Final Conclusions and Lessons Learned from Testing the Integrated Human Event Analysis System for Nuclear Power Plant Internal Events At-Power Application (IDHEAS AT-POWER)

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Probabilistic Safety Assessment and Analysis Conference (PSA 2017)
September 24-28, 2017, Pittsburgh, PA

Sandia National Laboratories

U.S.NRC United States Nuclear Regulatory Commission *Protecting People and the Environment*

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Study Objectives

- Evaluate whether IDHEAS AT-POWER can be practically applied to produce consistent and reasonable human reliability analysis (HRA) results.
- Identify strengths and weaknesses of the IDHEAS AT-POWER method to inform future developmental activities.

IDHEAS AT-POWER Overview

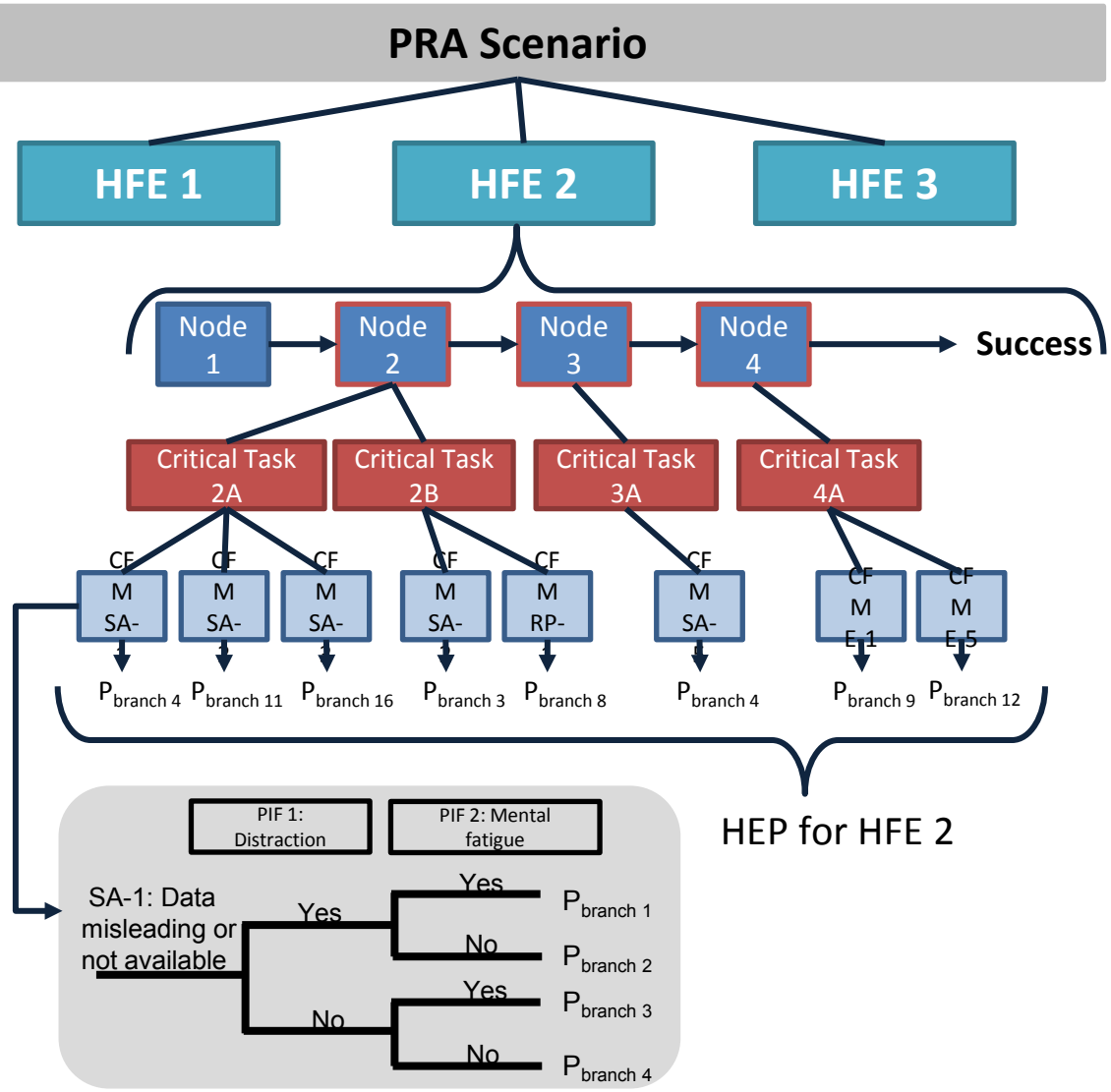
- Understand Scenario
- Identify and Define HFEs
- Task Analysis and Develop CRD
- Identify CFMs for Each Critical Task
- Determine Decision Tree Paths for CFMs and Compute HEPs
- Model Integration

HFEs

Crew Response Diagram (CRD)

Crew Failure Modes (CFM)

Decision Tree (DT) and HEPs



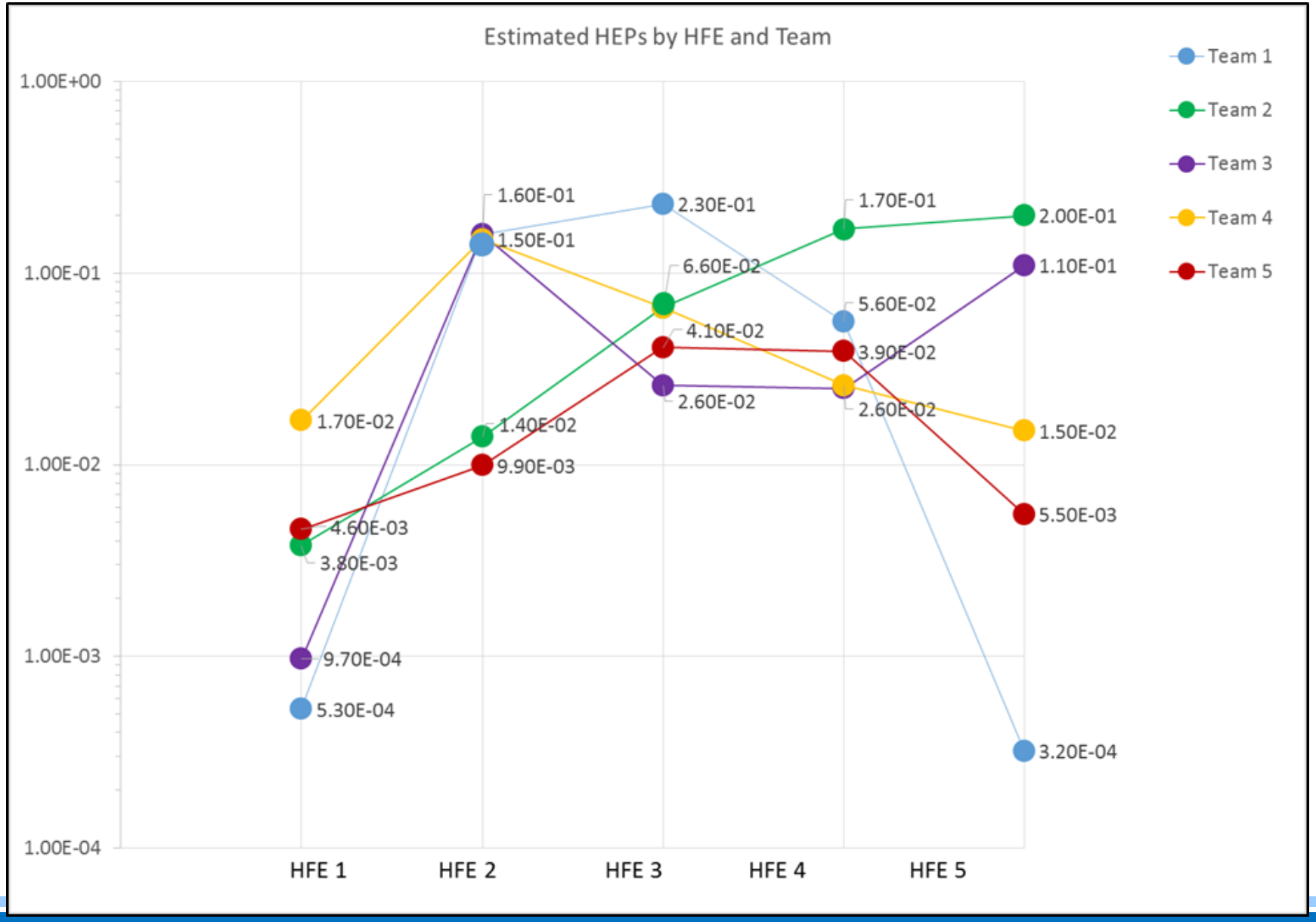
Study Scope and Design

- Testing focused on:
  - Task analysis and development of crew response diagrams (CRDs)
  - Identification of crew failure modes (CFMs) for critical tasks
  - Assessment of performance influencing factors (PIFs) using decision trees
- Time reliability analysis, model integration and dependency were not tested
- Four testing teams of 2-3 analysts & the project team
- Testing criteria (validity, traceability, consistency, usability, utility)

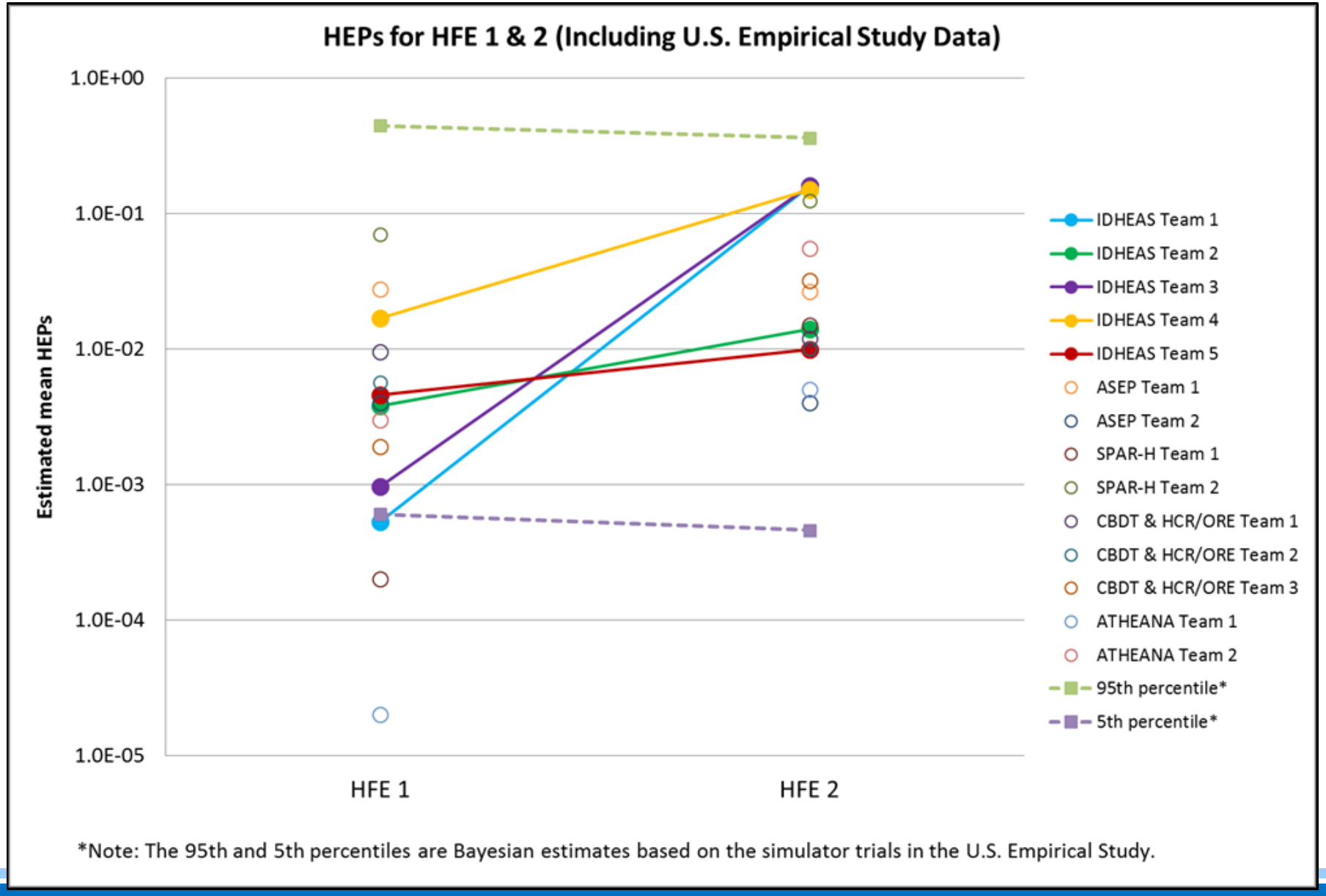
Testing Scenarios and HFEs

- 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)

Estimated HEPs using IDHEAS AT-POWER



Comparison to US Empirical Study



*Note: The 95th and 5th percentiles are Bayesian estimates based on the simulator trials in the U.S. 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
  - Plant procedures did not indicate clear path to achieve the operator response in the HFE
  - Analysts were not familiar with the scenarios
- Identification of critical tasks
- Modelling of execution tasks
- Modelling of recovery

Evaluation Summary

- Validity
  - All teams were able to use the method to produce reasonable results
  - Results of HFE 1 and 2 converge with the US Study
- Inter-analyst Consistency
  - Variability observed in crew response diagram construction, assessment of crew failure modes and performance influencing factors
  - Scenario uncertainty increased variability
- Traceability
  - Easy to identify differences in analysis results
  - Dependent on quality of documentation

Evaluation Summary cont.

- Usability
  - Resource intensive due to documentation and need for specific operational input
  - May improve with more experience and use of computerized software tool
- Utility
  - Thorough and defendable analysis
  - Crew failure modes help analysts think broadly about possible failures

Lessons Learned

- Selection of testing scenarios and definition of HFEs
  - Difficulty levels between HFEs were not pre-defined, could not reach consensus on difficulty rankings for HFEs
  - Detailed task analysis for HFE 3 complicated by inadequacy of plant procedure leading to no clear procedural path
- Impact of analyst team differences on testing results
  - Teams with less PRA experience found it more difficult to understand scenario dynamics.
  - Level of operations knowledge within HRA team affected ability to construct crew response diagram, determine timing, procedural paths, etc.
  - Between-team differences in understanding of method, frequency of referencing method guidance.

Recommendations for Training and Guidance Improvement

- Improve consistency in defining crew response diagram nodes and critical tasks
- Emphasize holistic modeling of execution tasks
- Minimize ambiguity in crew failure mode scope and applicability
- Improve consistency in performance influencing factor assessment

Recommendations for Future Method Development

- Develop supplementary crew failure modes (e.g., control actions, forensic “look back” activities)
- Evaluate decision tree failure probabilities
- Expand treatment of execution tasks

Project Status

- Draft report currently under review at the NRC
- Expected to be published as an NRC report in early 2018 (NUREG-2199, vol. 3)
  - NUREG-2199, vol. 1 is the IDHEAS AT-POWER method

Thanks!

Questions and Comments?

Testing Process