

Halden Reactor Project (HRP) Experiments on Advanced Technologies: Results and Insights on Conduct of Operations, Training, and Design

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HRP experiments



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Questions about new technology

1. Are the challenges to human performance the same in a computerized control room as in a panel based one?
2. Does more automated I&C introduce new vulnerabilities?
3. Does new technology impact teamwork and conduct of operations?
4. Is human performance with respect to safety impact similar in analog and computerized control rooms?

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Q1 and Q2: Human performance challenges and automation

Q1: Are the challenges to human performance the same in a computerized CR as in a panel based one?

Q2: Does more automated I&C introduce new vulnerabilities?

Example: Operator response to failures of a computerized procedure system (CPS) (HWR-1198, Taylor et al., 2017)

- New method, exploratory study, not statistical analysis

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AP1000-style CPS



Will the participants detect a failure in the automatic evaluation function of the computerized procedure system (CPS)?

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 (X) instead of green checkmark (✓)	All three ROs identified this failure.
	2) Green checkmark (✓) instead of red X (X)	None of the ROs identified this failure.

Q1 and Q2: Lessons learned

- There may be different challenges to human performance for “false positives” and “false negatives”
- **Design:** Think about how feedback from automatic evaluation systems in CPSs should be presented
- **Training:** Be more critical to all kinds of feedback
- **HRA:** Are automatic systems dominated by positive feedback? How is checking trained?

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Q2: Automation

- Summarized 20 years automation work in Halden
 - Automation transparency: Not enough to make automation transparent
 - Insufficient capacity to simultaneously monitor automation and detect deviating system states
 - Paid extra attention to the process state when working with the non-transparent interface
 - Which type of models and guiding principles should be used as basis for design of human-automation collaboration?
 - Level of automation: a mis-guiding concept?
- Skraaning & Jamieson, 2017. HPR-387

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Q3. Does new technology impact teamwork and conduct of operations?

- Study on handheld overview displays for ex-control room use:
 - Brought Shift Supervisor up-to-date before entering control room
 - Kaarstad et al., HWR-996; Kaarstad, HPR-384

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Q3: Does new technology impact teamwork and conduct of operations?

- In difficult scenarios
 - Team engineering expertise critical for performance
 - Quality of teamwork decreases with complexity and fatigue
 - Less structured meetings, poor quality of briefings/discussions
 - Communication errors
- Ref S. Massaiu, HWR-1121
- We need to make new technology help the crews, not increase the complexity: Adaptive Automation?

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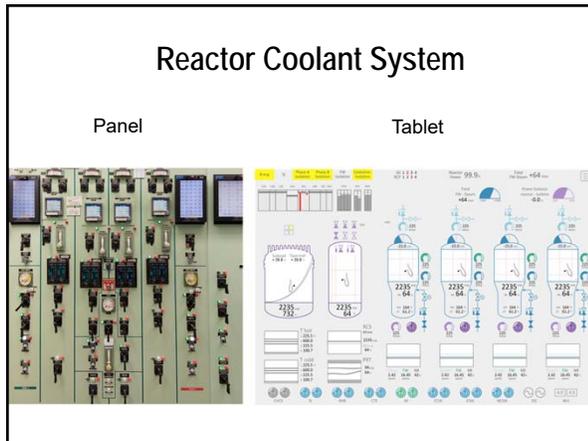
Q4: Is Human Performance wrt safety impact similar in analog and computerized control rooms?

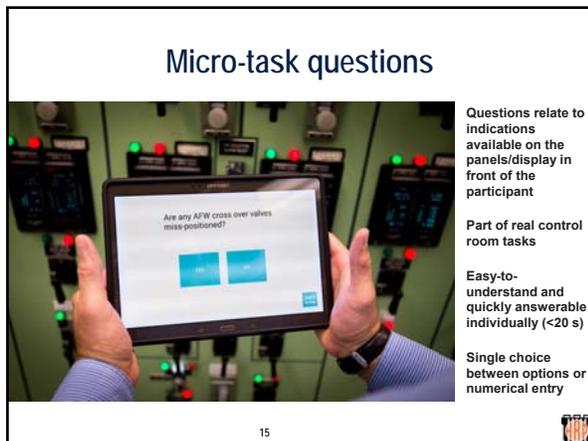
- New method: Micro-tasks (Ref. HWR-1130, HWR-1169, Hildebrandt et al., 2016)
 - Decontextualized tasks, typically identification/verification tasks
 - Frozen state of the plant, or mini-scenarios
 - Short data collections
 - Accuracy and speed (response time)

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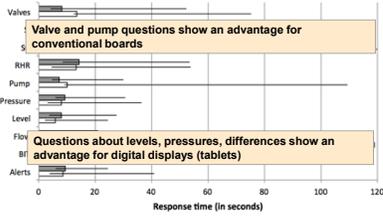


Slide 13

CT11 Suggested replacement for slide 10
Claire Taylor, 2/5/2018

Micro-Task study: Example

Response time by question type



Ref. HWR-1169, Hildebrandt & Fernandes (2016)

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Q4a: Does the cognitive task type matter?

- We compared results from two micro-task studies with task types in HRA methods (e.g., THERP)
 - Ref. Massau & Fernandes (PSAM Topical, 2017)
- Identification/verification tasks
 - Check/reading vs calculation
- Big difference in error rates in simple checks and calculation tasks
- Such empirical data should also update the HRA methods

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Q4: Human performance in analog and digital CRs: Results and lessons learned

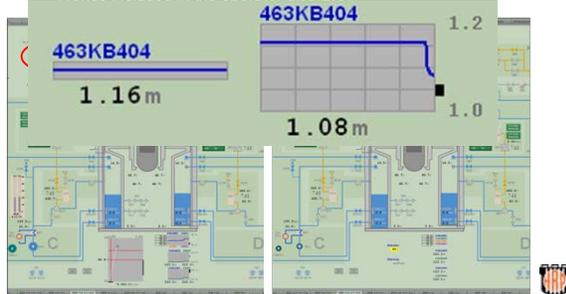
- More data is needed to consolidate findings
 - Collects more data, stores in Halden Project Human Performance DB
 - Methods and tools are in place to do this now
- Cognitive task types are as important as analog or digital presentation
- No final conclusions yet, but interesting patterns emerge
 - Ex: Comparisons and calculations can be better in (new) digital solutions
- **HRA**: How to use (modified) THERP for digital CRs
- **Design**: Find the best ways to present info

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Design: Micro-task use

- Prototyping for upgraded displays: Compare solutions for identification/verification tasks
 - Ref. HWR-1212, Eitheim et al., 2017
- Trends included in the operator displays?



Conclusions

1. Are the challenges to human performance the same in a computerized CR as in a panel based one?
 - There may be new and different challenges that should be taken into account
2. Does more automated I&C introduce new vulnerabilities?
 - Yes, be aware of these
 - Making automation transparent is not enough to optimize the performance of the joint human-automation system
3. Does new technology impact teamwork and conduct of operations?
 - Supports crew decision making if made in a good way
 - It is hard to improve the adaptive capacity of the crews (improve performance in novel/extreme conditions). We need to improve technical and organizational provisions; our studies indicate what can work
4. Is human performance wrt safety impact for identification/verification tasks similar in analog and computerized control rooms?
 - Preliminary result: Digital displays do not significantly increase the error rates. Different types of cognitive tasks (e.g., checking vs. calculating) makes a bigger difference.
 - We are planning more data collections

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References

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