



OECD Halden
Reactor Project

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Micro-tasks results on identification reliability

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The Micro-tasks method

Normal control room tasks

Small tasks, like a procedure step or part of a step

In fast sequence, unrelated to preceding and following task

Response time and accuracy are the performance measures

No recovery, not possible to go back to previous questions

Tasks: Questions or sentences

3

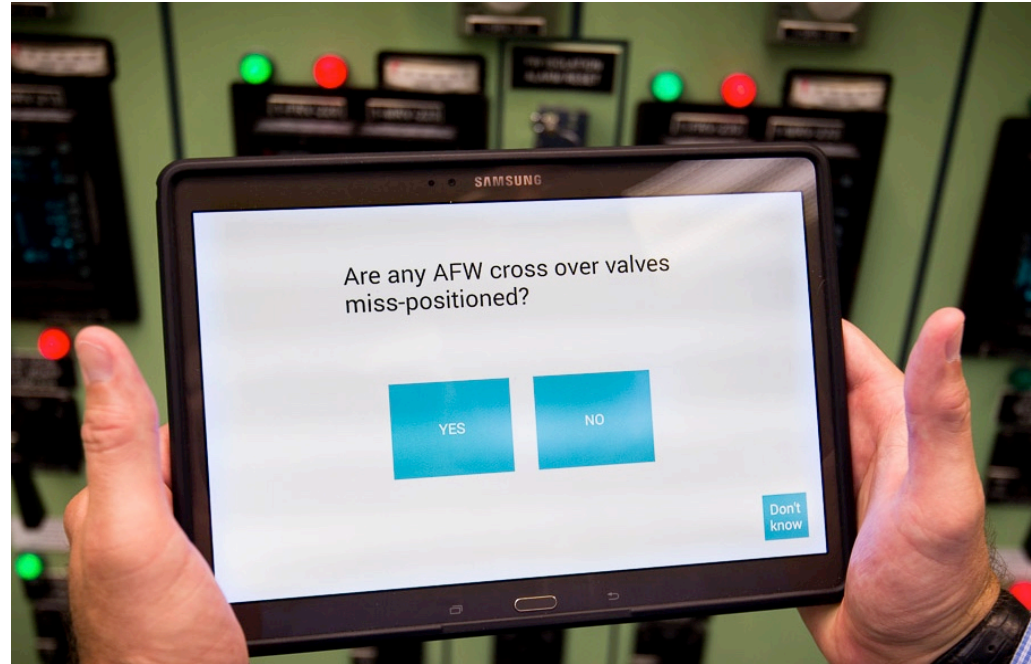


Relate to indications available on the panels/display in front of the participant

Part of real control room tasks

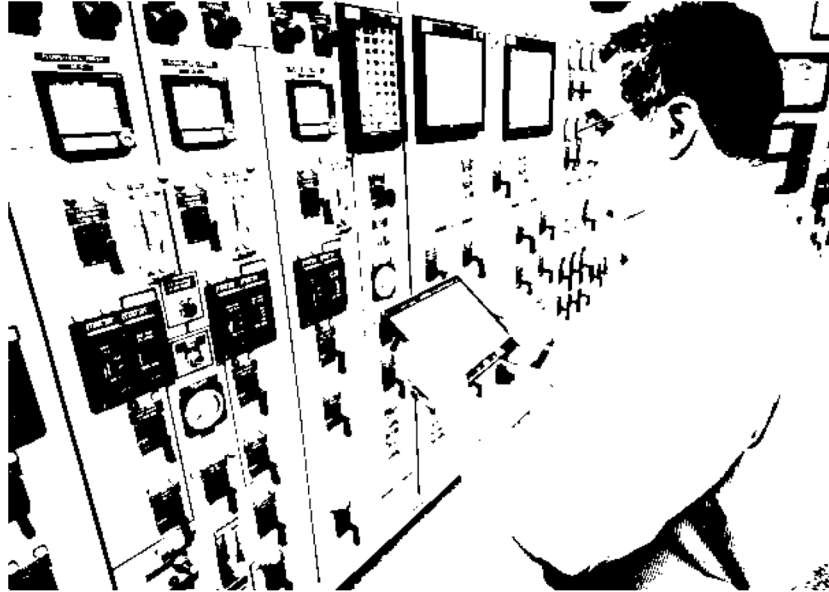
Easy-to-understand and quickly answerable individually (<20 s)

Single choice between options or numerical entry





Three data sets



Study 1: 16 licensed operators at a U.S. PWR training simulator

Study 2: 9 Swedish BWR operators at HAMMLAB HAMBO simulator

Study 3: 10 U.S. licenced PWR operators at HAMMLAB GPWR simulator

The operators answer independently in different control room locations

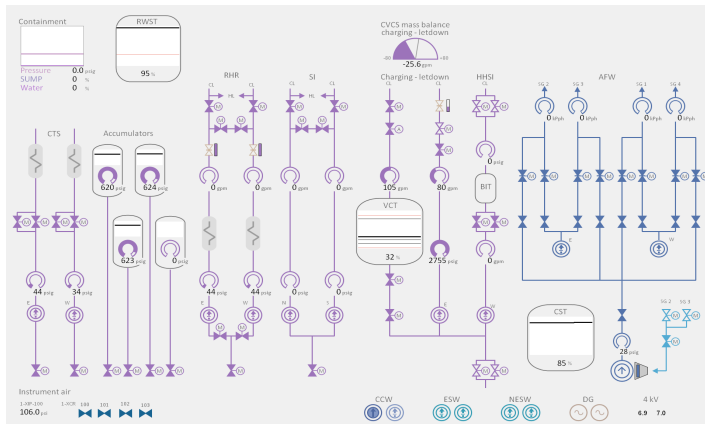
Trivia questions before the test to familiarize with the app



ANALOG PANELS

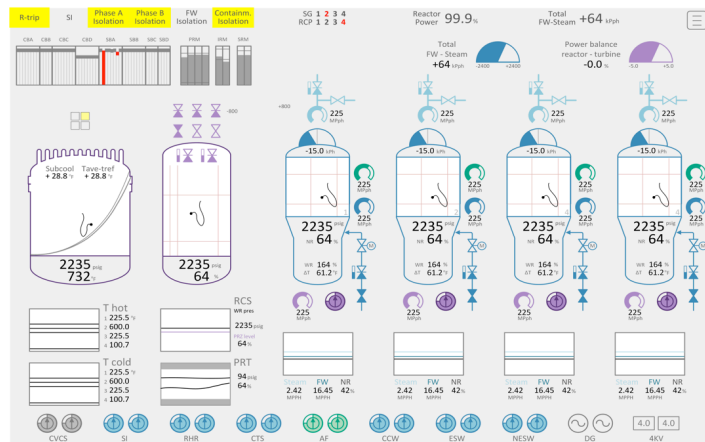
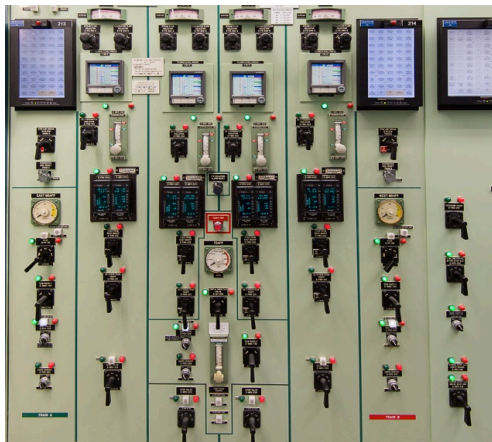
DIGITAL HSI

ECCS



Study 1

RCS



00:18:03

Monday
21 Jan 2013

311

FRYST

Larmöversikt

Trendöversiktning

Processöversiktning

Instruktioner

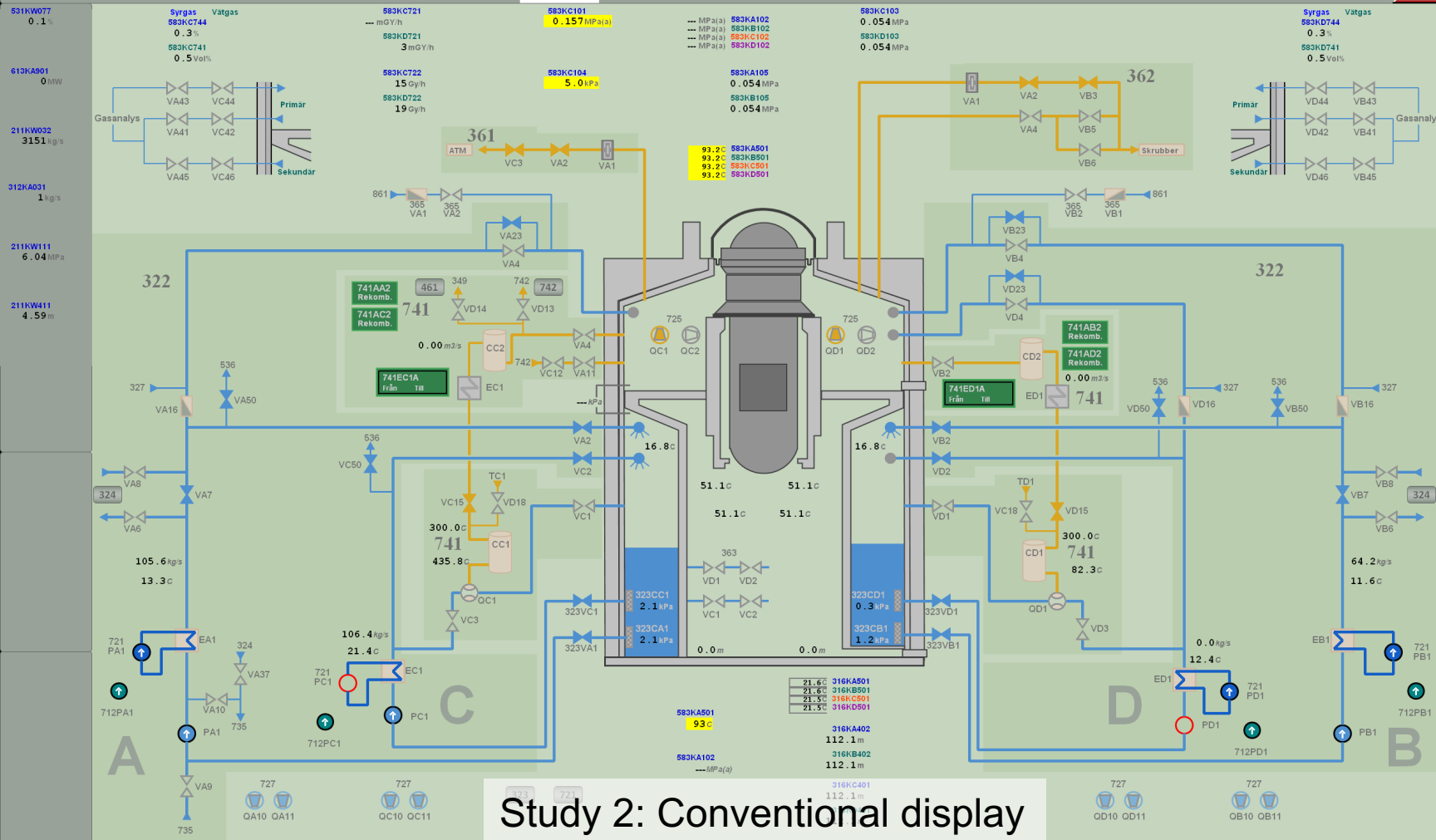
Störningsinstruktioner

Hanteringsbild PA

583

583

6



Study 2: Conventional display

00:18:03

Monday
21 Jan 2013

FRYST

Larmöversikt

Trendöversikt

Processöversikt

Instruktioner

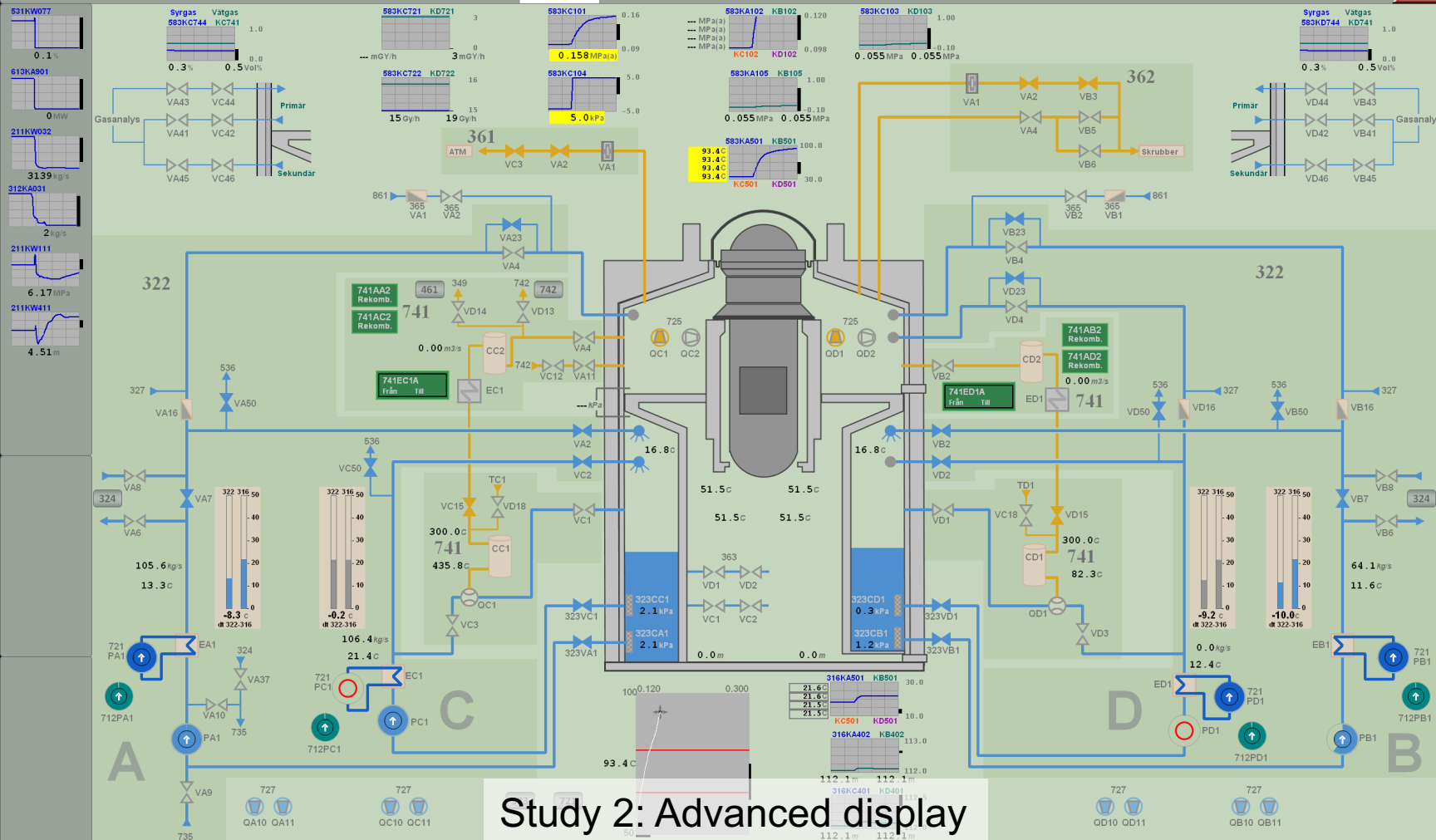
Störningsinstruktioner

Hanteringsbild PA

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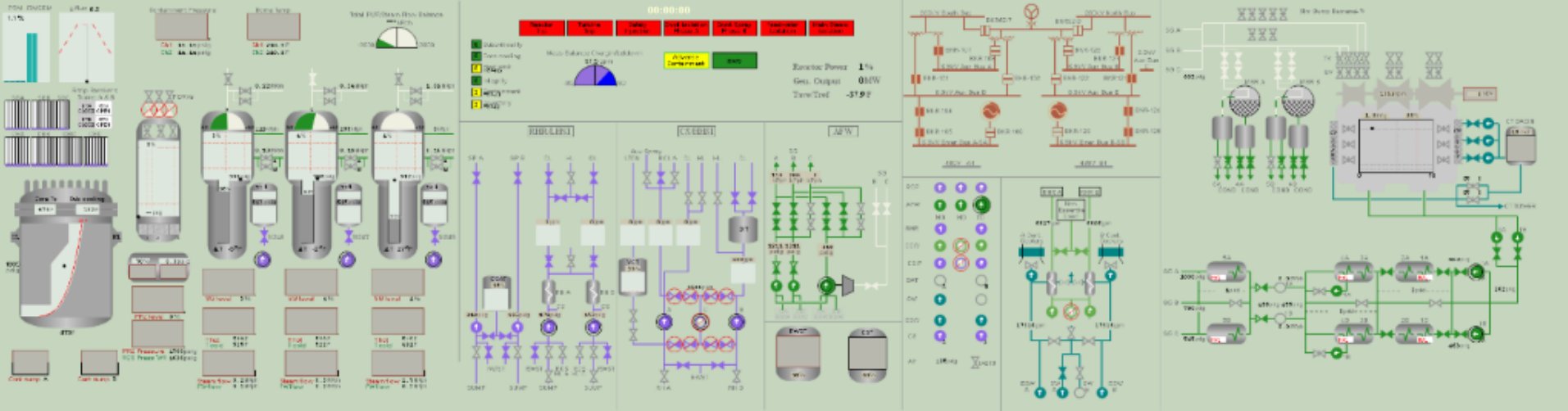
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583



Study 2: Advanced display

Study 2

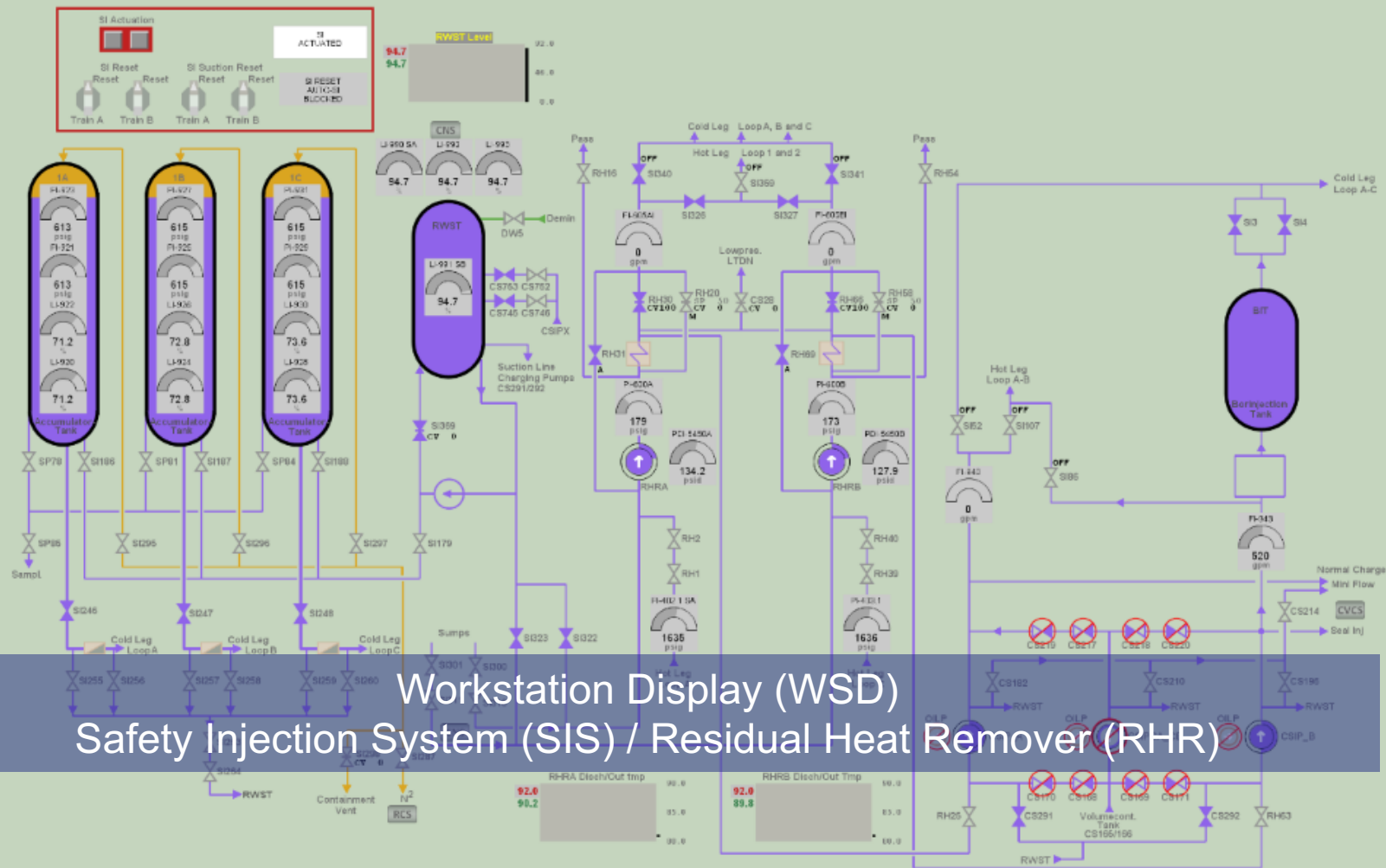


Large Screen Overview Display (LSOD)

Study 3



Study 3



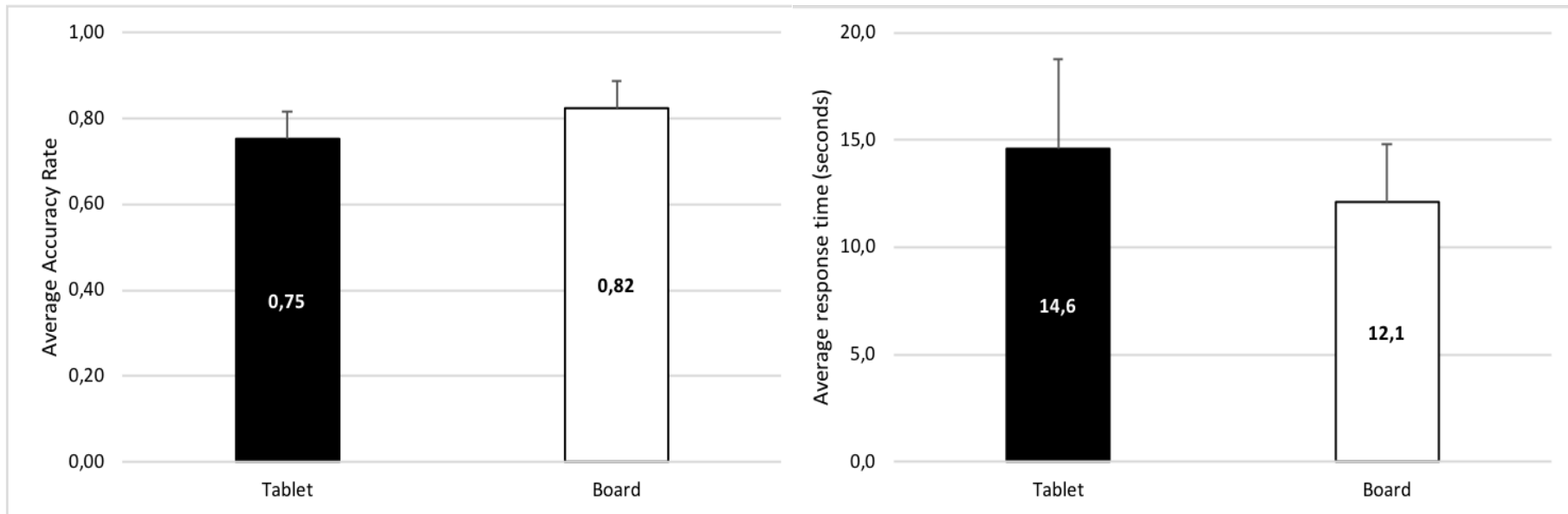


Results

Data set 1: Pressurized Water Reactor Training Simulator

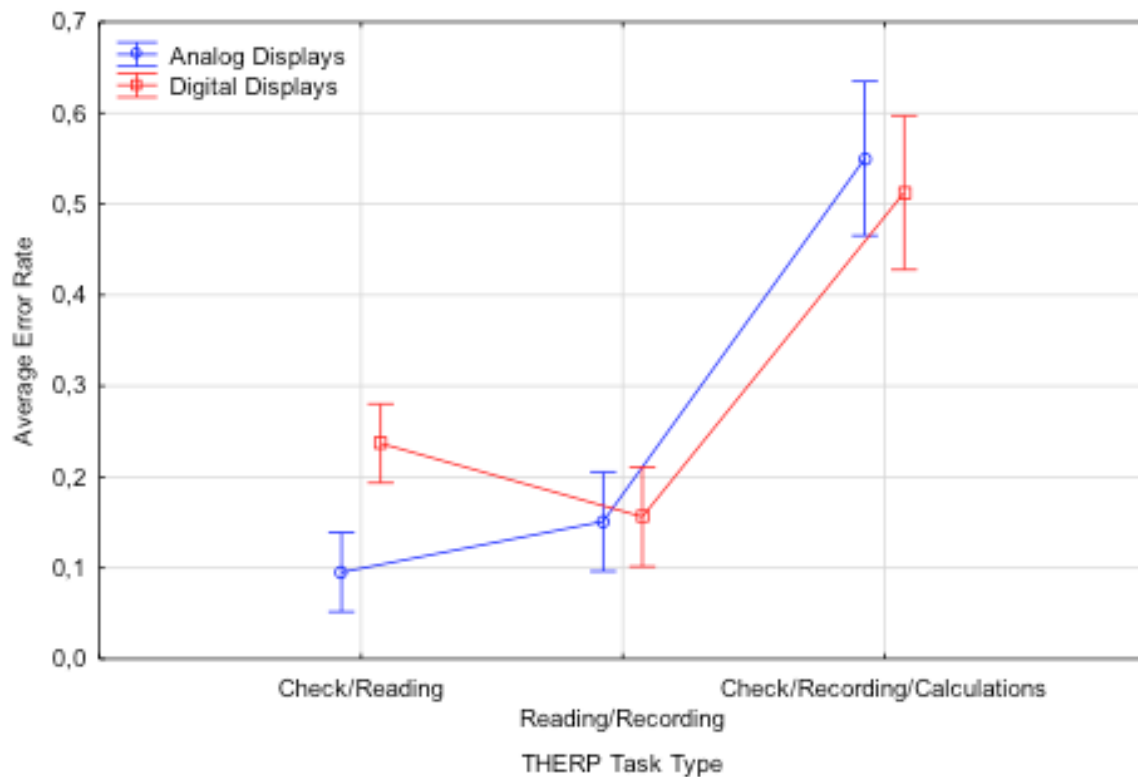


Data set 1 (PWR) accuracy and speed



The operators were more accurate and faster in the analogue panels than in the tablet

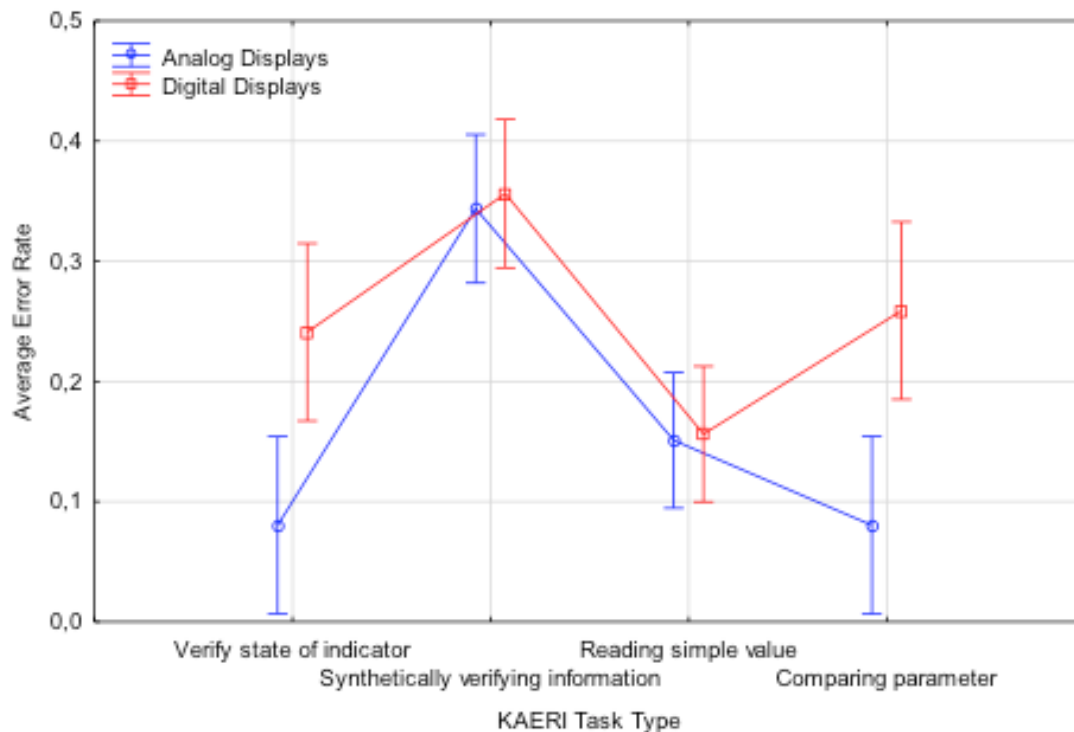
PWR THERP



Significant main effect of the task type $F(2, 1111) = 62.72, p < .00$

No main effect of the HSI $F(1, 1111) = 0.002, p = .96$

PWR KAERI



Significant main effect of the task type $F(3, 1109) = 18.10, p < .001$

No main effect of the HSI $F(1, 1109) = 3.04, p = .08$

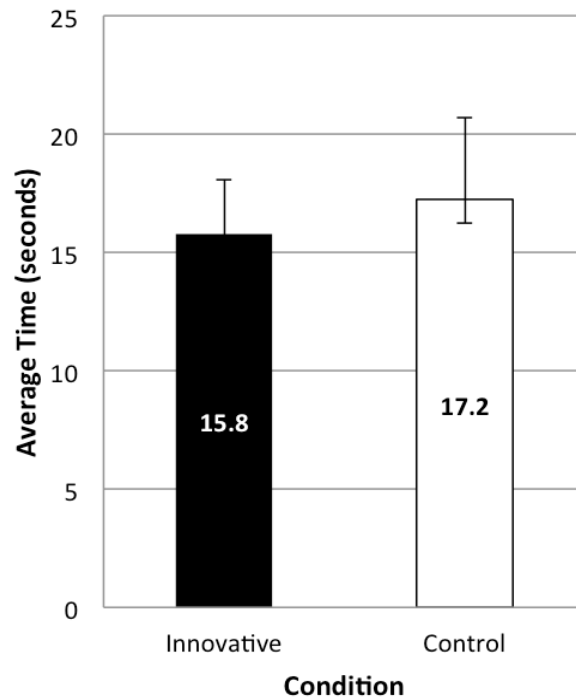
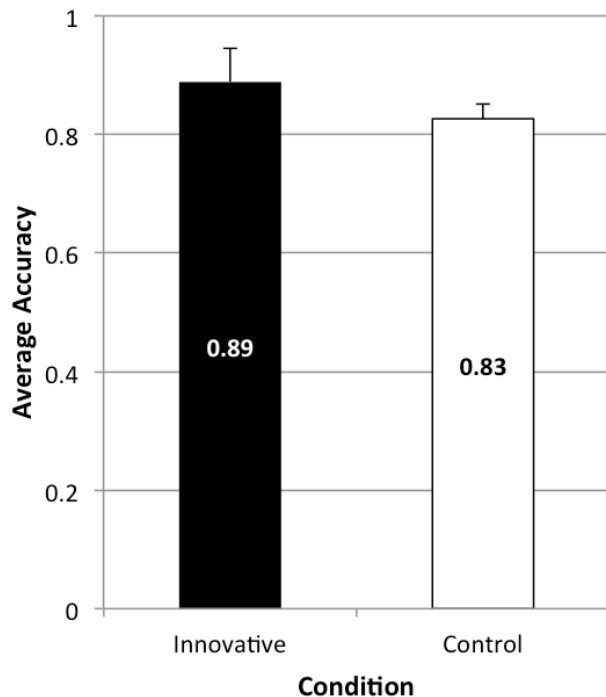


Results

Data set 2 Boiling Water Reactor HAMMALAB Simulator



Data Set 2 (BWR) accuracy and speed

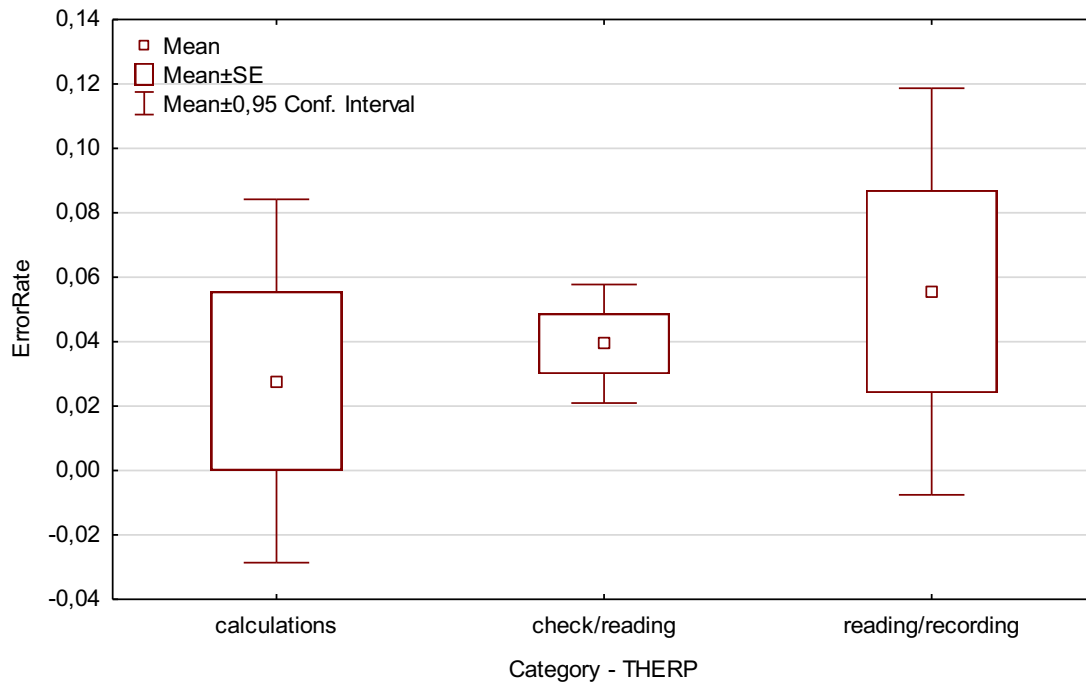


The difference in accuracy between innovative and conventional condition was not statistically significant

$t(8) = -1.79, p = 0.11$

Overall error rate was 8.7%

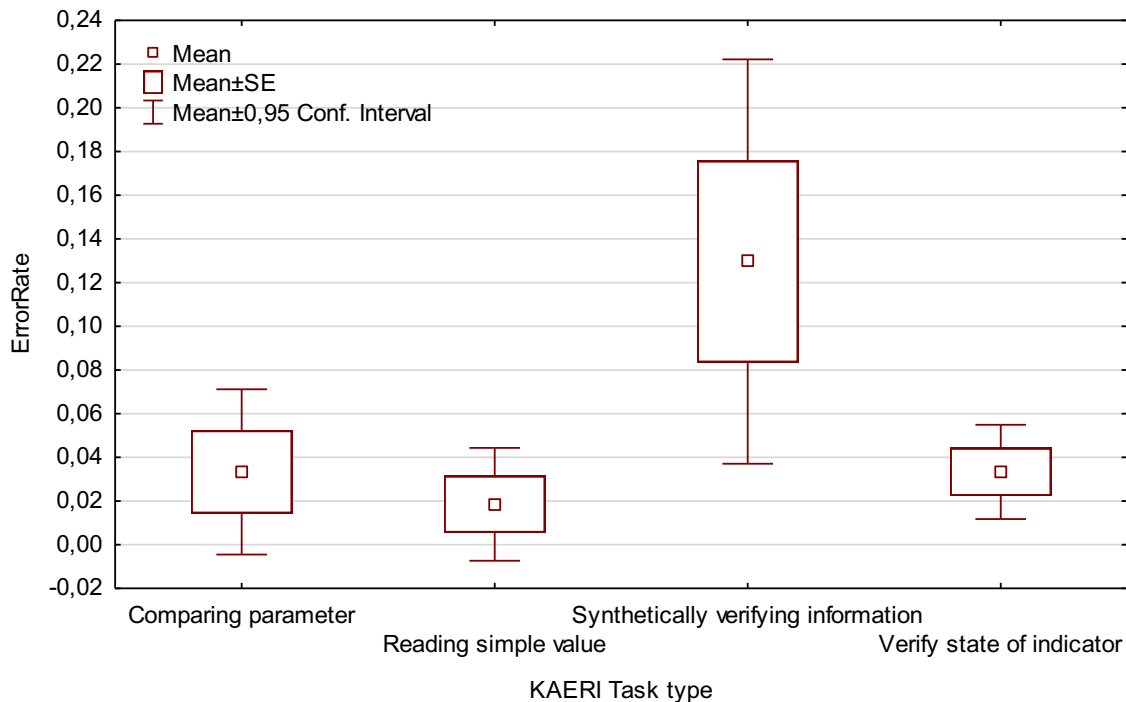
BWR THERP



Calculation has the lowest error rate: **opposite than in PWR data**

The sample sizes for calculation and reading/recording are small
(N=36 and N=54 respectively, as opposed to check/reading, N=432)

BWR KAERI



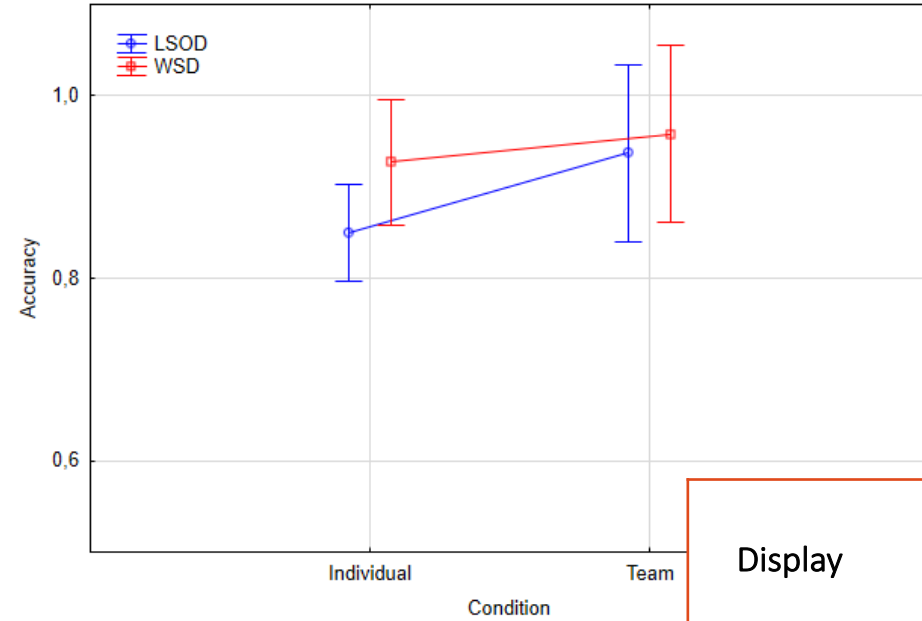
The pattern is **similar to the PWR study**

The sample size for synthetically verifying information is small, N=54

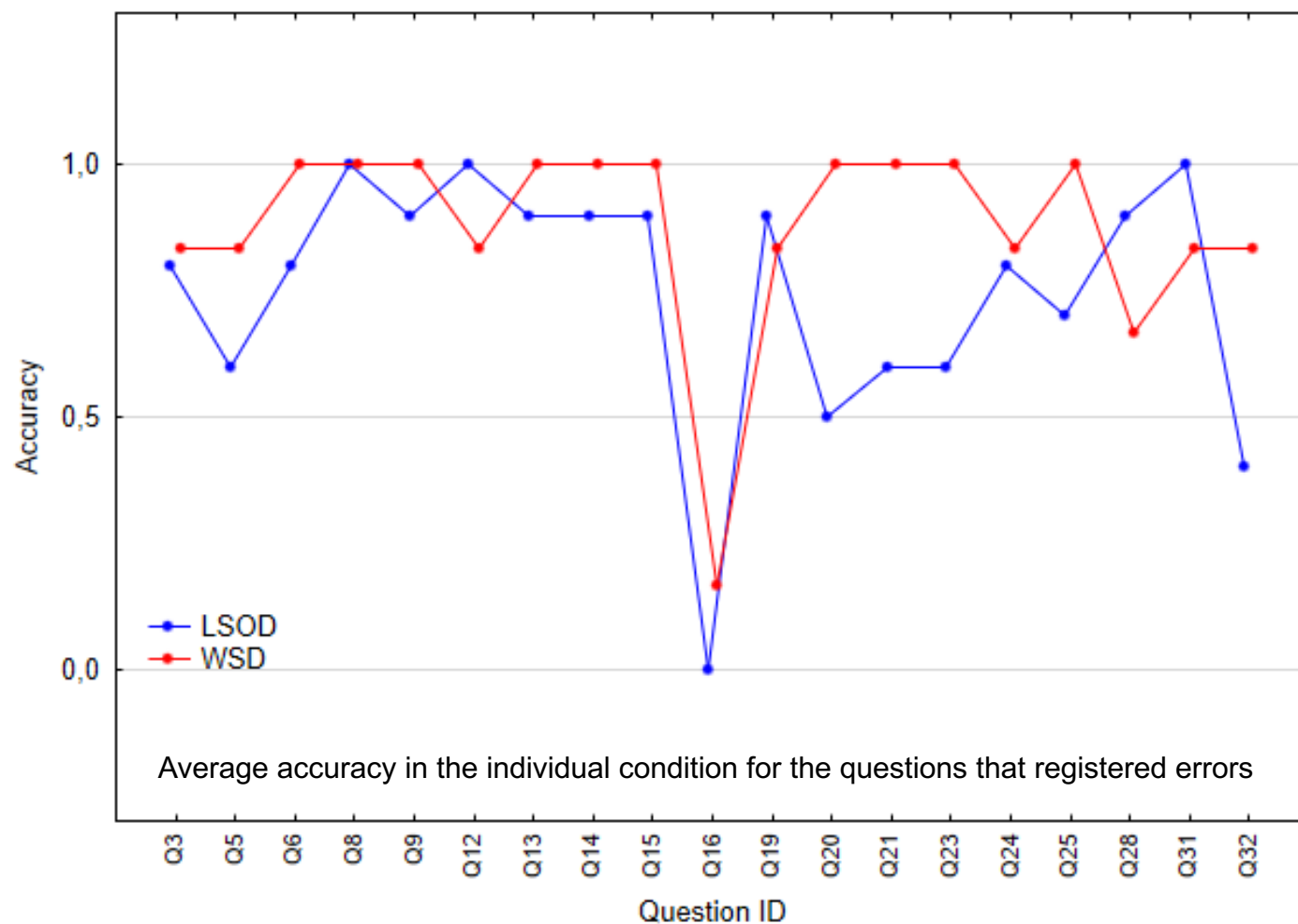


Results

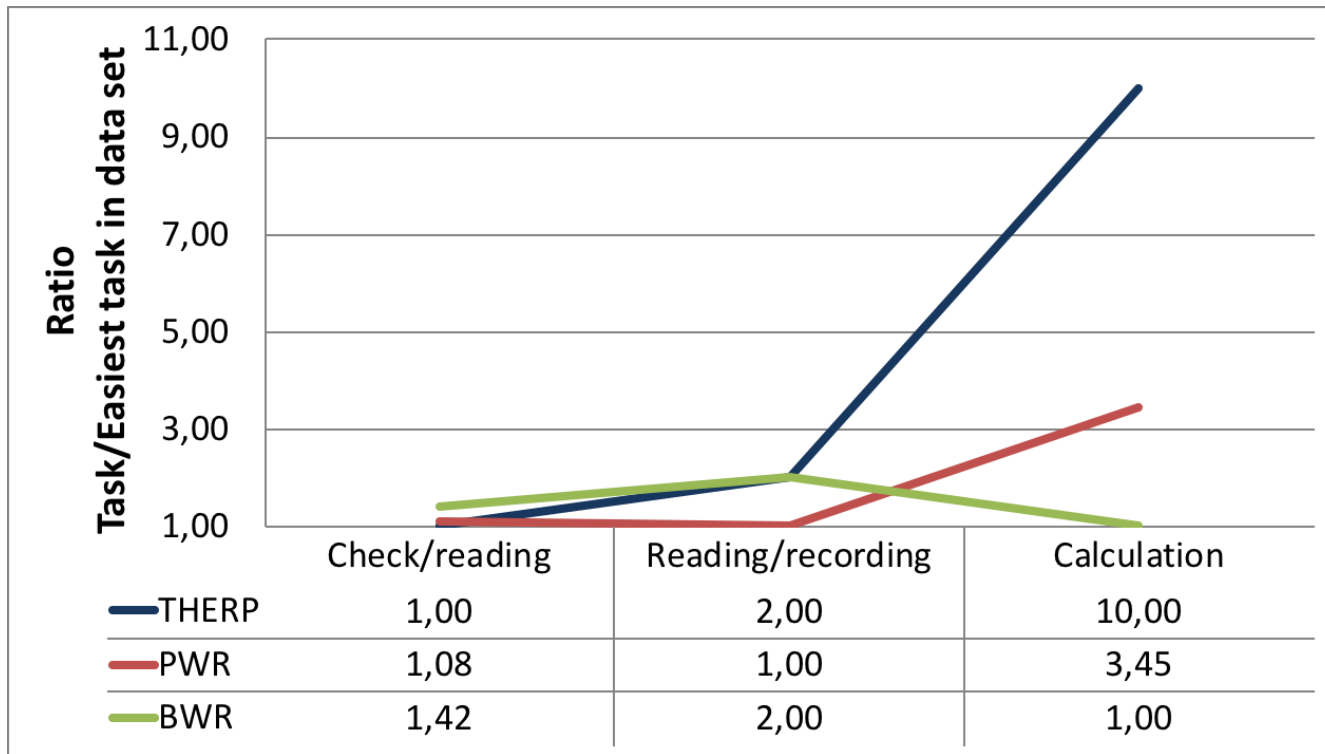
Data set 3 GPWR HAMMALAB Simulator



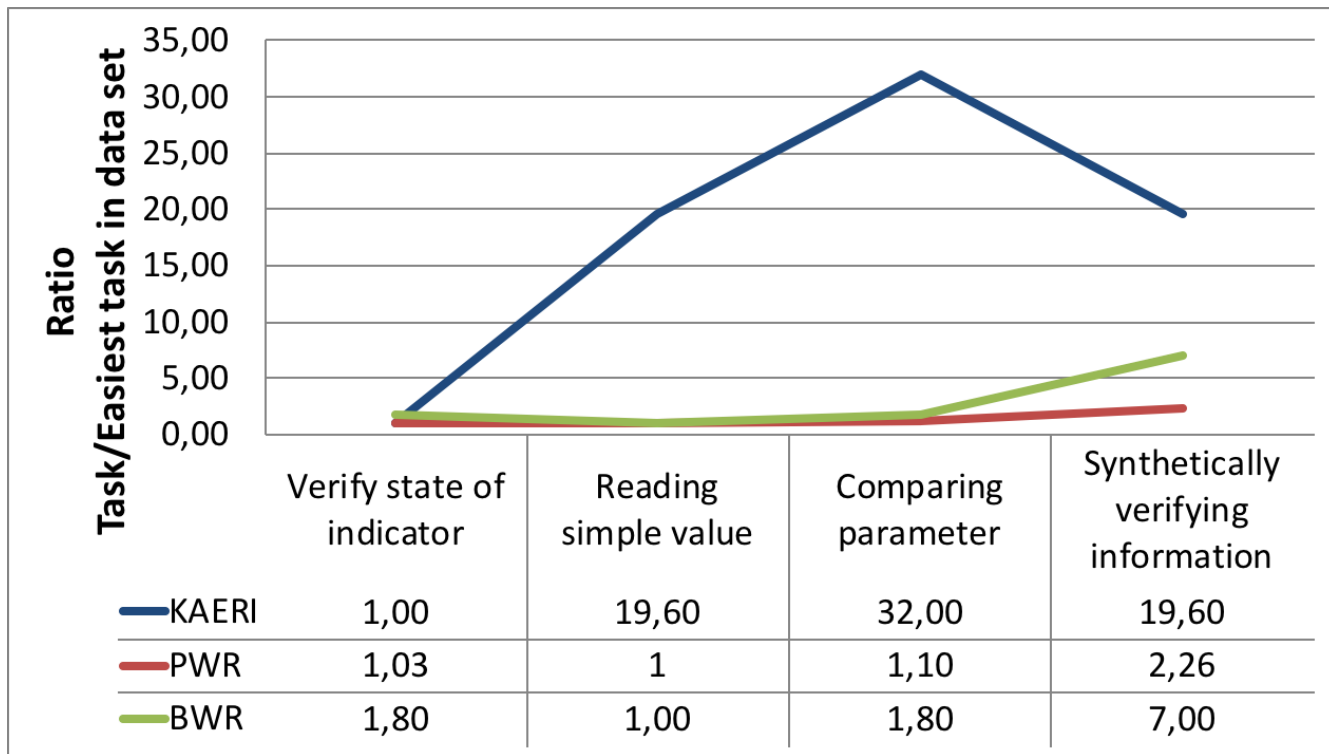
Display	Condition	Sec Means	Sec N	Accuracy Means	Accuracy N
LSOD	Individual	10,5	10	0,85	10
LSOD	Team	8,2	3	0,94	3
WSD	Individual	11,6	6	0,93	6
WSD	Team	10,9	3	0,96	3
All Groups		10,6	22	0,90	22



THERP's tasks relative differences



KAERI's tasks relative differences



Human error probabilities in THERP and KAERI and corresponding average error rates in the two micro-tasks data sets

Task	THERP	Micro-tasks 1	Micro-tasks 2	Task	KAERI (EOC)	Micro-tasks 1	Micro-tasks 2
Check/reading	0,001*	0,166 <i>N=608</i>	0,039 <i>N=432</i>	Verify state of indicator	0,0005	0,161 <i>N=224</i>	0,033 <i>N=270</i>
Reading/recording*	0,001** 0,003***	0,154 <i>N=384</i>	0,056 <i>N=54</i>	Synthetically verifying information	0,0098	0,350 <i>N=320</i>	0,130 <i>N=54</i>
Calculation	0,01	0,531 <i>N=160</i>	0,028 <i>N=36</i>	Comparing parameter	0,016	0,170 <i>N=224</i>	0,033 <i>N=90</i>
				Reading simple value	0,0098	0,154 <i>N=384</i>	0,019 <i>N=180</i>

*Digital indicator or analogue meter with easily seen limit marks; **Digital readout ≤ 4 digits; ***Analog meter



Micro-tasks vs. HRA error rates

The magnitude of the error rates observed in this study are higher than those commonly considered in HRA

Micro-tasks are **not** “average industrial conditions”, there are negative PSFs:

- Decontextualized, unrelated tasks

- shifting of the questions induced switch costs of executive control

- Tasks not meaningful

- Competition with colleagues (Speed-accuracy operating characteristic biased toward speed at the expense of accuracy)

- Questions appear easy but require processing time and create memory load

- No recovery potential

Micro-tasks relative differences are fairly consistent with THERP, not with KAERI HuREX data

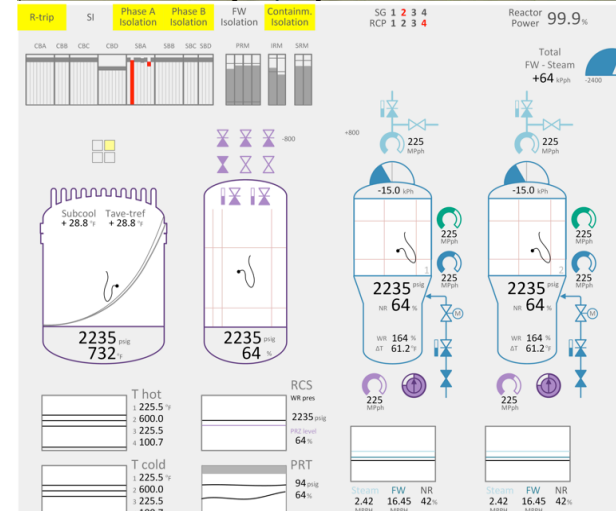
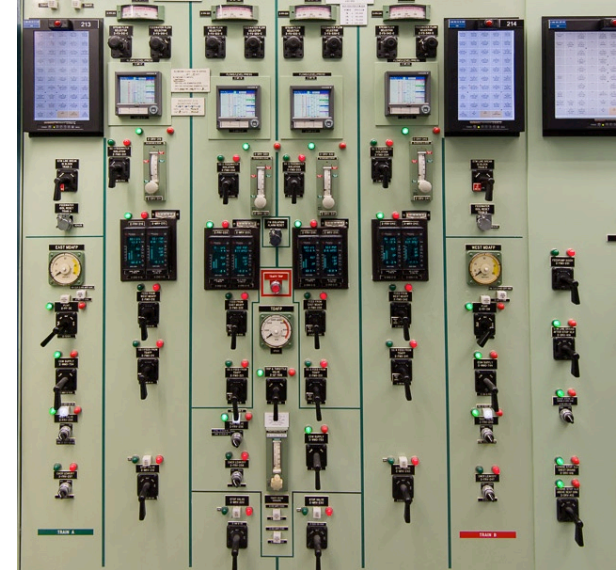
Effect of HSI on identification reliability

Small if any effect of the HSI

Error rate differences between task types are larger than the differences attributable to the HSI type.

Error rate increase due to HSI up to 72%

Error rate increase due to task up to 600%



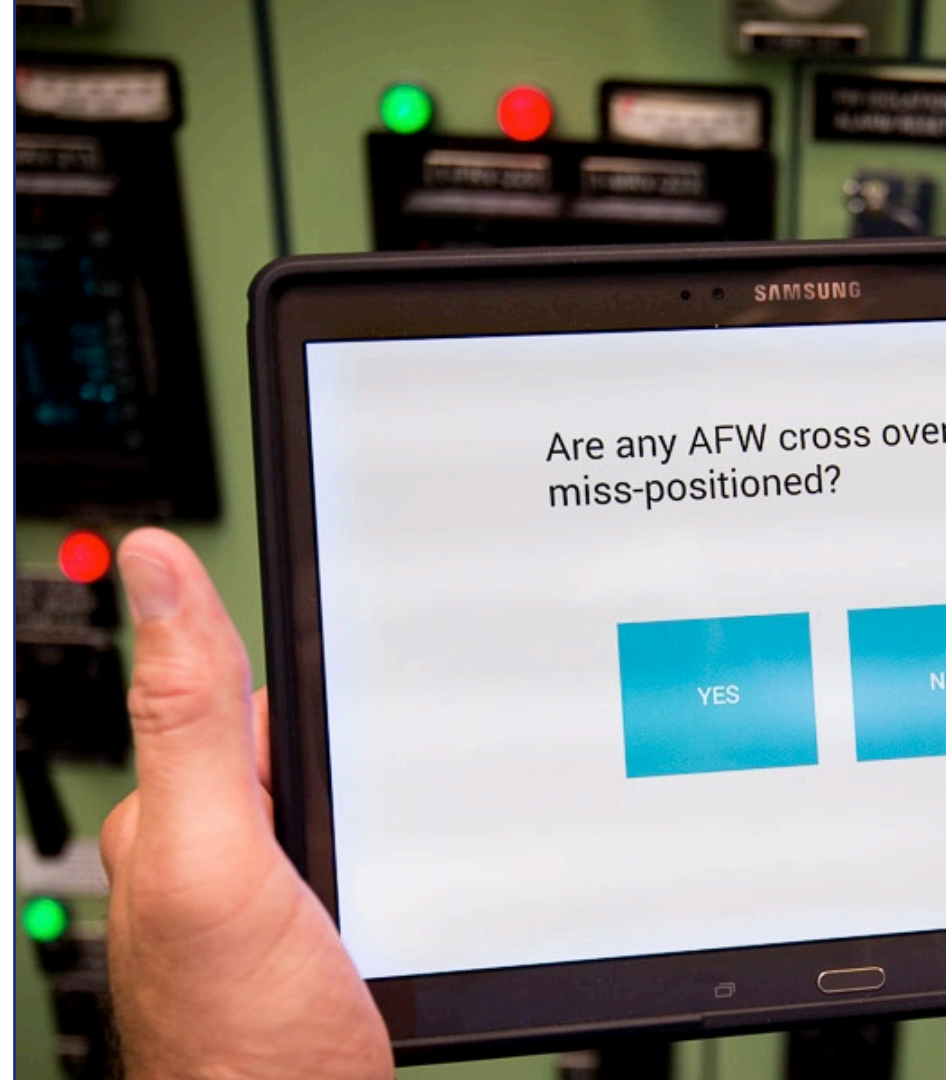
Conclusions

The Human System Interface has a relatively small impact on identification reliability

High error rates for Micro-tasks identification tasks than in HRA

Inconsistency with published HEPs rankings for identification task types

The micro-task method is an inexpensive way of broadening the empirical base of the HRA





References

Fernandes, A. (2019). Exploring the Effects of Large Screen Overview Displays: A Microtask Study. HWR-1276, Halden Reactor Project, Norway.

Jung, W., Park, J., Kim, Y., Choi, S. Y., & Kim, S. (2018). HuREX – A framework of HRA data collection from simulators in nuclear power plants. Reliability Engineering & System Safety. <https://doi.org/10.1016/j.ress.2018.07.036>

Massaiu, S. & Fernandes, A. (2019). The reliability of identification tasks in digital and analogue interfaces: A re-analysis of two micro-tasks studies. HWR-1218, Halden Reactor Project, Norway.

Swain, A. D., & Guttman, H. E. (1983). Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications - Final Report (No. NUREG/CR-1278).



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Back-up slides





THERP Identification tasks

Reading/recording: reading exact values on the display and recording

E.g., Reading from an analogue meter (HEP=0,003), Reading from a digital readout (HEP=0,001)

Check-reading: determining that the display it is within certain limits

Determines the presence of one of two conditions (e.g., light on or off?)

Could require more detailed qualitative discriminations (e.g., have the pointer moved upwards since the last check?) E.g., Check-reading digital indicators (HEP=0,001)

Calculations: simple arithmetic calculations

have the error probability of 0,01 both when executed with paper and pencil or with calculators.



THERP HEPs

Reading from a chart recorder (HEP=0,006)

Reading from a printing recorder (HEP=0,05)

Reading from a graphs (HEP=0,01)

Reading from a indicator lamps used as quantitative displays (HEP=0,001)

Recording numbers < 3 digits (HEP = negligible)

Recording numbers > 4 digits (HEP = 0,001 per symbol)

Check-reading analog meters (HEP=0,001-0,003)

Check-reading analog-type chart recorders (HEP=0,002-0,006)

Check-reading status/indicator lamps (HEP negligible).



KAERI (HuREX) Identification tasks

Korea Atomic Energy Research Institute (KAERI) Human Reliability data EXtraction" (HuREX)

Verify state of indicator as indicated by its discrete position

e.g., on/off, open/closed, running/not-running

Synthetically verifying information by using two or more information sources and integrating additional information

e.g., "Check if RHR pumps are operable"

Reading simple value of a continuous parameter that can be measured

e.g., "Check charging pump flow rate"

Comparing parameter

e.g., "Verify that the Reactor Coolant System pressure is less than 15kg/cm²", "Determine the Reactor Coolant System pressure"