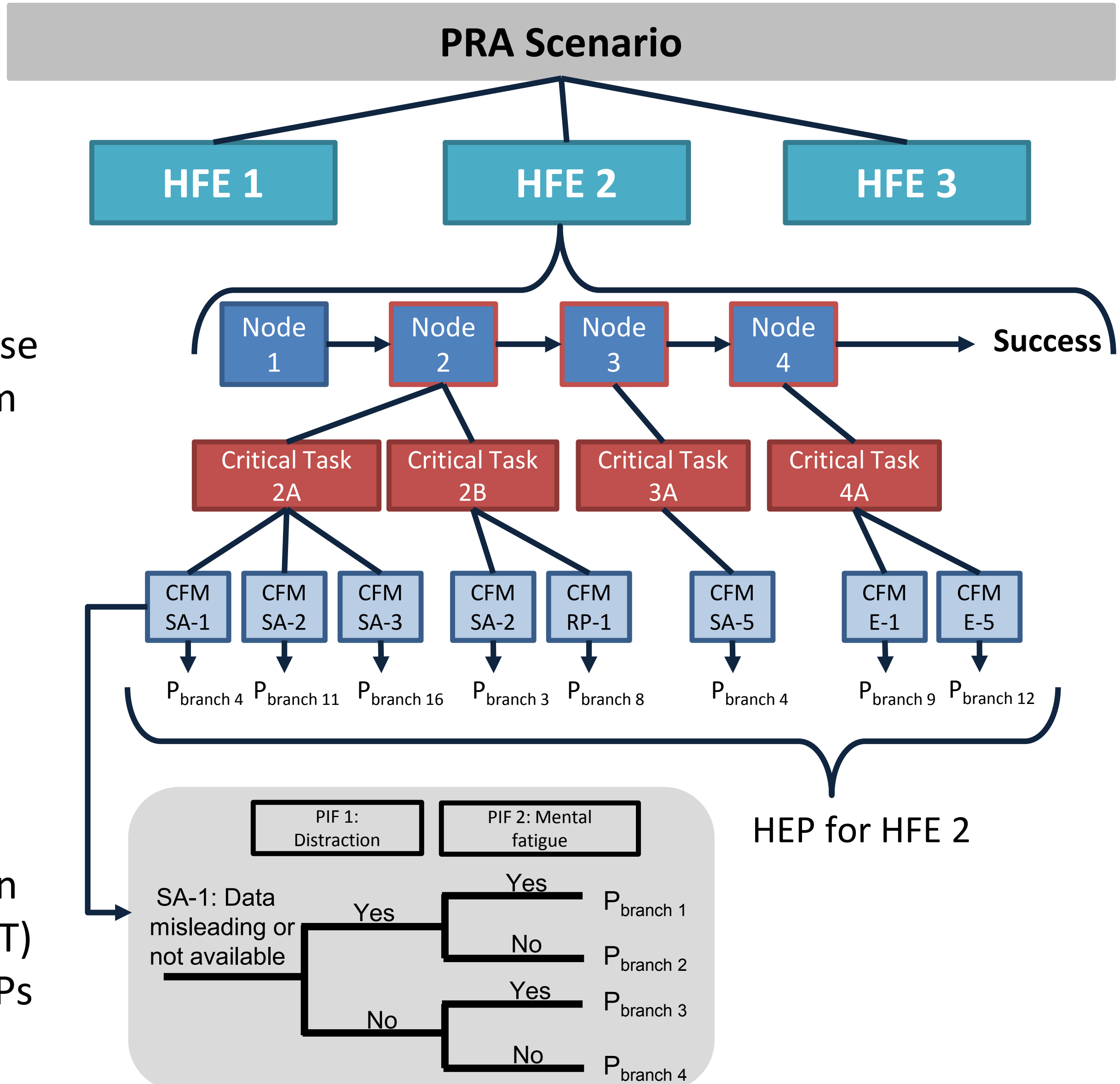
- Understand Scenario
- Identify and Define HFEs
- Task Analysis and Develop CRD
- Identify CFMs for Each Critical Task
- Determine Decision Tree Paths for CFMs and Compute HEPs
- Model Integration

HFEs

Crew Response Diagram (CRD)

Crew Failure Modes (CFM)

Decision Tree (DT) and HEPs



Scope of Testing

- The teams were provided with a description of a PRA scenario and the HFE(s) to be analyzed
- Testing focused on:
  - Task analysis and development of CRDs
  - Identification of CFMs for critical tasks
  - Assessment of PIFs (choice of DT path)
- Time reliability analysis, model integration and dependency were not tested

Study Methodology Overview (1/2)

- Study design
  - Testing scenario and human failure events (HFEs)
  - Testing criteria
  - Information package (CFM DTs w/o HEP values)
  - Four testing teams of 2-3 analysts
- Training workshop
  - Training on method and brief on scenarios
  - Initial interview with designated operator
- HFE analysis
  - Worked in teams over 3 month period
  - Telephone interview with designated operator
  - Sent follow-up questions as needed

Study Methodology Overview (2/2)

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- Analysis output
  - Used template to document results
  - Post-analysis questionnaire
  - Expected HEPs
- Reasonableness check
  - HEPs calculated by project team provided to testing teams
  - Teams given opportunity to revise analysis but none chose to
  - Initial interview with designated operator
- Evaluation workshop
  - Reviewed each team’s analysis
  - Provided feedback on experience using the method

Testing Scenarios and HFEs

- Uncomplicated Steam Generator Tube Rupture
  - **HFE 1:** Failure to isolate the ruptured steam generator and control pressure below the SG PORV setpoint before SG PORV opening
- Loss of Feedwater with Misleading AFW Flow Indicator
  - **HFE 2:** Failure to establish B&F within 45 minutes of the reactor trip, given that the crews initiate a manual reactor trip before an automatic reactor trip
- Electrical Fire resulting in Loss of RCP Seal Cooling and Delayed Seal Injection
  - **HFE 3:** Failure to restore CCW to the RCP thermal barrier heat exchangers by re-opening FCV-626
  - **HFE 4:** Failure to trip the RCPs during a loss of all seal cooling and injection
  - **HFE 5:** Failure to depressurize the RCS during a small loss of coolant accident (SLOCA)

Predicted vs. Expected HEPs

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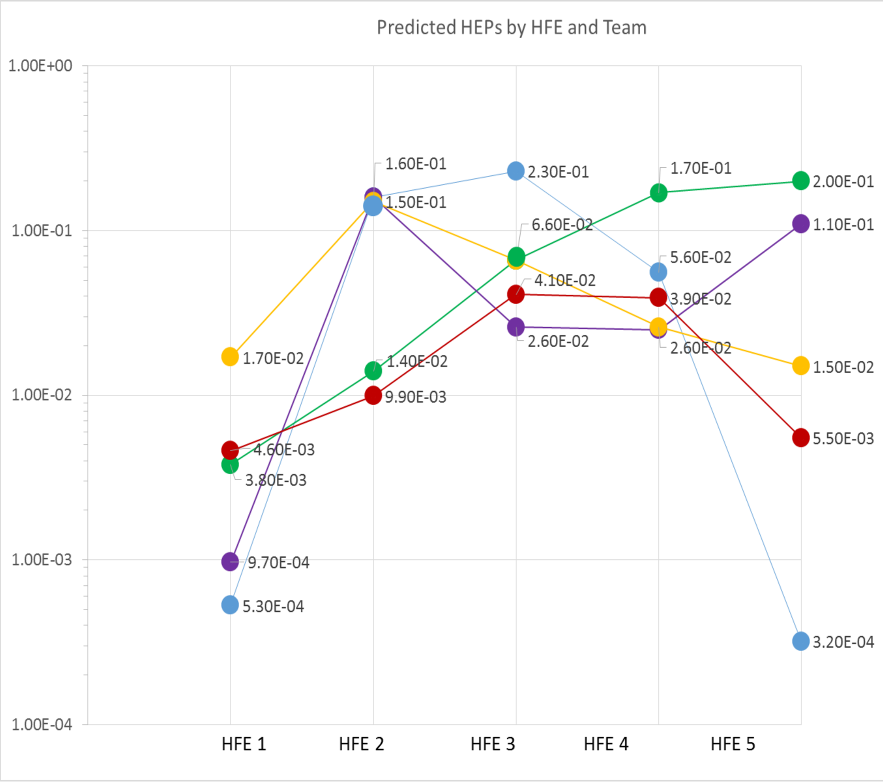
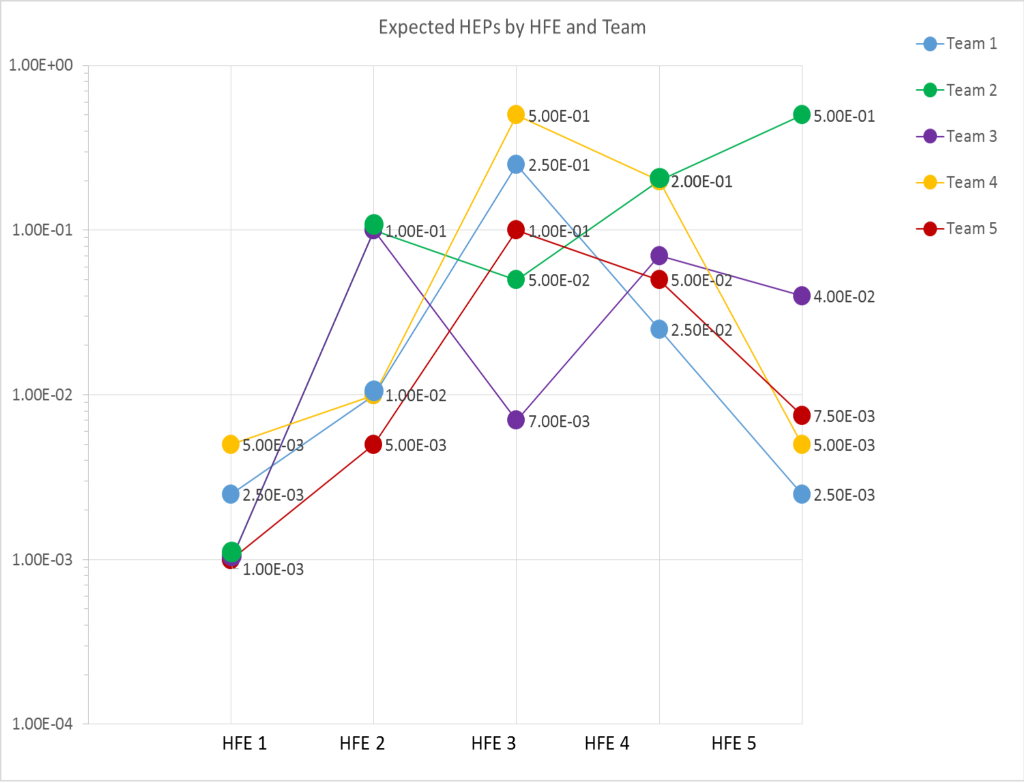
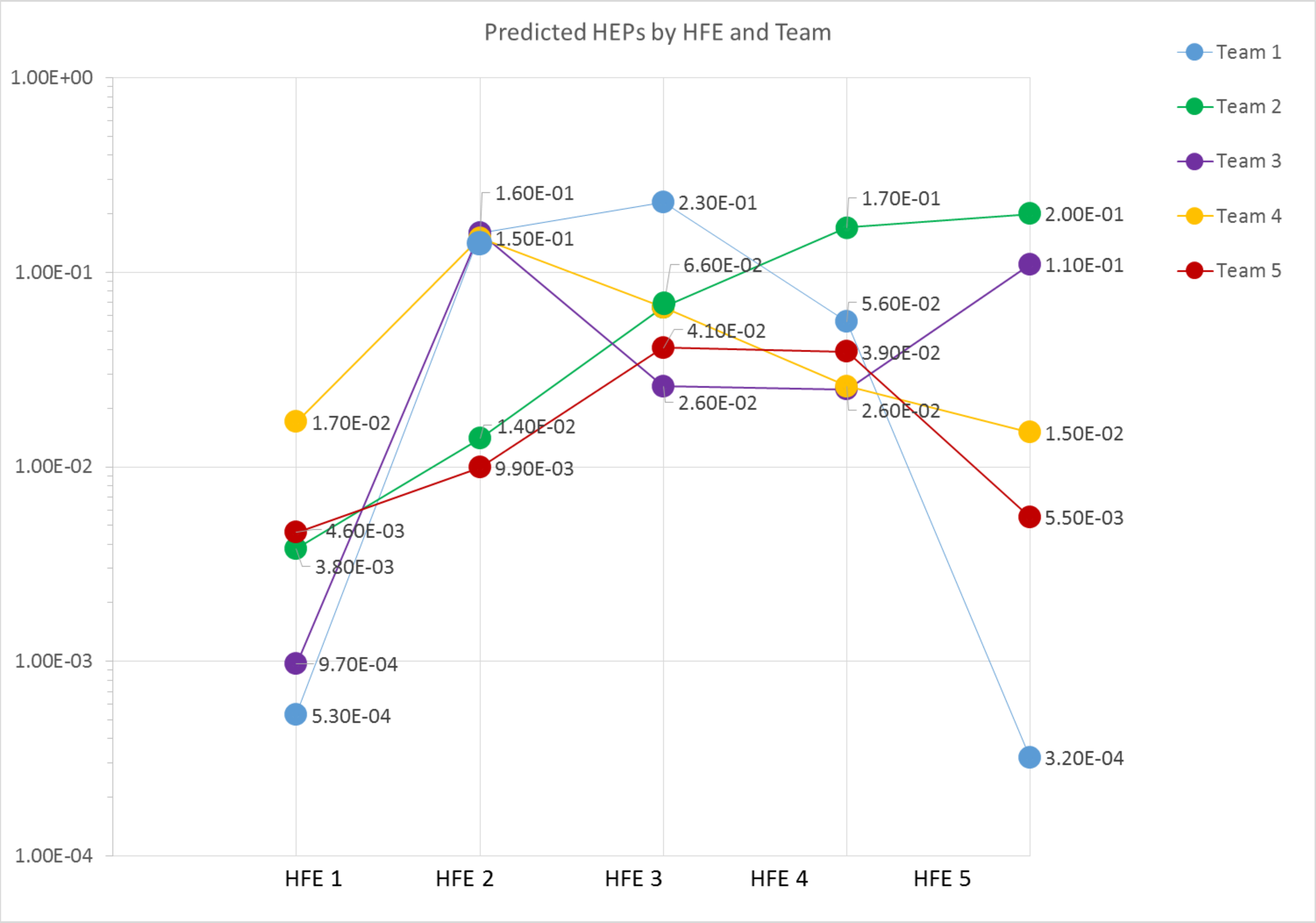
Predicted HEPs



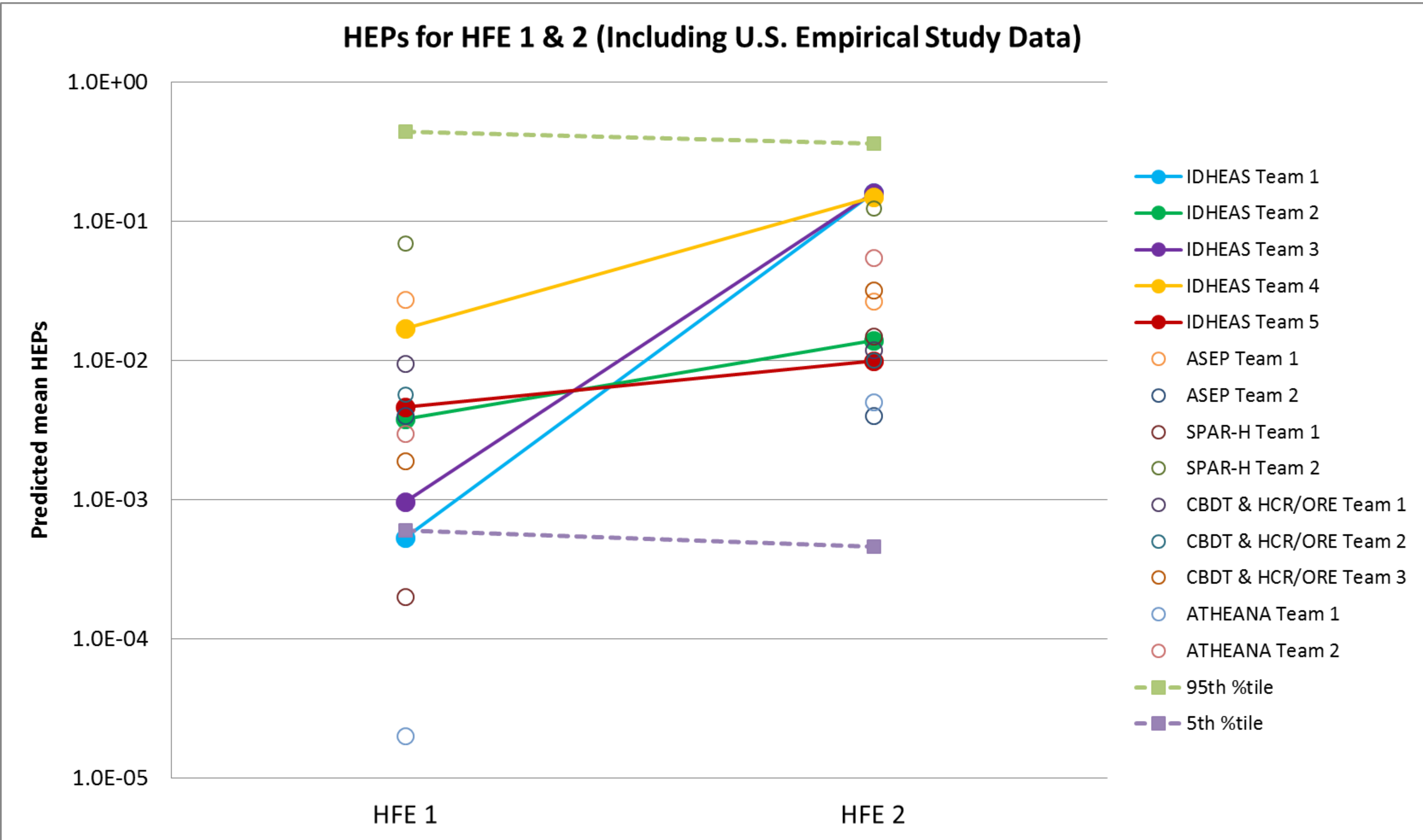
Expected HEPs



Predicted HEPs



Comparison to US Empirical Study



Observations from the Quantitative Results

- Variability observed in both expected and predicted HEPs
- Correlation between expected and predicted HEPs
- No team was consistently conservative or optimistic
- Differentiation across HFEs varied across teams
- Predicted HEPs converged with results from the US Empirical Study

Observations from the Qualitative Analysis

- Predicted procedural paths and performance drivers converged with simulator data for HFEs 1 and 2
- More variability for HFEs 3 and 4
  - Procedural paths were not well defined
  - Analysts were not familiar with the scenarios
- Identification of critical tasks
- Modelling of execution tasks
- Modelling of recovery

Preliminary Evaluation Summary (1/2)

- All teams generally applied the method as intended and were able to produce reasonable results
- Validity
  - Results of HFEs 1 and 2 converge with the US Study
  - Most predicted HEPs comparable to expected HEPs
  - No team produced consistently optimistic or conservative HEPs
  - Ability to capture a broad range of failure modes, contextual conditions, and influences
- Inter-analyst consistency
  - Variability in procedural path, critical task identification, task decomposition, recovery modelling, CFM and PIF assessment
  - Caused by judgment in addressing scenario complexity and uncertainty, unclear guidance or misinterpretation of guidance

Preliminary Evaluation Summary (2/2)

- Traceability
  - Clear link between qualitative analysis and quantitative results
  - Easy to identify differences in results
  - Dependent on quality of documentation
- Usability
  - Not easy to learn and resource intensive to use
  - Significant operations input
  - 2x the amount of time of other HRA methods currently in use
  - May improve with experience and use of computerized software tool
- Utility
  - Thorough and defendable analysis
  - CFMs help analysts think broadly about possible failures

Additional Observations

- Sensitivity of binary decision trees
- Subjective judgment in method application
  - Interpretation of unclear procedural directives
  - Interpretation of guidance for CFM selection and PIF assessment
- Treatment of execution
  - Holistic treatment of execution
  - Two generic categories: simple and complex

Thanks!

Questions and Comments?