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Experiments performed in Halden simulators, the link between technology and crew roles and teamwork

RIC Panel TH40: Operating Crew Performance with Advanced Technologies: Insights from Experiments and Simulator Training

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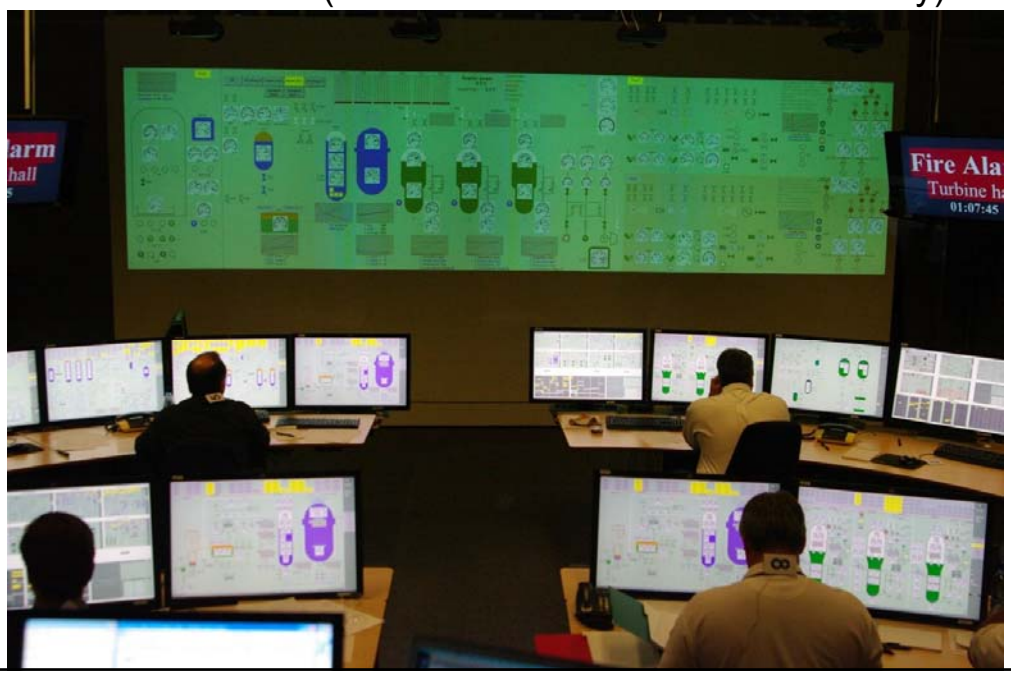
HAMMLAB (HAlden huMan-Machine LABoratory)



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Message

- New technology impacts performance through interaction with the work practices in the control room.
- The roles of the crew impact the crew performance.

Outline

- Experiences from three studies
  - Study I: Complexity, masking and teamwork
  - Study II: Computerized procedures, crew roles and performance
  - Study III: Crew roles, work style and performance

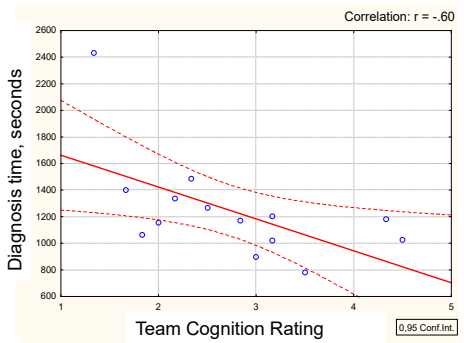
Study I: Complexity, masking and teamwork

- The more complex the tasks get, the more does (bad) teamwork impact performance
- Team Cognition in a Complex Accident Scenario[1]
  - Mission analysis - Cognition beyond procedure guidance
  - Process of consultation while performing technical work
  - Distributed leadership (mainly between Supervisor and Reactor operator)
  - Team orientation
  - Backup and support

[1] HWR-955: Team Cognition in a Complex Accident Scenario. P.Ø. Braarud and B. Johansson, 2010

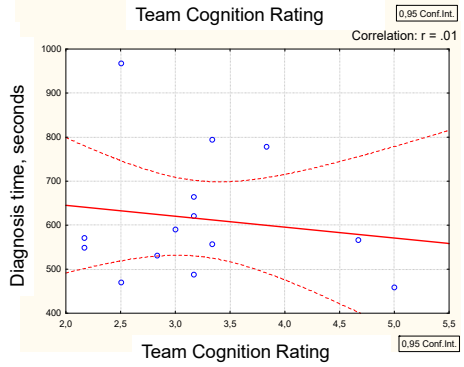
Complex:

- Team Cognition important for diagnosis time in complex situations



Base:

- Less important for diagnosis time in "base" (prototypical) situations



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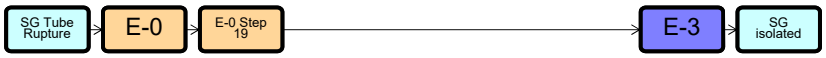
Study I: Complexity, masking and teamwork

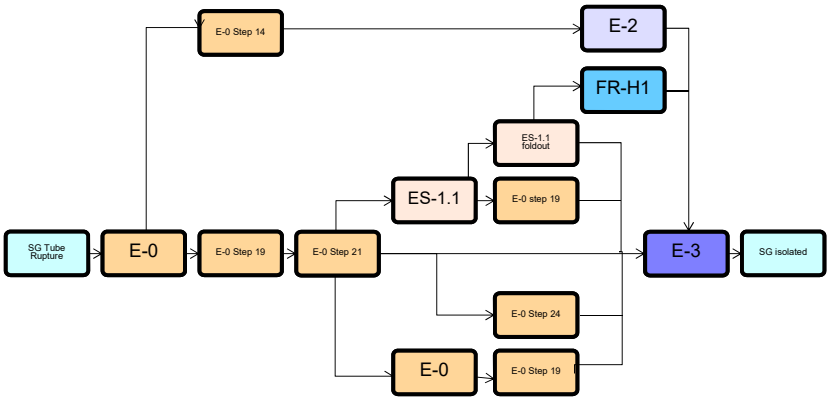
- Complex and base conditions
- Observed procedure use issues in the complex scenarios[2]
  - Mismatch between procedures and plant situation: Non-typical conditions, lack of detailed guidance

[2] HWR-1121: Diagnosis and Decision-Making with Emergency Operating Procedures in Non-Typical Conditions: A HAMMLAB Study with U.S. Operators. S. Massaiu and L. Holmgren, 2014.

Typical conditions



Non-typical conditions



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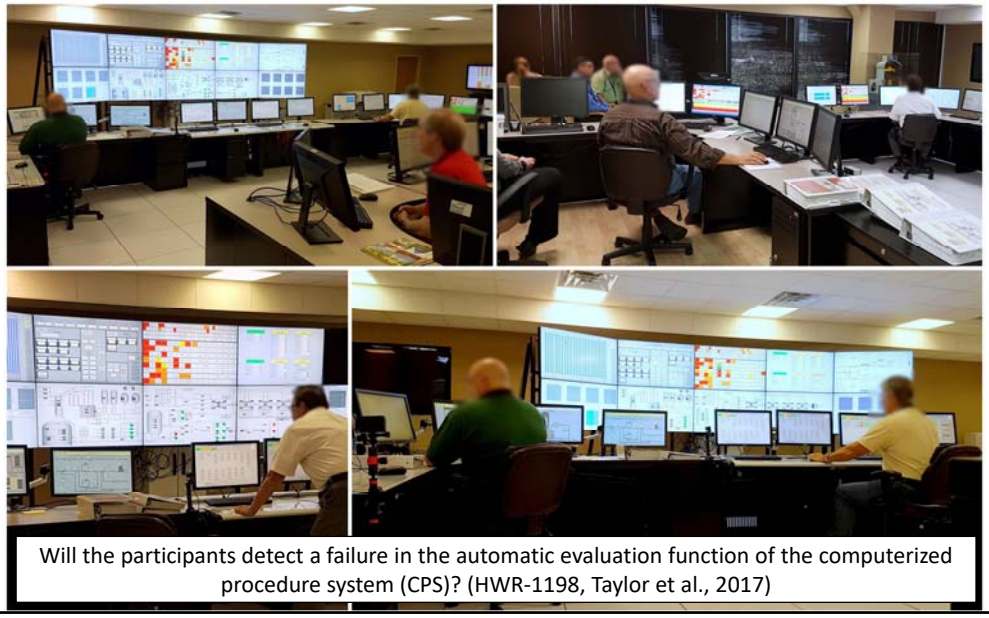
Study II: Computerized procedures, crew roles and performance

- False positives vs false negatives

AP1000-style Computerized Procedure System



Will the participants detect a failure in the automatic evaluation function of the computerized procedure system (CPS)? (HWR-1198, Taylor et al., 2017)

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Failure types

- **Failure of the automatic evaluation function**
  Improper evaluation of parameters resulting in a failed input to the CPS – the CPS will either:
  - display a red X (✗) for a procedure step, indicating that the required parameter is *not* met, when in fact it is met **(false negative),** or
  - display a green checkmark (✓) for a procedure step, indicating that the required parameter *is* met, when in fact it is not met (**false positive**).

Results

- False negatives were identified
- False positives were **not** identified

Study Topic	Failure description	Operator response
(A) Detecting failures of the automatic evaluation function	1) Red X (✗) instead of green checkmark (✓)	All three ROs identified this failure.
	2) Green checkmark (✓) instead of red X (✗)	None of the ROs identified this failure.

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False positives not observed in a real plant

- Lacking identification of false positives was observed in a training centre with non-licensed operators
- However, in a follow-up study at a NPP training simulator, this behavior was ***not*** observed
  - The crew checked everything
  - Their work style is stated in the conduct of operations, and trained
- What about workload?

Computerized procedures

- Crews may follow computerized procedures closely
  - "shadowing" the procedures
  - Increased workload for the shift supervisor, especially due to confirmation tasks in the computerized procedures[3]
  - What about more complex situations?

[3] Kim, Y., Jung, W. & Kim, S. (2014). Empirical investigation of workloads of operators in advanced control rooms. Journal of Nuclear Science and Technology, 51:6, 744-751.

Study III: Crew roles, work style and performance

a) Grouping
b) Role of the Shift Technical Advisor (STA)

CREW 1-3

CREW 4-9

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Conduct of operations, grouping

- Is work style impacted by the digital control room?
- Does a more compact control room “invite” people to closer group work?
- How is communication changed based on the layout and style of the control room?
- If communication is affected, how does this impact situation awareness for the crew?

IIIb) Role of the Shift Technical Advisor (STA)

- Presence of an STA had positive effects in given circumstances[4]
- STA did *not* improve general performance of the crew, plausible reasons:
  - Working as a team member
  - Being delegated tasks from the Shift Supervisor
- The STA did not work as the independent advisor he was meant to be
- Observation that the STA had better overview when situated in a room watching the crew on video (without interacting with the crew)
- Studying this in an experiment this year

[4] HWR-1216: The 2013 Resilient Procedure Use Study with Swedish Operators: Final Results. S. Massaiu and L. Holmgren, 2017.

Configurability

- Digital control room solutions are flexible by nature
- Many different control rooms can be the result of the same vendor

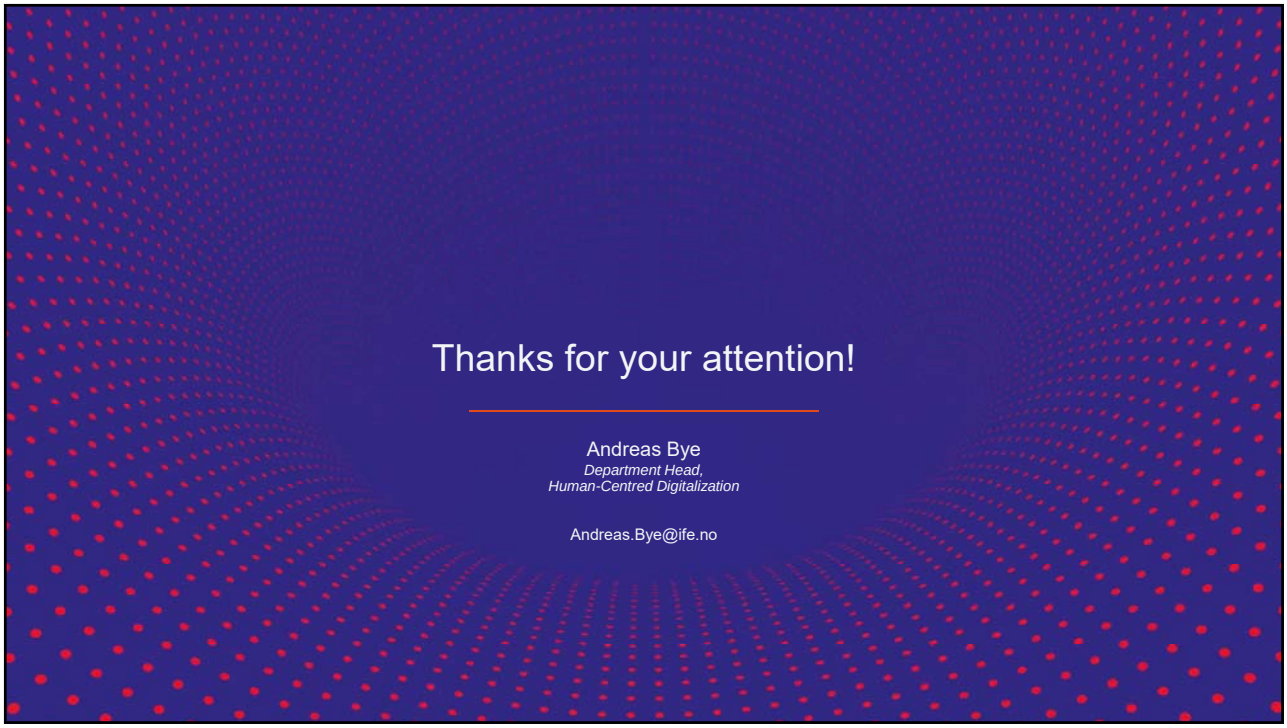
- One must evaluate the link between chosen solutions and the crew roles and teamwork (e.g., the use by the whole crew of a large overview screen)

Implications for Human Reliability Analysis (HRA)

- What is the impact of teamwork and crew roles on recovery of human action failure?
  - To which extent can certain combinations of new technology and conduct of operations credit recovery?
- Dependency between human failure events – failure of one human action leads to the failure of subsequent human actions
  - Still difficult question: dimensions of time, same crew, new cues, etc.
    - Can new combinations of conduct of operations and new technology be taken into account?
    - E.g., automated checks?

Conclusion

- The roles of the crew and their teamwork is crucial for the crew performance
- New technology must be evaluated together with its intended concept of operation
- Unexpected side effects of new technology may be present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