Conclusions on Human Reliability Analysis (HRA) Methods from the International HRA Empirical Study

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Motivation

- Human performance is an important contributor to risk

- Many different HRA methods in use today

- Diverse underlying models, producing different results

- Reliable estimates are needed for risk-informed decisions

- Lack of data, particularly on cognitive and collaborative aspects of crew performance
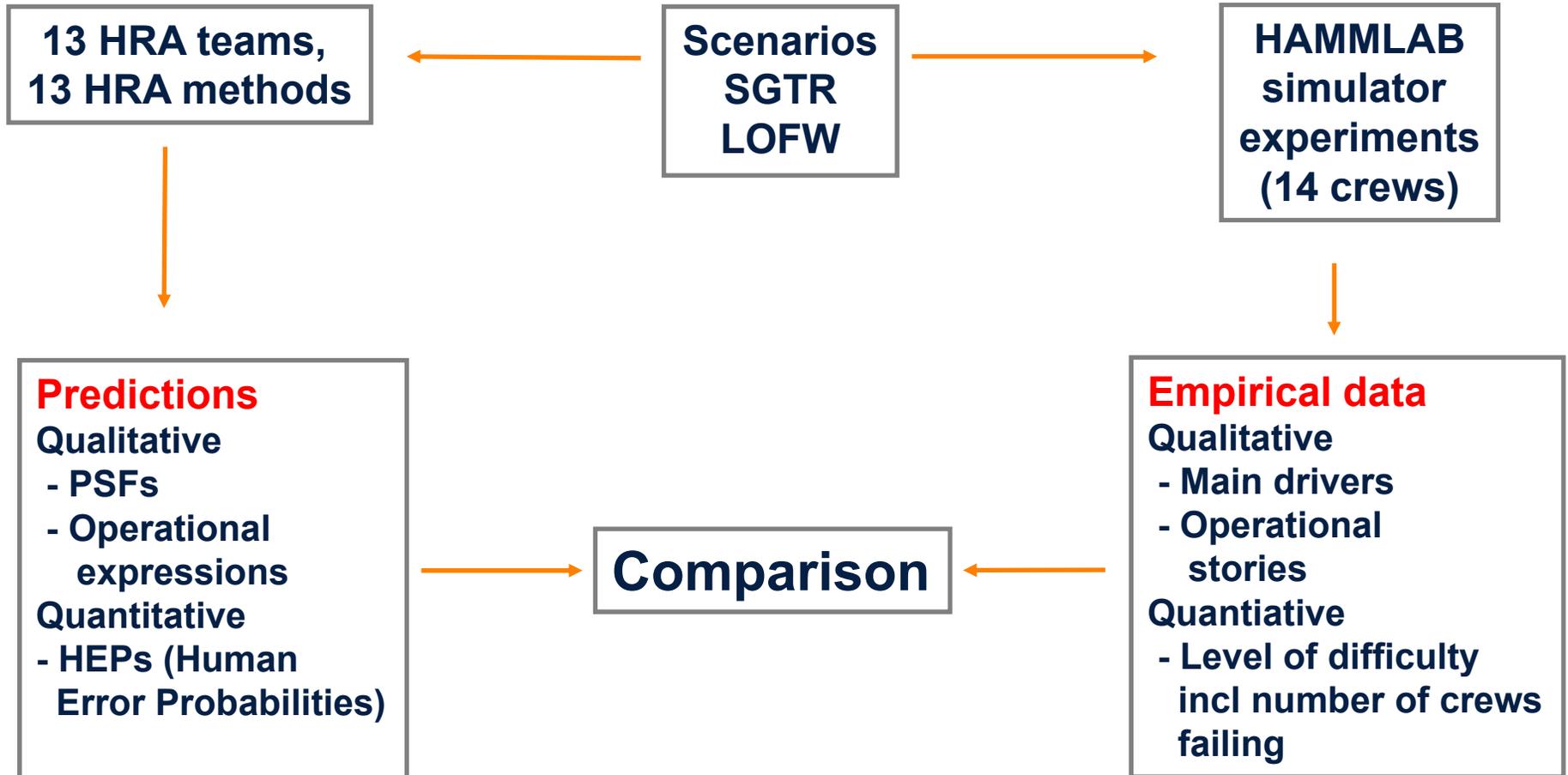
Objectives of International HRA Empirical Study

- Use simulator data to assess strengths and weaknesses of HRA methods

- Identify any limitations in predictive capability of the methods

- Improve the robustness of HRA methods and practices

Study overview

13 HRA teams, 13 HRA methods

Scenarios SGTR LOFW

HAMMLAB simulator experiments (14 crews)

Predictions
Qualitative
 - PSFs
 - Operational
   expressions
Quantitative
- HEPs (Human
  Error Probabilities)

Comparison

Empirical data
Qualitative
 - Main drivers
 - Operational
   stories
Quantiative
 - Level of difficulty
   incl number of crews
   failing

Achievements

- The first major effort to establish an empirical basis for HRA
  - Actual comparisons of predictions to observations (HAMMLAB)
  - All methods on the same playing field
  - Evidence of how people apply methods
  - Demonstrated the dynamic nature of crew-system interactions
    - Needed to be considered in HRA
- Established the use and usefulness of simulator experiments for HRA
  - Developed experimental design focusing on HRA
  - Developed method-to-data comparison methodology
- International and interdisciplinary study team
  - Buy-in from all 13 HRA teams
  - Acceptance of results and motivation for improving HRA methods and practices
- Addressed qualitative predictive power of HRA
  - capability to predict failures and underlying drivers

Key insights on HRA methods, 1

- Addressing diagnosis and related activities
  - Several methods allow analysts to model execution of procedures as purely task oriented (little diagnosis involved)
  - Cognitive demands are considerable for crews executing emergency procedures in complicated scenarios
    - E.g., interpretation of cues and procedural criteria in a dynamic environment
  - Failure in considering crews' cognitive activities while working with procedures may lead to lack of identification of important influencing factors and in underestimation of HEPs
  - Examples: SPAR-H and ASEP need to include diagnosis, CBDT+THERP needs to include use of DTs

Key insights on HRA methods, 2

- Identification of failure mechanisms and contextual factors
  - Methods that focus on this (the way crews could fail a task) produced richer content in the qualitative analysis
    - Examples: ATHEANA, MERMOS, CESA
  - than PSF-based methods
    - SPAR-H, ASEP, THERP, PANAME, HEART
  - More detailed prediction of what could occur
    - More reliable results (better justification)
    - However, not necessarily more accurate HEPs

Key insights on HRA methods, 3

- Judging the degree of influence of PSFs and choosing the right PSFs is difficult
  - Variability in the PSF based methods
  - 1) different degrees of qualitative understanding of the details of the scenario
    - Lack of guidance as to what level of detail to address, e.g., in procedure execution
  - 2) differences in the interpretation of the scope of the PSFs and in the ratings
    - For a given issue or performance condition
    - Improved guidance required, e.g., complexity and HSI in SPAR-H
    - Overlap of PSFs

Key insights on HRA methods, 4

- Range of PSFs covered not always adequate
  - Some methods lack adequate PSFs for the observed phenomena
  - Some methods focus on evaluation of available time, then a few PSFs to adjust
    - May produce reasonable HEPs
    - However, may be for the wrong reason, a lucky shot

Main conclusion

- The qualitative scenario analysis performed to support HRA quantification is an important contributor to the adequacy of HRA predictions
  - Otherwise, no basis to address the range of conditions possible in PRA scenarios
  - The use of HRA is not only the number for PRA, but also insights for error reduction, which depends on a detailed understanding of the difficulties for the crews

Summary and Outlook

- The HRA Empirical Study produced a large set of diverse findings on the different HRA methods and their use

- Method assessments based on reference data from simulator studies useful to establish agreement among experts

- Qualitative and quantitative HRA issues can be explored from a manageable number of scenarios and crews

- Additional simulator studies desirable to better substantiate the results and address generalizability of the findings

    - A USA "domestic empirical study" is underway exploring intra-analyst variability -- supported by Halden

- Improving HRA (accuracy as well as reliability) requires enhancements to both the qualitative and quantitative analysis

- The NRC and EPRI are collaborating on developing a hybrid method improve the robustness of HRA