The International HRA Empirical Study – A Benchmark Study of HRA Methods Using Control Room Simulator Data

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The Issue

- Differences in the underlying frameworks, data, and quantification algorithms of HRA methods yield different human error probabilities and different insights regarding the potential drivers of error/failure
  - Models are based on formal and informal theories of error but have not been tested with empirical data.
  - In regulatory applications HRA limitations are compensated for by using measures such as sensitivity analyses.

International HRA Empirical Study

- **Motivation**
  - Provide guidance for **HRA users** (regulators, utilities)
  - Provide insights for **HRA method developers**
- Based on insights into **performance of the methods**
  - Predicting Human Error Probabilities (HEP)
  - Predicting Performance Shaping Factors (PSFs)
  - Predicting crews' operational problems
  - Insights for error reduction
- **Partners:** NRC, VTT, INL, EPRI, NRI, EDF, IRSN, PSI, KAERI, Vattenfall, Risø, U of Maryland, Alion, Politecnico di Milano

Acknowledgements

INTERNATIONAL HRA EMPIRICAL STUDY - PILOT PHASE REPORT

DESCRIPTION OF OVERALL APPROACH AND FIRST PILOT RESULTS FROM COMPARING HRA METHODS TO SIMULATOR DATA

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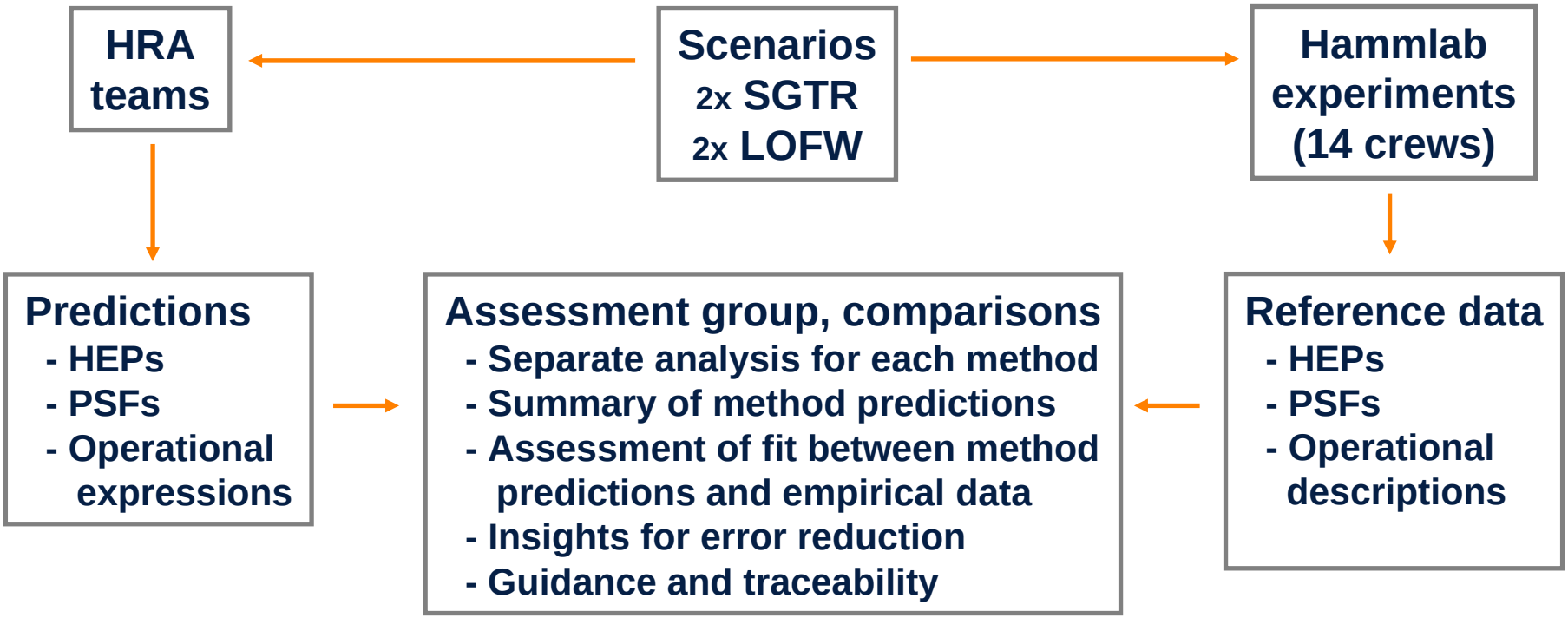
1 U.S. Nuclear Regulatory Commission, USA,
2 Paul Scherrer Institute, Switzerland,
3 Sandia National Laboratories, USA,
4 Scientech, USA,
5 Idaho National Laboratory, USA

HRA methods in the study

Method : HRA Analysis Team					
ASEP/THERP	NRC staff and consultants, USA	CBDT	EPRI (Scientech), USA	HEART	Vattenfall & Ringhals NPP, Sweden
THERP with Bayesian Enhancement	VTT, Finland	Decision Trees + ASEP	NRI, Czech Rep.	KHRA	KAERI, Korea
ATHEANA	NRC staff and consultants, USA	MERMOS	EDF, France	CREAM	NRI, Czech Rep.
SPAR-H	NRC staff and consultants, USA Idaho National Engineering Laboratory, USA	PANAME	IRSN, France	CESA	PSI, Switzerland

Methodology & study design

- Comparison of HRA predictions to HAMMLAB reference data
  - (HEPs); PSFs (factorial methods);
  - Operational expressions (scenario-based methods)



PWR Simulation: HAMMLAB Control Room

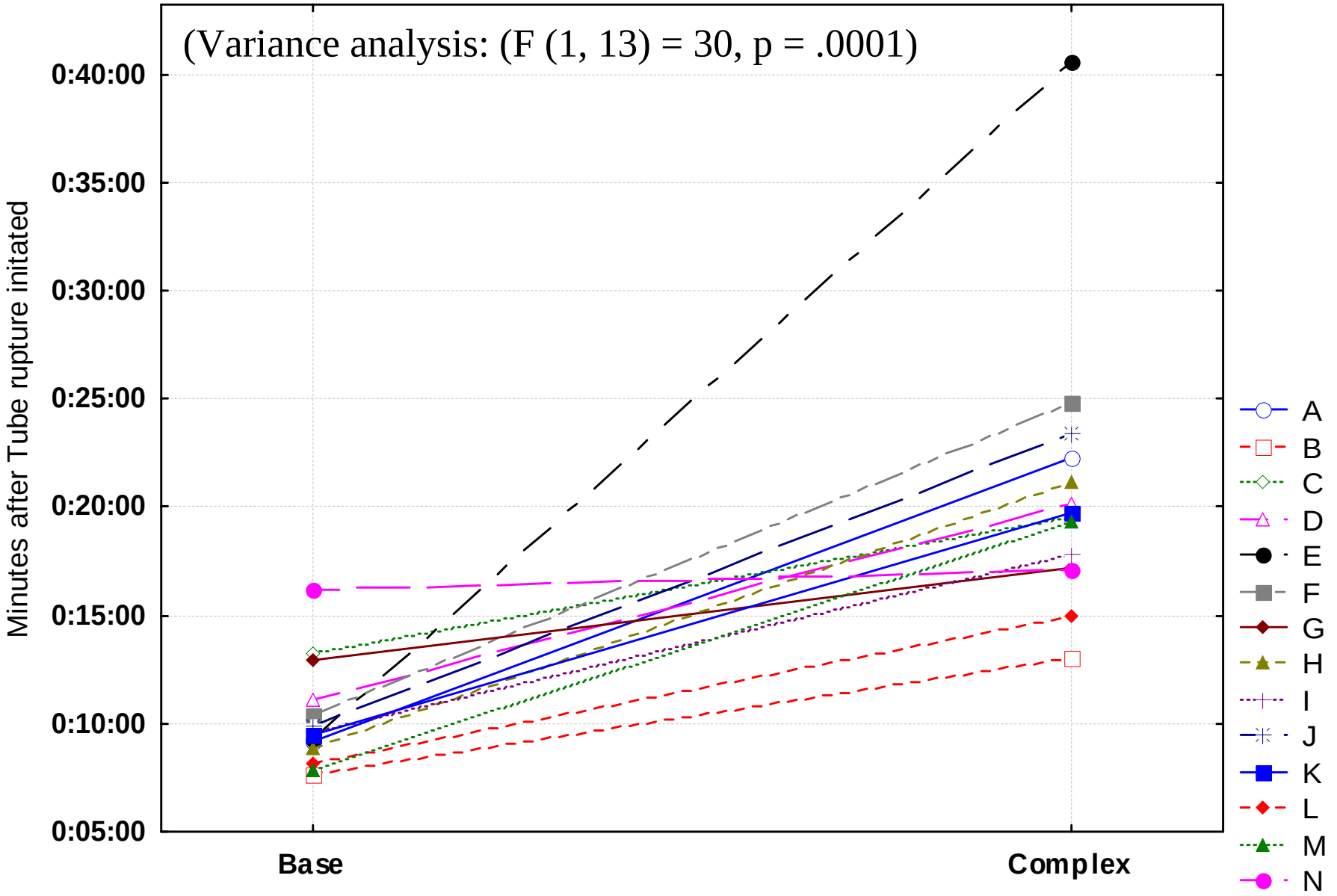
Status, 1

- HAMMLAB data collection completed (2006) (SGTR and LOFW)
- Phase 1: Pilot Completed in 2008
  - Used two SGTR human actions to establish the method
  - Established method for crew performance data analysis in a format suitable to HRA
  - Established method for evaluating HRA results on the basis of experimental data
  - Compared HRA results to HRP data for the two human actions
  - HRP report (HWR-844), to be published as NUREG/IA-0215, Spring 2009

Status, 2

- Phase 2: Data analysis of seven more SGTR human actions
  - Workshop meeting with participants, March 2-4, 2009
  - ACRS briefing, March 6, 2009
  - Document in draft HRP report, September 2009, and in NUREG/IA, March 2010
- Phase 3: Analysis and documentation of the LOFW human actions
  - HRA teams have submitted their analysis of LOFW human actions
  - HRP has completed simulator data analysis
  - Now comparing analytical results to HRP data, due Summer 2009
  - International meeting on LOFW results scheduled for Nov 2009
  - Documentation of Phase 3 results expected in Spring 2010
- Complete documentation of the study by Sept 2010

Performance time of diagnosing tube rupture in the baseand the complex scenario, all crews



Initial Findings

- Empirical data
  - Complexity manipulation had a significant effect
  - Crew characteristics (teamwork etc) significant effect on performance
  - Significant crew-to-crew variability
  - HAMMLAB provided rich reference data
- Insights on HRA methods
  - All methods identified some of the important driving factors
  - General under-estimation of the difficulty of the complex scenario
  - Significant variability in PSF identification between methods
  - Some HRA methods could benefit from additional guidance:
    - How to develop the qualitative analysis
    - How to judge the strength of PSFs

Conclusions

- The methodology developed is working well
  - Can see in detail how methods are applied
  - Can see in detail how crews perform
  - Allows lessons learned about HRA methods
    - Strengths, weaknesses
  - Can compare all types of HRA methods to the empirical data
    - PSF drivers, factorial methods
    - Operational expressions, scenario-oriented methods
  - Uncomplicated scenarios do not provide significant insights about how the methods are applied
    - More challenging scenarios test methods' limits and hence, help in identifying the limitations of methods
  - HRA teams positive about the study
- The Pilot produced results that can be used to improve HRA now

Backup slides

Process Simulated

- The HAMMLAB PWR simulator used for this study was a full scope simulator of a French plant (CP0 series).
- HAMMLAB uses a computerized human machine interface for the PWR simulator.
- The HAMMLAB PWR procedures are based on the procedures used at the participating operators' home plant. The procedures are adapted to the simulated PWR and the HAMMLAB interface.
  - The participating operators' home plant uses the Emergency Response Guidelines (ERGs) developed by the Westinghouse Owners Group

Simulation Set-up

- Scenario run plans and experiment staff procedures to ensure same conditions for each crew
  - For example to secure data collection to avoid re-start of scenario
- Experimental staff performs:
  - Running the simulator, administer the scenario run
  - Giving expert comments
  - Observing crew behaviour
  - Recording of video / audio
  - Role play of and communications of personnel external to the control room
    - Field operators
    - Technical departments
    - Safety Engineer on duty, Plant Management, Other

Participating crews

- Licensed PWR operators (Sweden)
- 14 crews consisting of
  - *Shift supervisor* (SS):
    - Overviews the situation and calls for meetings when needed. Calls the safety engineer. Monitors critical safety functions. Must be consulted if procedure needs interpretation. Can help with alarms if asked
  - *Reactor operator* (RO):
    - Reads the emergency procedures. Reacts to reactor alarms
  - *Assisting reactor operator* (ARO):
    - “The arms and eyes” of the reactor operator. Does most of the actions in the emergency procedures on order from the reactor operator. Monitors steam generators and controls auxiliary feed water (AFW) flow