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Human Reliability : Prospects for the evolution of the numbers and credibility

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CRA‘s UK 5th PSA/Human Factors Assessment Forum
Hellidon Lakes Hotel, 17-18 Sept. 2014

Prospects for the evolution of the numbers and credibility

- **Background:** Data scarcity, expert judgment
- **What impacts credibility?**
- **The HRA Empirical Studies**
- **Some data efforts and outlook**

Background

The scarcity of objective and quantitative data on human performance in NPPs is a serious limitation... [p. 1-6]

In some cases, they are extrapolations from performance measures, which may be only marginally related. In other cases, the HEPs represent our best judgment.

Both (models) are based in large part on a group consensus... [p. 12-12]

Swain & Guttmann, NUREG/CR-1278, THERP, 1983

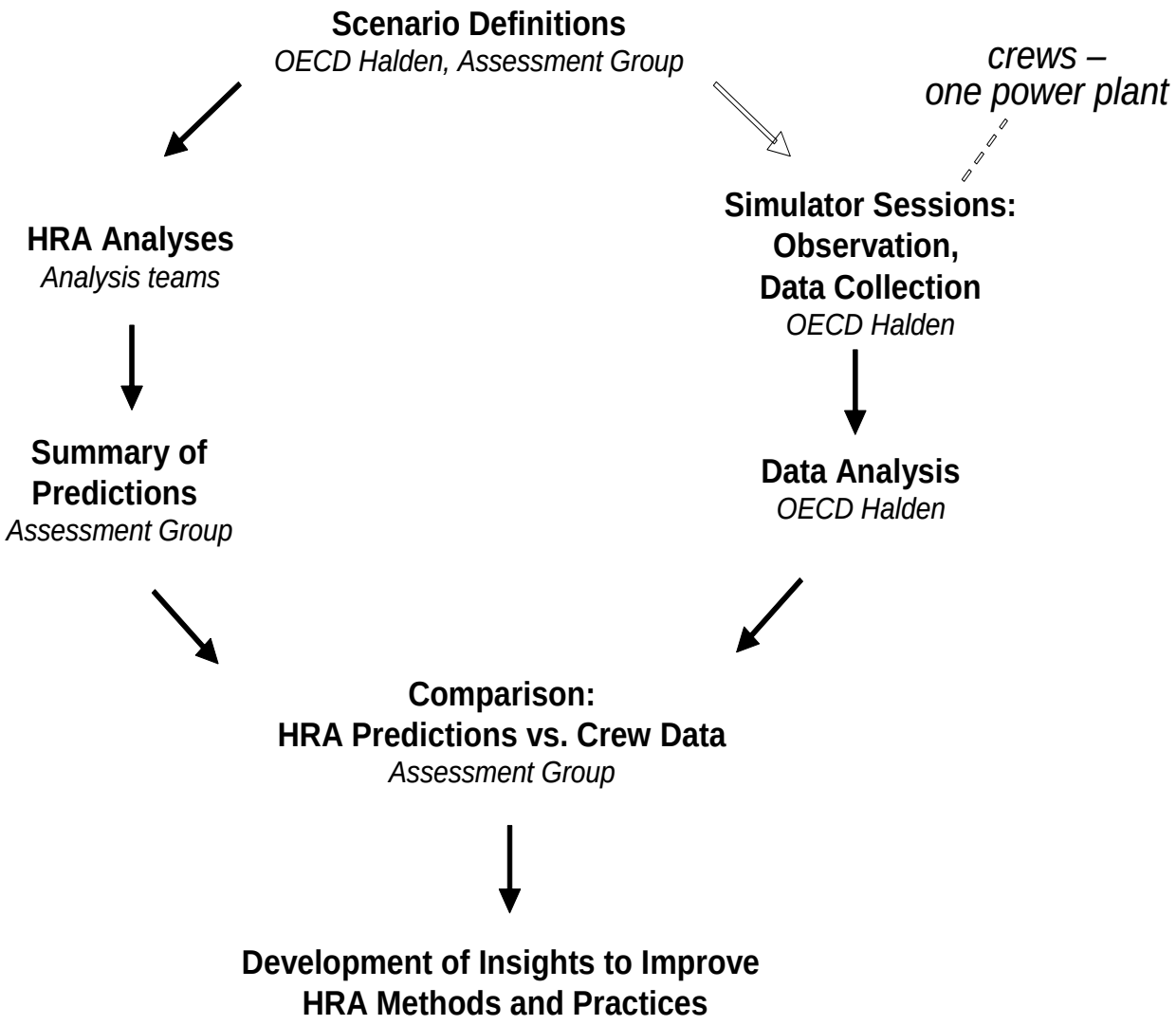
HRA methods and data – selected examples

1. **THERP method**
   - Data from other domains adjusted and tabled
   - Some simulator timings underlie the expert-drawn diagnosis curves
   - Later, validation of "execution"/manipulation/implementation tasks
2. **HCR and HCR/ORE**
   - Simulator study to validate HCR
   - HCR/ORE (Operator Reliability Experiments) curves derived from the simulator data
3. **CBDT (Cause Based Decision Trees)**
   - Hierarchy of branches (decisions) based on simulator data and observations
4. **CORE-Data and NARA**
   - Database of HEPs for real tasks with context/PSF information
   - Failure probabilities for NARA "generic" task types derived from database
5. **International and Domestic (U.S.) HRA Empirical Studies**
   - Simulator studies to obtain reference failure probabilities for assessment of method qualitative and quantitative predictions

Credibility

- **Consistency with measurements (data)**
- **Inter-analyst consistency (method reliability)**
  - Failure probabilities
  - Ranking of HFEs
  - Identification of the underlying issues (qualitative findings)
- **Face validity, plausibility of findings**

The HRA Empirical Studies



International Study

- 14 teams, 13 methods
- 10-14 operator crews
- 2 scenarios x 2 variants
- 9 HFEs

U.S. (Domestic) Study

- 9 teams, 4 methods
- 4 operator crews
- 3 scenarios

+ full-scope training simul.

+ plant visits, simulator observations, interviews

+ intra-method analyses

Steering

E. Lois, US NRC

A. Bye, HRP

V.N. Dang, PSI

J. Julius, Scientech / EPRI

P. LeBot, EDF

Assessment & Comparison

E. Lois

A. Bye

V.N. Dang

J. Forester, Sandia

J. Julius

R. Boring, INL

I. Männistö, VTT

P. Nelson, UNAM

G. Parry, US NRC

A. Kolackowski, SAIC

Halden (Simulator study & data analysis)

P.O. Braarud

H. Broberg

M. Hildebrandt

B. Johansson

S. Massaiu

Crews

14 licensed 3-person nuclear power plant crews

HRA Team Participants

NRC, US

EPRI, US

INL, US

NRI, Czech Rep.

VTT, Finland

EDF, France

IRSN, France

KAERI, Korea

UNAM, Mexico

Ringhals, Sweden

Vattenfall, Sweden

PSI, Switzerland

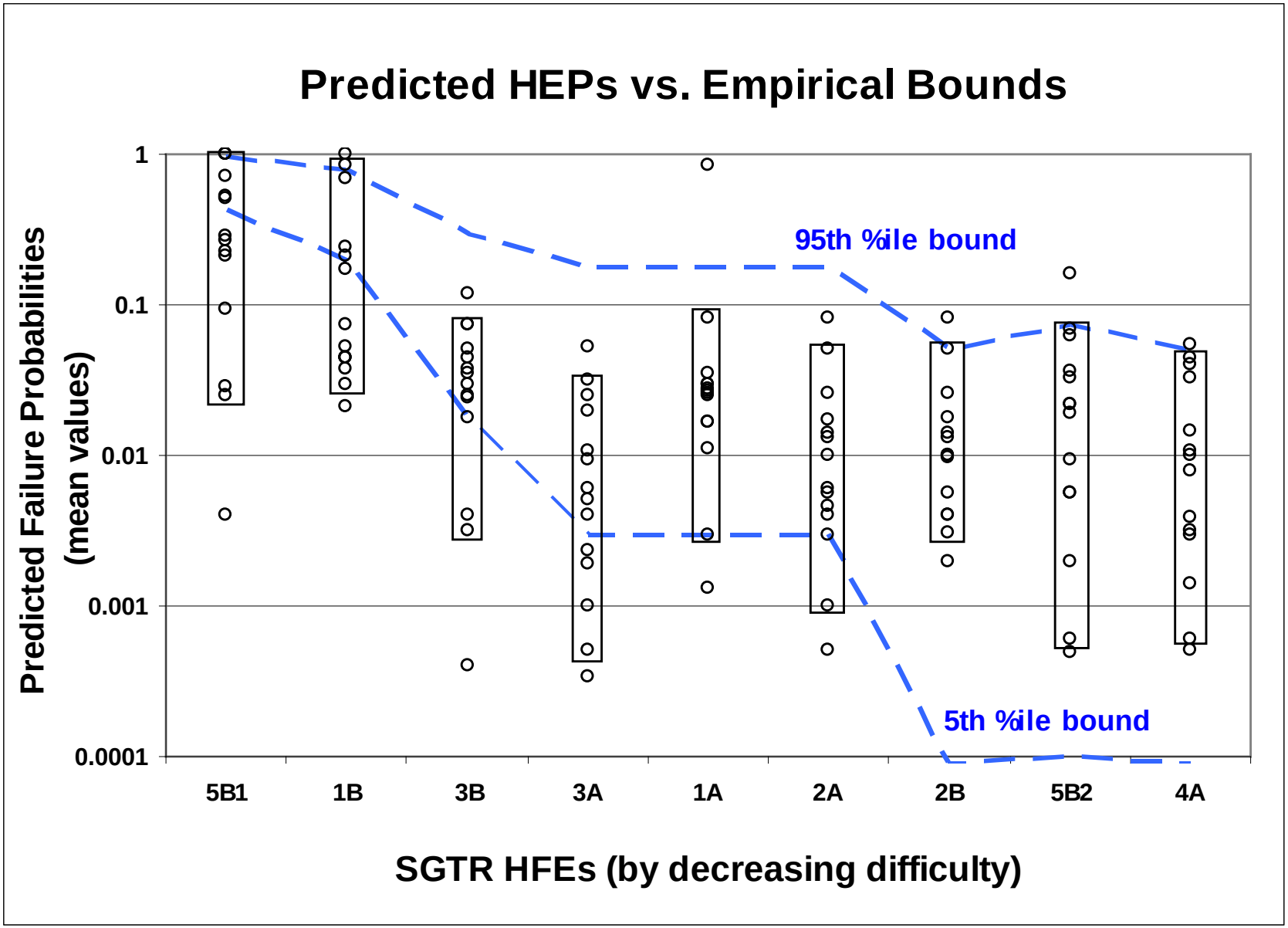
NUREG/IA-0216 & NUREG-2127

J. Forester, A. Bye, V.N. Dang, E. Lois, J. Julius, S. Massaiu, H. Broberg, P.Ø. Braarud, R. Boring, I. Männistö, H. Liao, G. Parry, P. Nelson

NUREG-2156

J. Forester, H. Liao, V.N. Dang, A. Bye, M. Presley, J. Marble, H. Broberg, M. Hildebrandt, E. Lois, B. Hallbert, and T. Morgan

Int'l Study – Bounds and Predicted Values

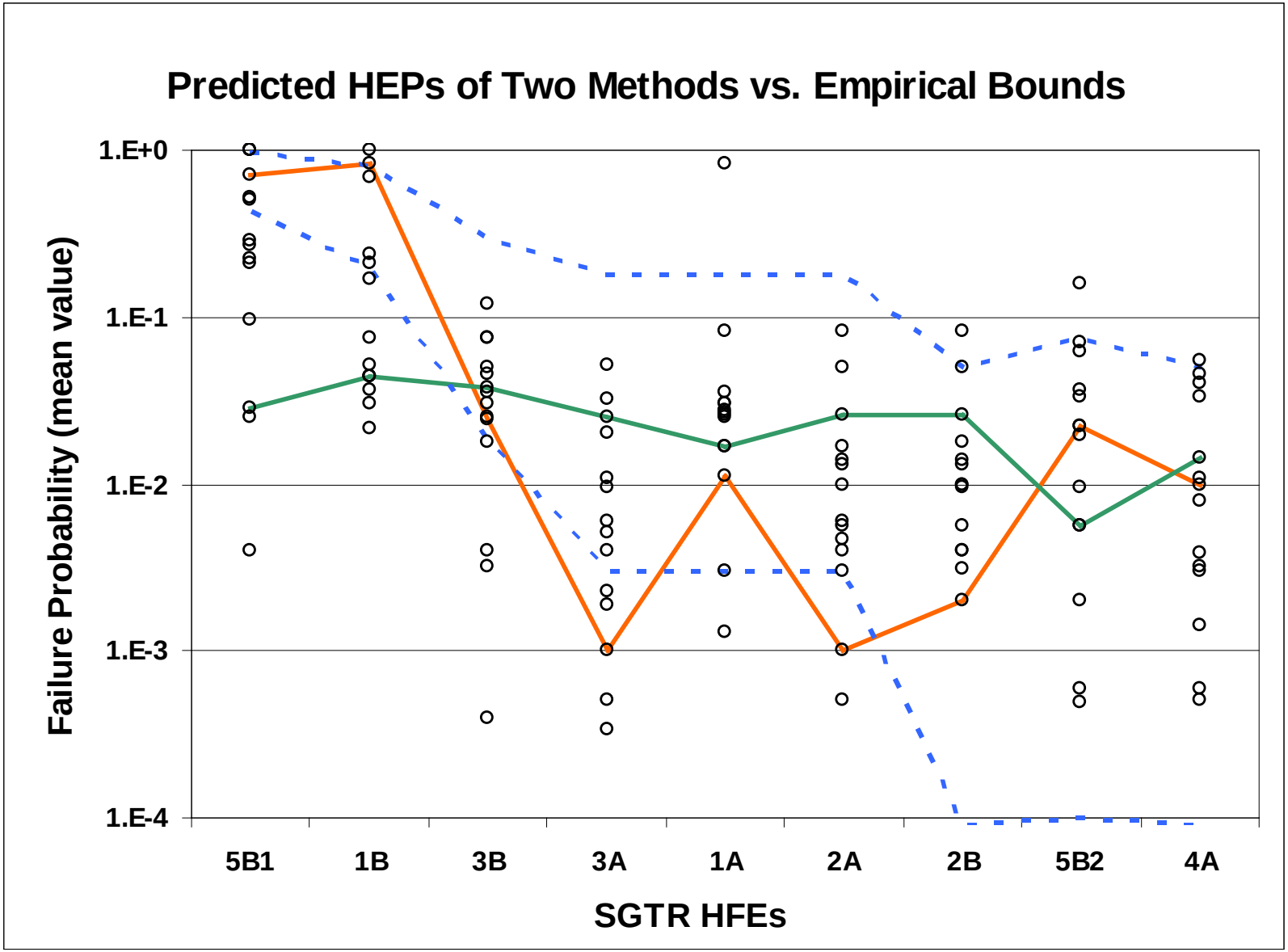


Qualitative predictive power evaluations

- **PSF assessments--**how well the method applications predicted the **specific performance issues and drivers** observed in the reference data
- **Operational expression assessments--**how well the method applications predicted the **ways crews could fail and the operational situations that could contribute** to the failure paths

Quantitative predictive power evaluations

- Potential optimism of the **most difficult HFEs**
- Consistency of the **ranking** of the HFEs (on the basis of estimated HEPs) with the difficulty rankings based on the empirical evidence
- Quantitative **differentiation** of the HFEs by HEP
- Predicted HEPs **relative to the confidence and uncertainty bounds** of the reference data


Predicted HEPs of Two Methods vs. Empirical Bounds
Failure Probability (mean value)
1.E+0
1.E-1
1.E-2
1.E-3
1.E-4
5B1
1B
3B
3A
1A
2A
2B
5B2
4A
SGTR HFEs

Outcomes of the Empirical Studies (1)

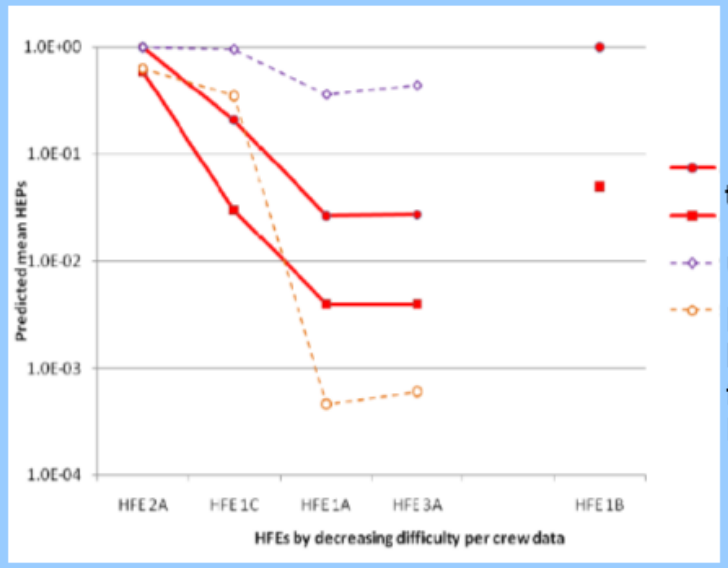
Optimistic HEPs for the **most difficult HEFs**: Evidence of producing optimistic HEPs for the most difficult HEPs

Ranking of HEPs: In many cases, HEPs do not reflect the relative difficulty levels of the HFEs observed in the evidence

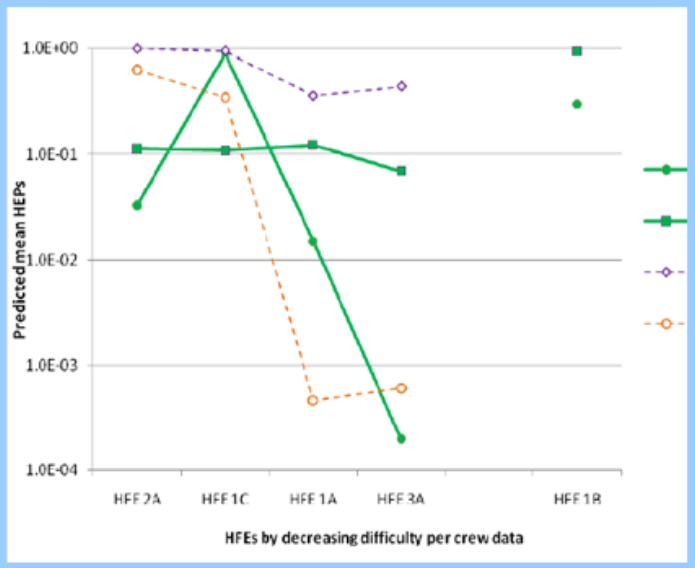
Range and differentiation of HEPs: The analyses did not always adequately discriminate among the difficulty levels, even in cases where they produced appropriate ranking

Conservative or realistic HEPs: None of the methods consistently produced high (or low) HEPs for the set of HFEs

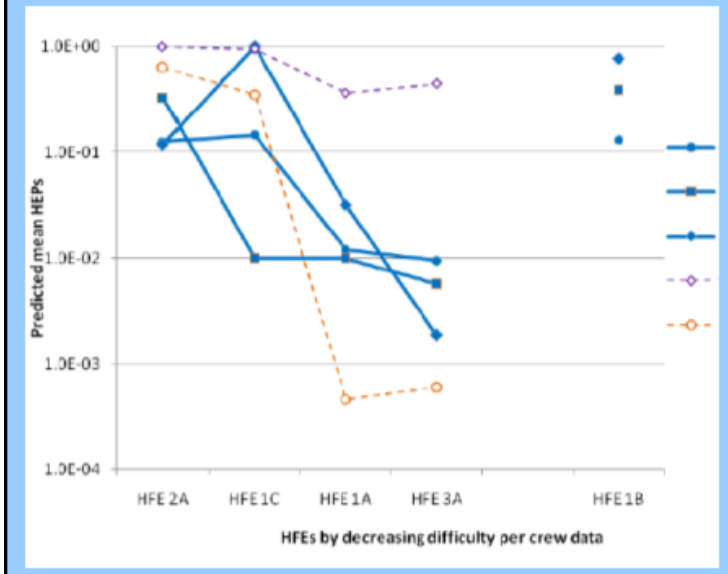
Strengths and weaknesses of **individual methods**



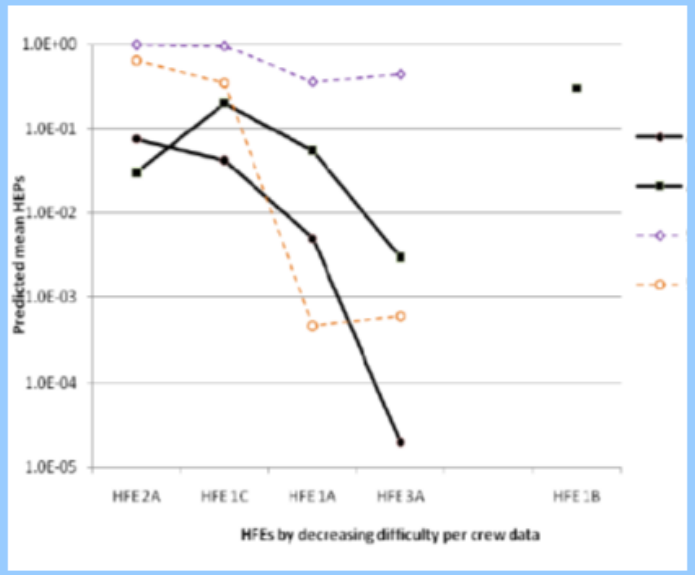
ASEP



SPAR-H



"HRA Calc" / HRAUG guide



ATHEANA

Outcomes (2)

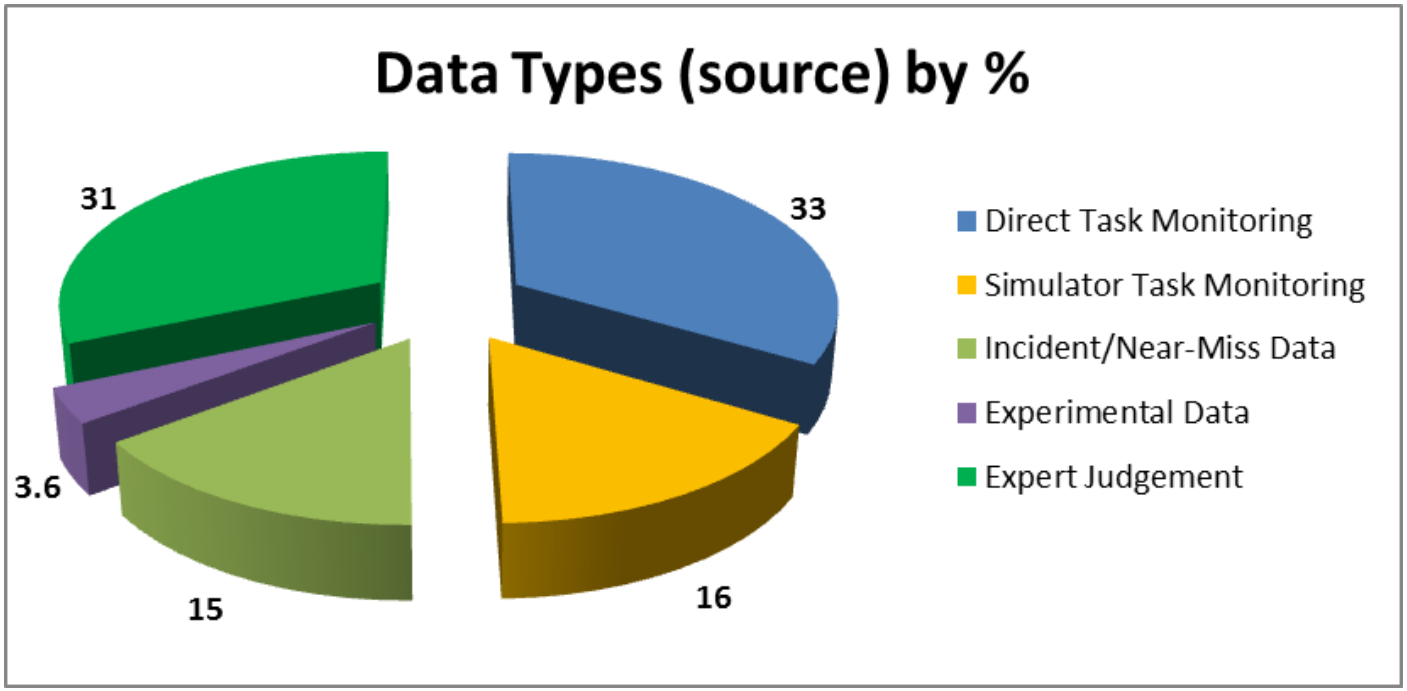
- **Data facilitates discussions, cuts through the terminology issues**
- **Data provided a (more) objective basis for comparing methods and their applications**
- **Focus of data analysis was on**
  - **- what happens,**
  - **- how crews respond,**
  - **- the crew strategies and behaviors, and**
  - **- performance issues associated to challenging scenarios**

  more so than on timing / duration and failure counts

Current data efforts

- **CORE-DATA (since 1995, 1999, on-going)**
  - Input to NARA and other HRA methods
- **EDF Simulator Experiments (continuing)**
  - Operational knowledge base for analysts
  - Observations on strategies, meta-strategies, tendencies, and variability among crews
- **Scenario Authoring, Characterization, and Debriefing Application - SACADA (since 2012, 2014)**
  - Data from licensed operator simulator training
- **Various**
  - Durations and deviations from expected response

CORE-DATA



2006, Eurocontrol Note No. 02/06

- Each data point a specific task, with failure probability distribution

- **Training scenarios decomposed into critical tasks**
  - **Scenario – malfunction – Training Objective Element (TOE)**
- **Data collected for each TOE**

Situational Factors (Context)

Organized by macrocognitive function

- Monitoring/detecting
- Understanding
- response planning
- Manipulation
- communication and coordination

Performance

- Overall performance rating
- Dominant cognitive function
- Specifics of the performance problem
- Causes
- Recovery
- Final effect of performance problem
- Remediation
- Dependence

SACADA (2)

Applications of SACADA data (Chang et al, 2014)

- Collecting performance issues associated with scenarios, systems, or components
- Identification of deviations from expected responses (and context/causes)
- Duration (time to perform) information
- Effect of contextual factors

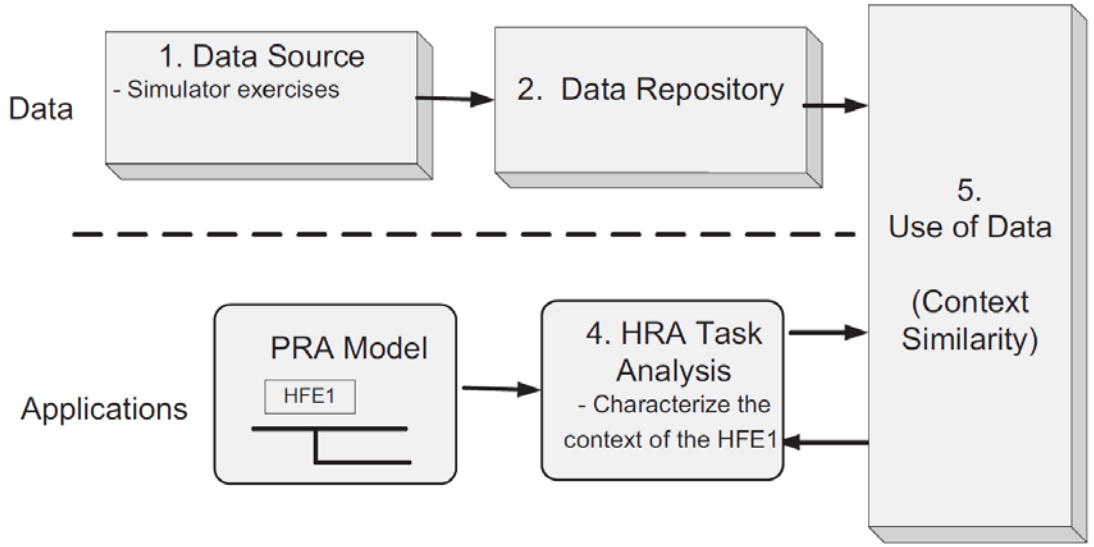
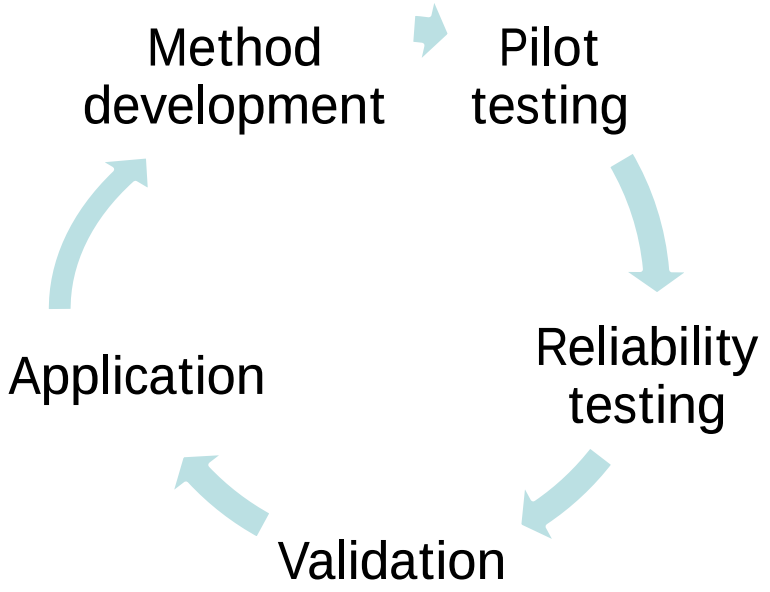


Fig. 2. The framework of generating context similarity based HEPs.

Outlook

- **“Round-trip” development**
- **Supported by data**
- **Designed for testability**



Summing up

Data-centered method developments
vs.
Extensions of existing methods

Expert judgment and existing methods are not going away soon

- New guidance
- Unquestioned usefulness in the right hands

HRA practice

- Need to go beyond what current methods ask
- Collect and use simulator data
(more than one crew, more than indications and timing)

Thank you for your attention.

Questions ?