

# Overview and Preliminary Results of the U.S. Empirical HRA Study

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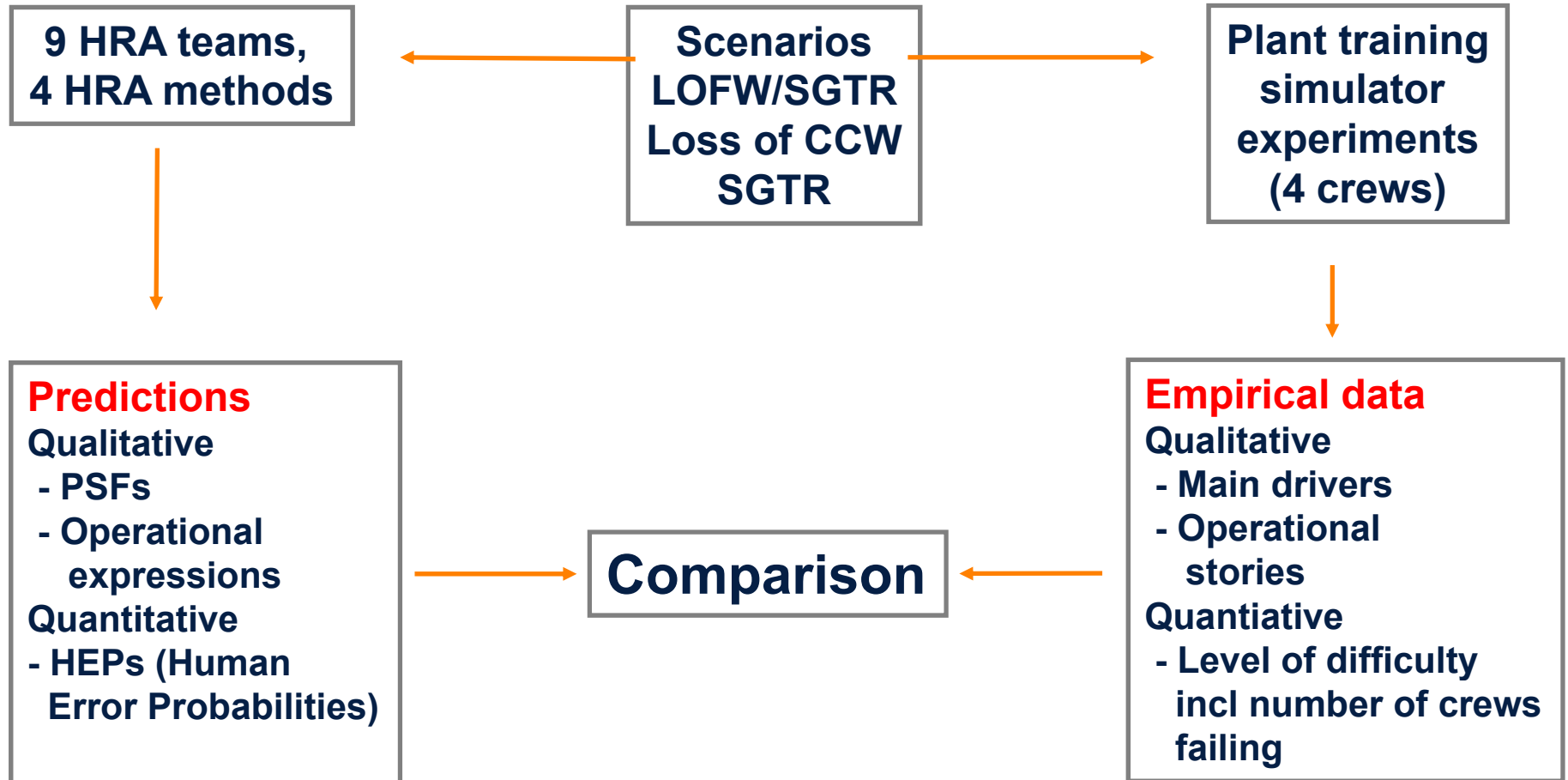


# Objectives of U.S. HRA Empirical Study

- Follow-up study on strengths and weaknesses of HRA methods from International Study
- Method effects vs analyst effects?
  - Several HRA teams per method
- Effect of information to HRA teams?
  - Plant visit, observations and interview
- Similar results for U.S. crews as for European crews?



# Study overview



# Scenario 1 incl Human Failure Events (HFEs)

- Loss of Feedwater (LOFW)
  - 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
  - Criterion to start procedure including Bleed & Feed met, but due to the masking not clear
  - HFE 1A: Failure to establish Bleed & Feed within 45 minutes, given a manual reactor trip had been done
  - HFE 1B: Failure to establish Bleed & Feed within 13 minutes, given an automatic reactor trip
- Steam Generator Tube Rupture (SGTR) followed the LOFW
  - HFE 1C: Failure to isolate the ruptured SG and control pressure below the SG PORV setpoint



# Scenario 1 results

- HFE 1A: All crews made it
- HFE 1B: No data
- HFE 1C: 3 of 4 crews did not accomplish the action within success criteria
  - within the 40 minutes timeframe
  - 3 crews succeeded from a plant perspective, 2 of these crews isolated SG and controlled the pressure, but used longer time
  - 1 crew isolated SG but did not manage to control RCS pressure and the SG PORV opened, leading to release of radioactivity



## Scenario 2

- Loss of CCW and RCP sealwater
  - Failing distribution panel increased the complexity and masked the status indications
  - Very short time windows
  - HFE 2A: Failure to trip the Reactor Coolant Pumps and start Positive Displacement Pumps to prevent RCP seal LOCA
- No crews accomplished it
- After the complex situation lead to a delayed start of the procedure, crews did not have enough time
  - NOTE: After these test runs, the plant has focused the training on this event



## Scenario 3

- Textbook SGTR (Steam Generator Tube Rupture)
- HFE3A: Failure to isolate the ruptured SG and control pressure below the SG PORV setpoint
- All crews succeeded



## Difficulty ranking of HFEs

HFE	Task	US rank	Failure rate	Difficulty
HFE 2A	Stop RCPs and start PDP in scenario 2	1	4 / 4	Very difficult
HFE 1C	Identify and isolate ruptured steam generator in scenario 1	2	1 / 4 (3/4 given 40 minute time criterion)	Difficult
HFE 1A	Start bleed and feed in scenario 1	3	0 / 4	Fairly difficult to difficult*
HFE 3A	Identify and isolate ruptured steam generator in scenario 3	4	0 / 3	Easy



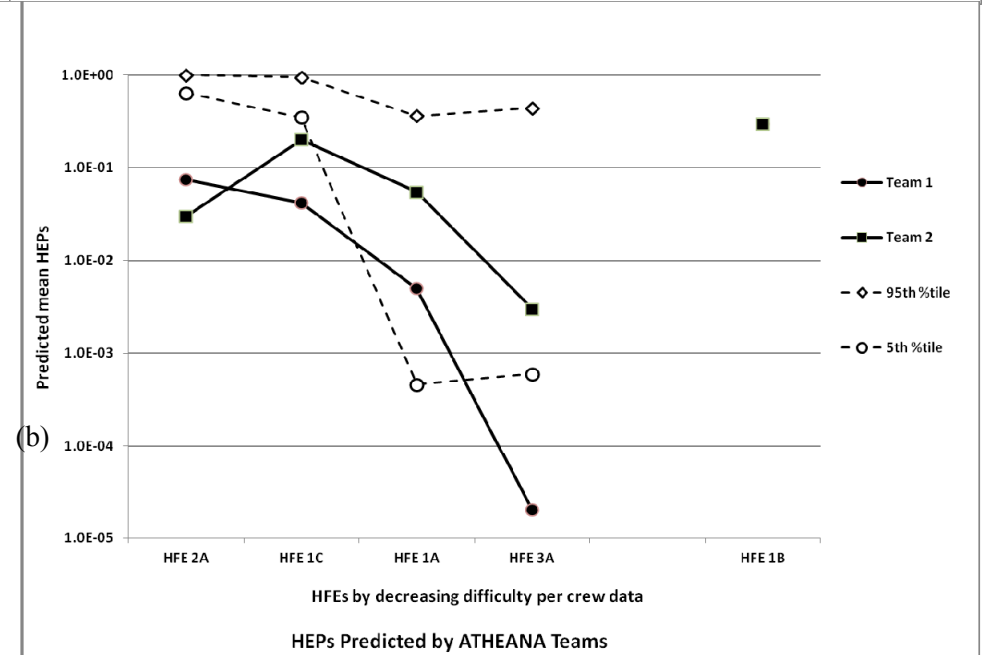
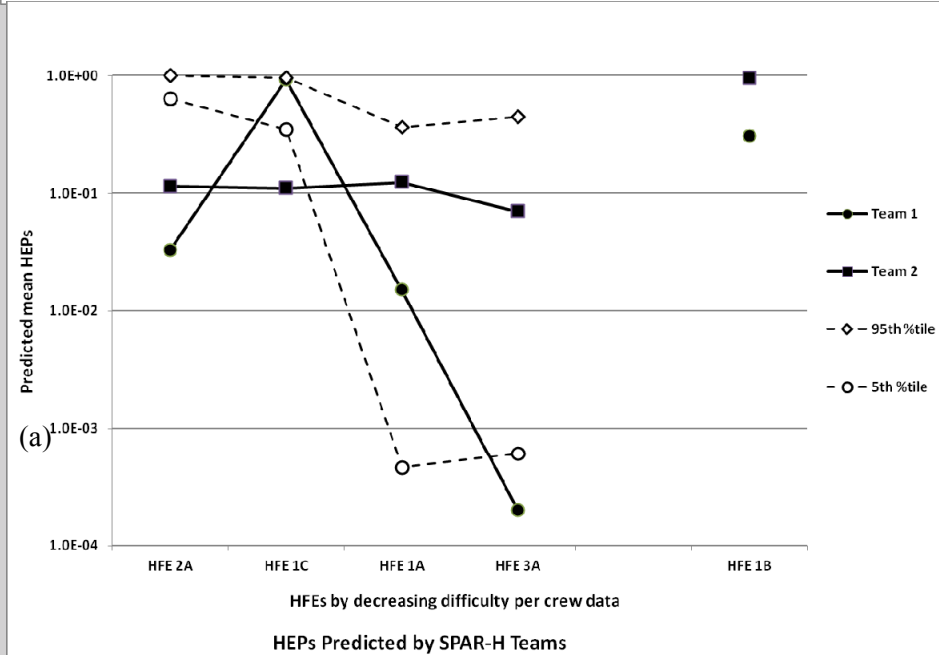
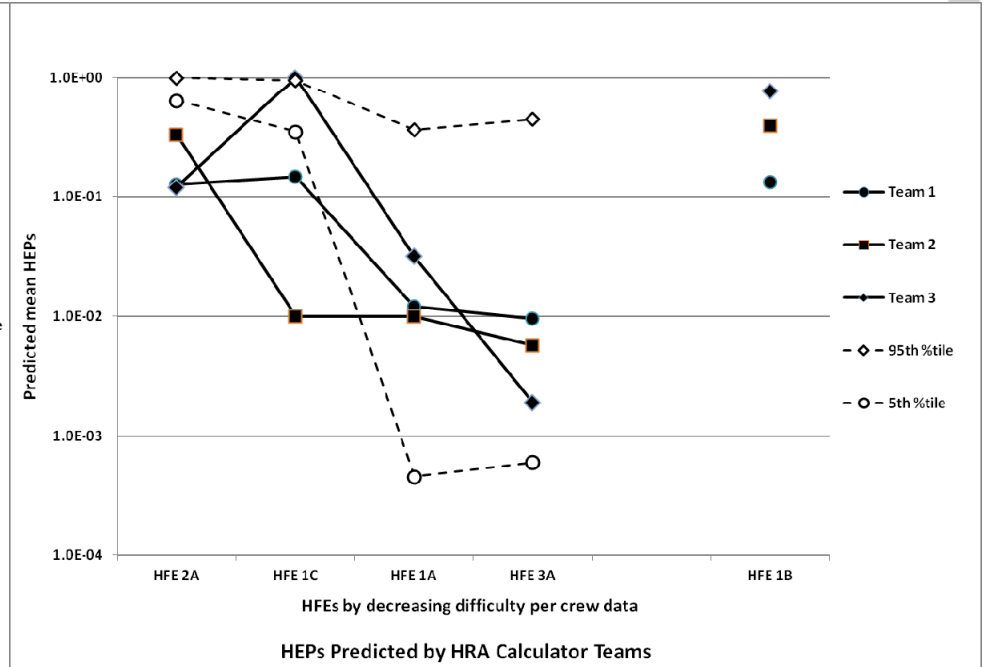
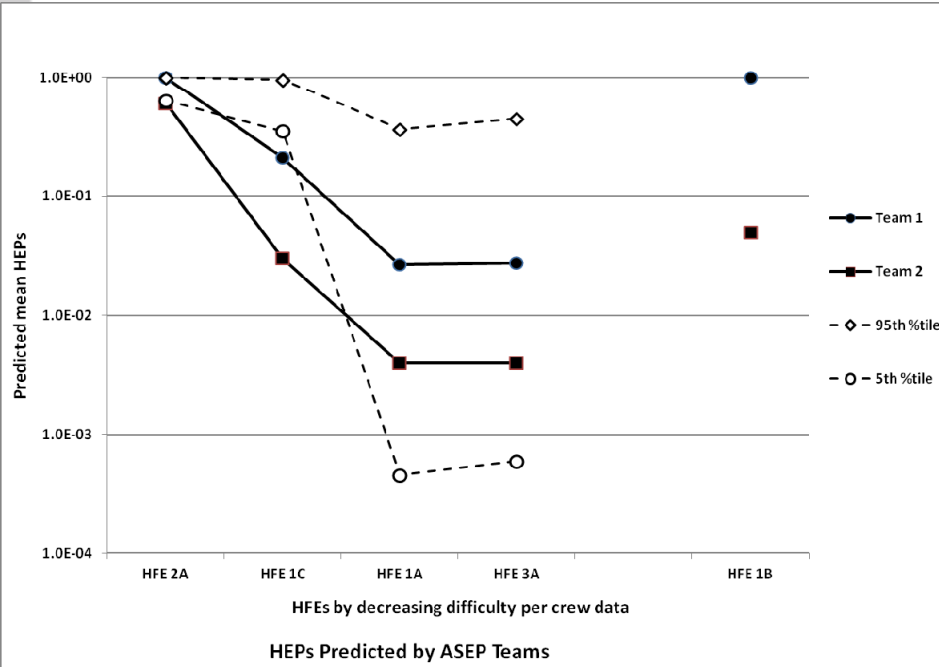


# Overall findings on HRA methods, 1

- Ranking of HFEs was reasonable for most methods
  - Exceptions: relation between HFE 2A and 1C



# Predicted mean HEPs by HRA methods with empirical bounds



## Overall findings, 2

- For most HFEs, one order of magnitude difference across teams using a given method
  - Also variability in crew performance
  - Model average behavior



## Overall findings, 3

- Some methods seem to be more consistent than other methods in this study
  - ASEP
  - ATHEANA
  - SPAR-H maybe a special case in this study, two different applications of the methods, needs more investigation



## Overall findings, 4

- Except ASEP, all other teams underestimated HFE 2A
  - Differences in interviews with experts led to different results
    - General interview with instructors
    - Detailed apriori scenario analysis then a general interview
    - Detailed scenario analysis including a walk-through/talk-through with instructors
  - Training on specific events is an influencing factor
    - Loss of CCW and RCP sealwater



## Overall findings, 5

- All teams agreed that HFE 3A was easiest, but significant variability
  - No common baseline for easy actions or standard scenarios



# Main conclusions, 1

- Follow-up study on strengths and weaknesses of HRA methods from International study
  - Many of the findings from the first study confirmed
- Method effects vs analyst effects?
  - Could conclude better on method effects when several teams for same method
    - Intra-method paper (Marble et al., this conference and session) discusses comparisons
  - Still focus on qualitative insights
    - Rather few teams per method
    - Some HRA teams used the methods differently



## Main conclusions, 2

- Effect of information to HRA teams?
  - Plant visit important
  - Insights in how to perform interviews and collect data
- Similar results for U.S. crews as for European crews?
  - Found similar variability in crew performance as in the International study
    - Difficult scenarios, variability expected

