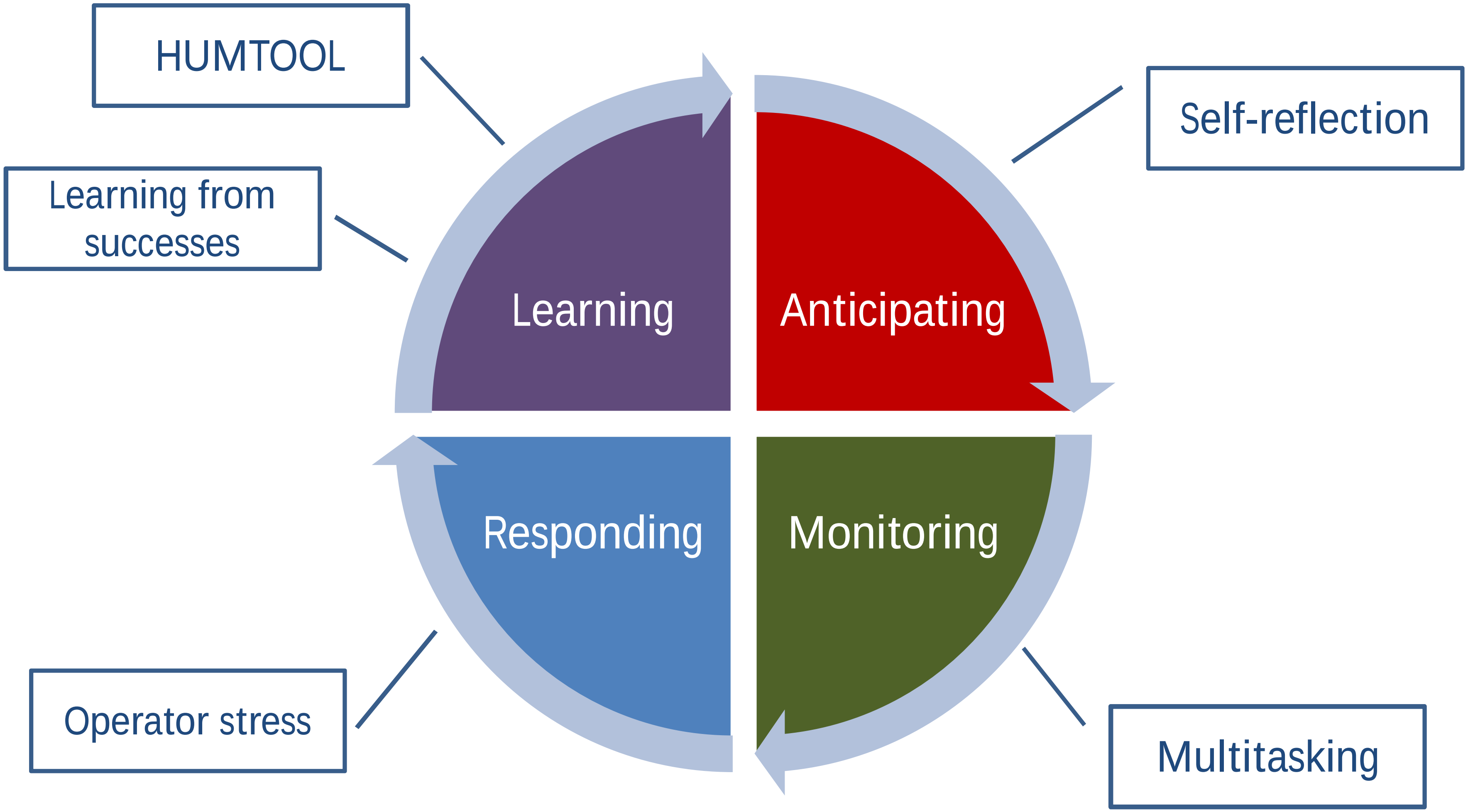
Crafting Operational Resilience in Nuclear Domain (CORE)

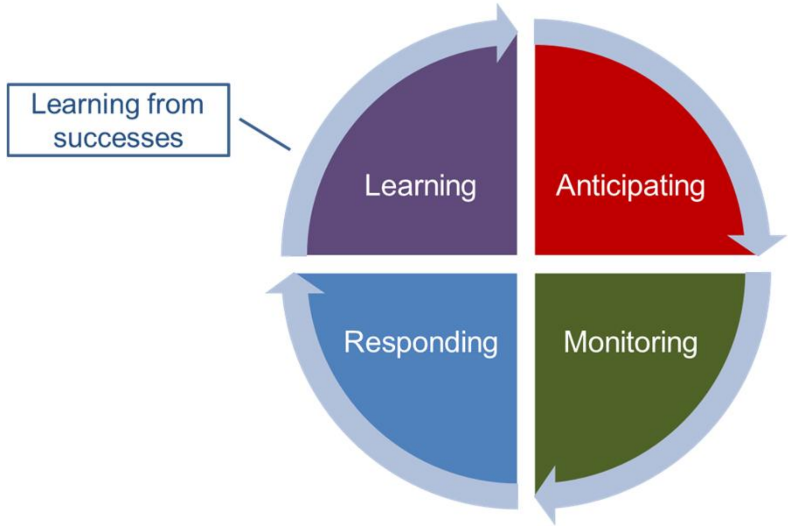
VTT Technical Research Centre of Finland
Finnish Institute of Occupational Health (FIOH)

SAFIR2018
Interim Seminar
23.03.2017

Project activities

CORE themes in terms of capabilities of operational resilience





Learning from successes

Learning from successes - Rationale

- Increasing emphasis has been put on the contribution of successful activities on safety
  - E.g., Resilience Engineering, “Safety-II” principle

- Some potentially relevant, practical reasons to focus on successes:

  → Understanding successes can reveal the factors that ensure system performance in both expected and unexpected situations

  → Understanding successes can avoid complacency and organization drift

  → Understanding successes can provide a huge amount of additional information to that provided by accident/incident investigations

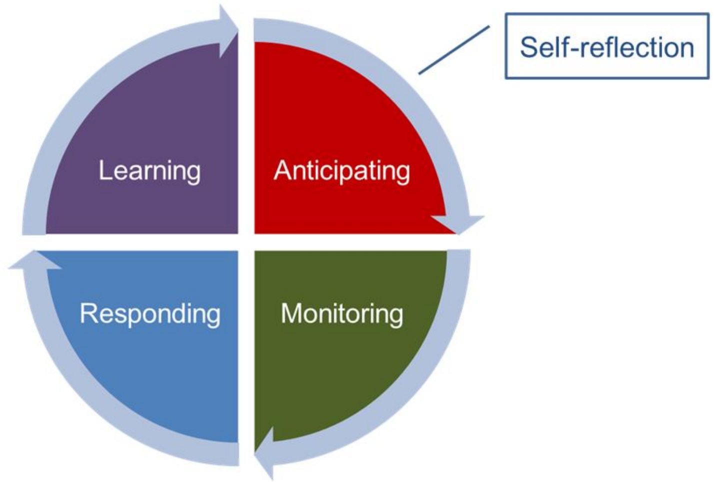
Learning from successes - Insights from empirical studies

- There has been genuine interest towards the idea of learning from successes among NPP personnel
- A variety of potentially useful practices or forums for learning from success already exist, including:
  - Informal “corridor talks”
  - Casually discussing successful experiences in periodic group meetings
  - Noting positive aspects during event-investigation meetings
  - Encouraging to bring up successes in post-job reviews or feedback meetings

- HOWEVER, while some existing practices do acknowledge/document successes,
  - Successes are rarely profoundly analysed, or
  - Successes are shared locally among teams or pairs
    - → Actual lessons might not be effectively generated
    - → Ineffective organizational learning may result
    - → Knowledge might be lost in turnover or organizational changes

Learning from successes
- Development of tools

- To address the potential shortcomings in learning from success, we have developed
  - Tools and principles to identify and generate lessons from successful experiences, and
  - Tools and principles to facilitate the acquisition and sharing of lessons learned from successes from/to others
- A set of guidelines has been developed regarding learning from successes
  - Proposes eight basic principles that should be considered when promoting learning from successes
  - Proposes a generic process for performing an analysis of successes
    - E.g., who to involve and how to organize the analysis, what steps are recommended to go through and examples of guiding questions for each step
- Further tools are under development...



Work-based learning development

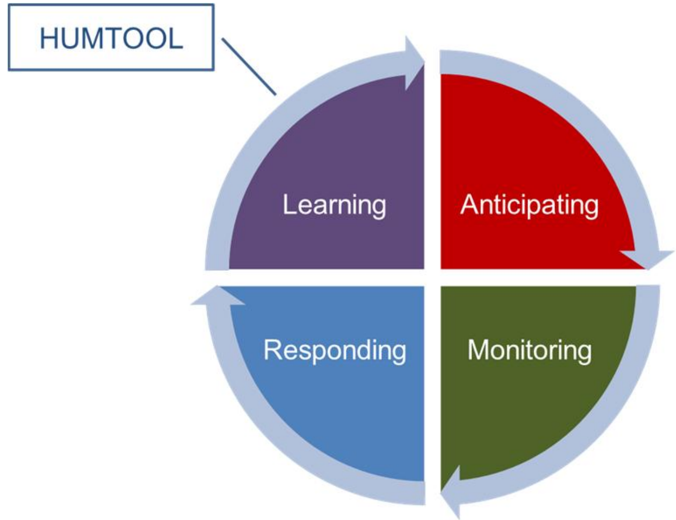
Identified shortcomings in operator training

- No possibilities to observe colleagues in one's own tasks
  → not sufficient dissemination of good work practices
- Uncertainty about sufficient "routine" for handling emergencies
  → not enough simulator training opportunities
- Uncertainty about developing problem-solving capabilities
  → simulator training focusing on procedure execution
- Mostly top-down approach to training in which operator specific needs and wants are ignored
  → Operators and their know-how not the source of new learning sufficiently

Self-reflection method for operator training

- Aims for method:
  1. Self-evaluation
     - thinking and writing about one's own simulator performance by structured criteria
  2. Group reflection
     - team discussion on simulator performance
  3. Dissemination of good practices
     - discussion between shifts

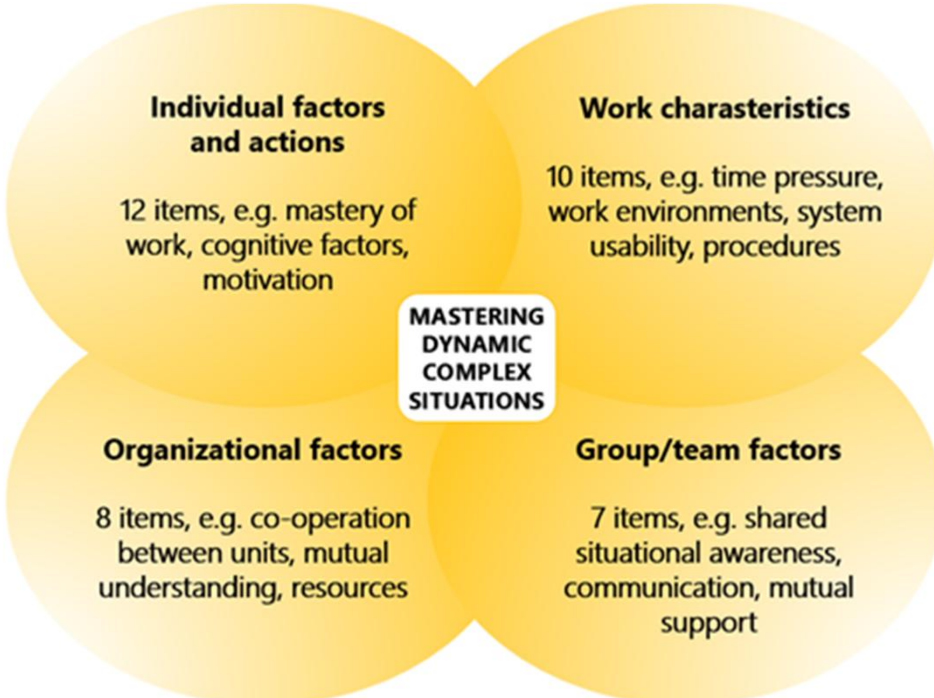
- Preliminary findings about the method:
  - Operators seemed positive about it: "could be actualized after some training sessions"
  - Has been taken into testing even without researcher presence
  - Lively discussion within the shifts emerged about safety-relevant themes → plant dynamics, stress, collaboration and use of procedures



HUMTOOL

HUMTOOL – Highlights (1)

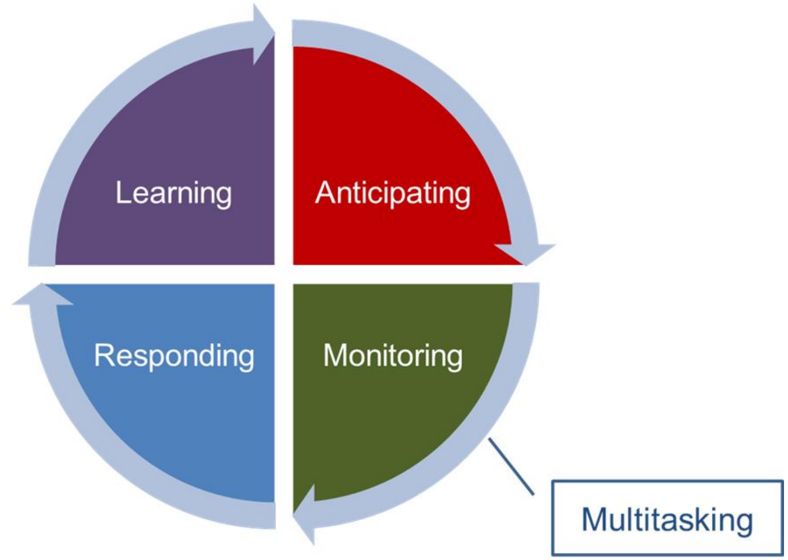
- We assessed human contribution in the current safety management system in nuclear industry
- We modified and tested a Human Factors (HF) tool as an investigation method in operative event (OE) analysis of nuclear industry



Contents of HF Tool

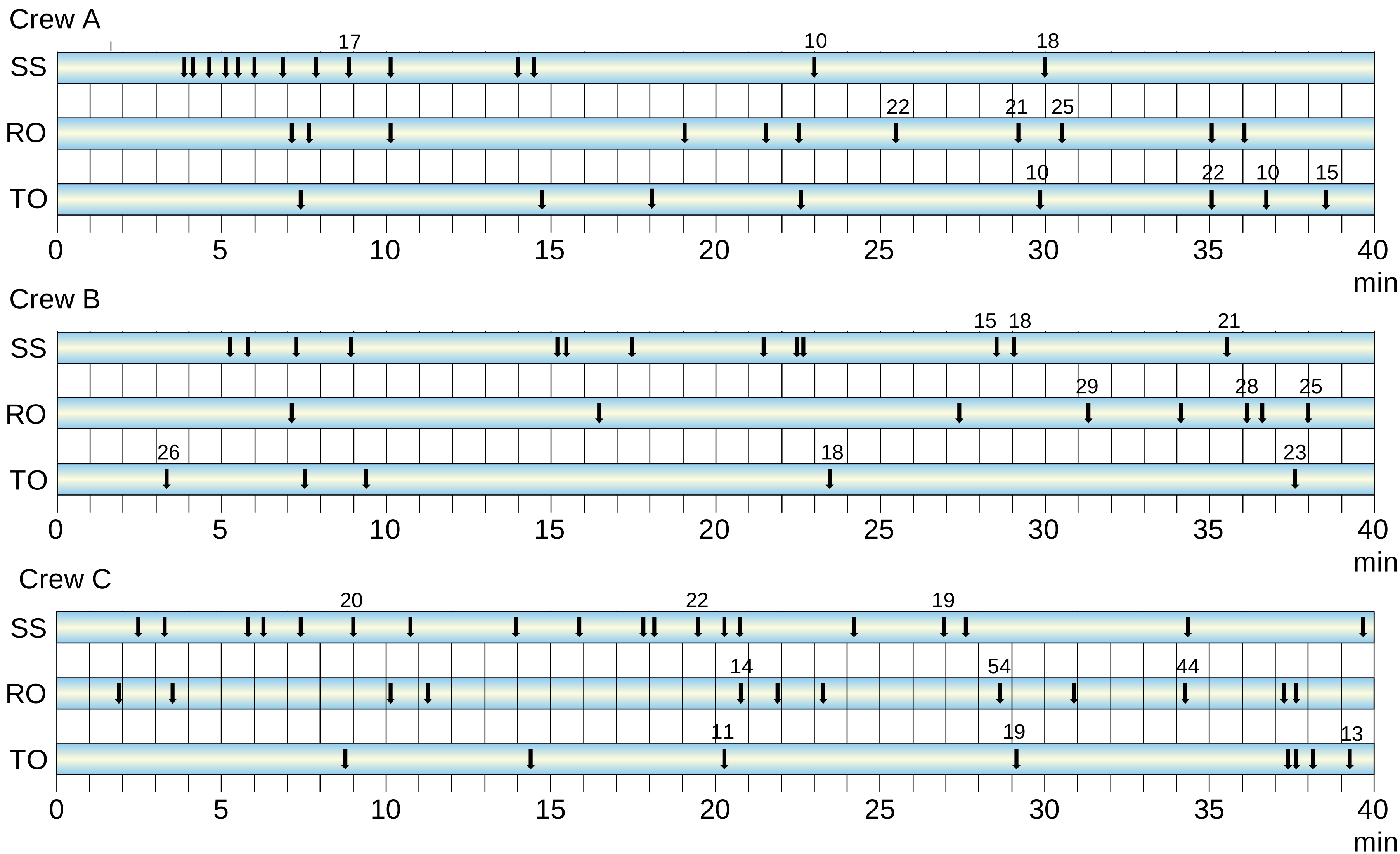
HUMTOOL – Highlights (2)

- We have found that:
  - OEs are mainly handled from technical aspects
  - Humans are usually regarded as a source of errors
  - There is a need for more concrete and holistic HF-tools and models, representing
    - macro-ergonomics and a new paradigm
    - positive safety thinking (Safety-II), supporting safety promotion and co-operation among nuclear stakeholders
- While testing the tool we found that:
  - New HF tool offered a more accurate picture of the HFs affecting OEs
    - moving focus from individual errors to all layers of system safety
  - HF tool focused on successes and the factors that maintain safety
  - HF tool offered learning potential for safety improvements
  - Users found the HF tool clear and easy to use and useful for OE investigation



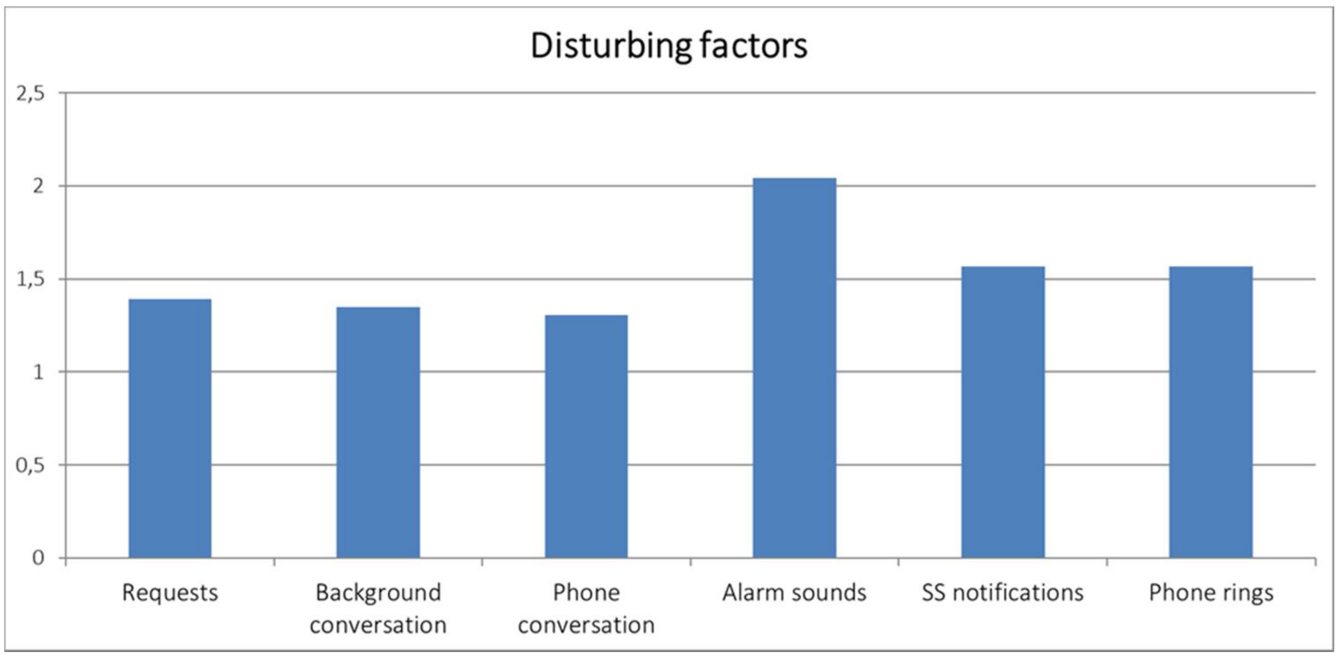
Supporting operational resilience

Interruptions in operator work
(Example: LOCA at training simulator)



Some key findings regarding interruptions

- Tasks that were frequently interrupted:
  - Procedure reading and execution 30%
  - Process monitoring 20%
  - Process control (panels & desks) 7%
- Operators typically reacted immediately to interruptions
- Operators tried to avoid multitasking in procedure execution: they accomplished each procedure path from the beginning to the end without moving to the next one



Some recommendations for interruption mgmt


Proper communication etiquette should be introduced


Irrelevant speech and noise should be minimized


Workplace should be made more resistant to interruptions


Task boundaries are suitable points for interruptions

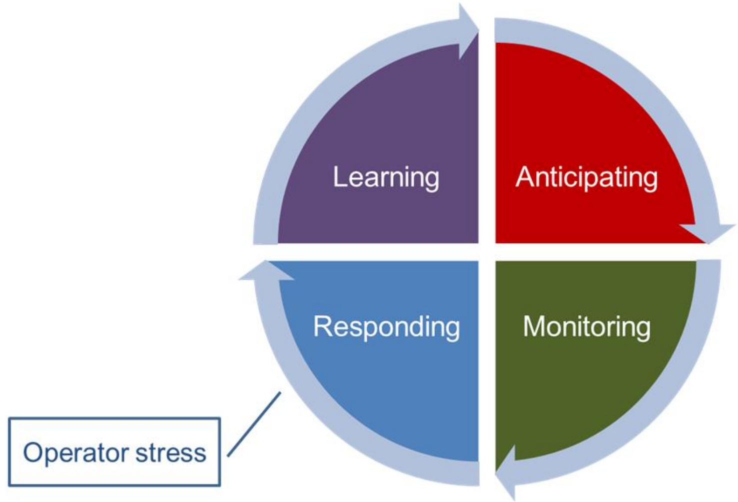

User-controlled multitasking should be facilitated


If the interruption could not be avoided, users should be warned beforehand


Users should be trained to avoid interruptions


Cues could be delivered reminding about the previous task’s status in order to help recovery from an interruption

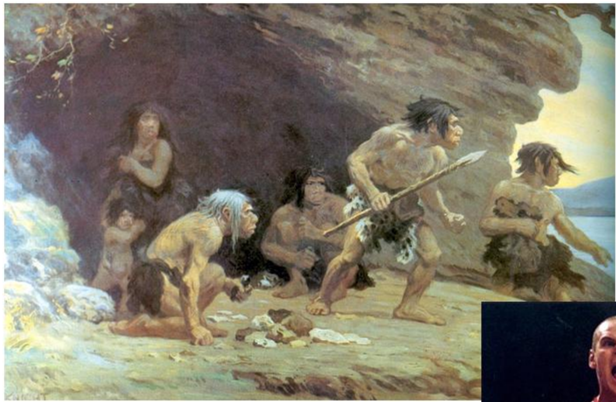
Finnish Institute of Occupational Health

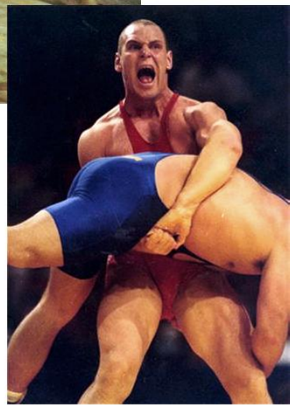


Stress management

Operator stress in simulated incident and accident scenarios

- Stress affects performance
  - Sensory systems, attention, memory, problem solving
  - Changes team dynamics: communication, decision making and situation awareness
  - The higher the stress level, the more detrimental the effects -> debilitating effects are more likely in crisis situations
- The need for objective stress measures
  - Sensitivity to perceive and become of aware of one’s stress varies between individuals and situations (e.g., work cultures) due to differences in motivation, attention and memory
  - Querying stress levels interrupts the task and may insert bias





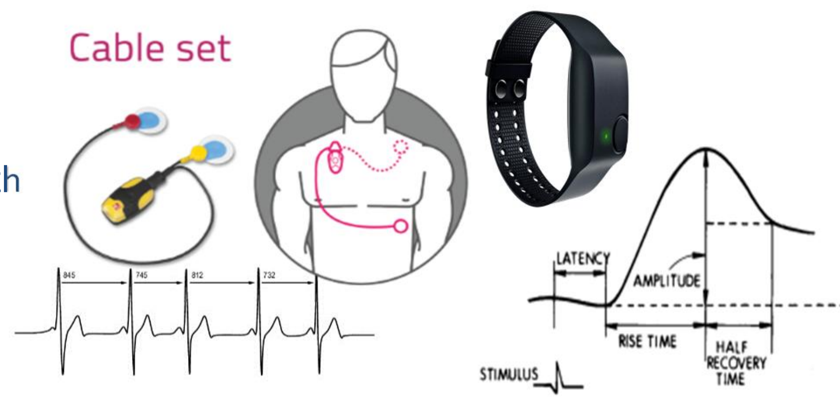
Stress is a physiological state ensuring our survival, prepares for ”fight of flight”

Finnish Institute of Occupational Health

Operator stress in simulated incident and accident scenarios

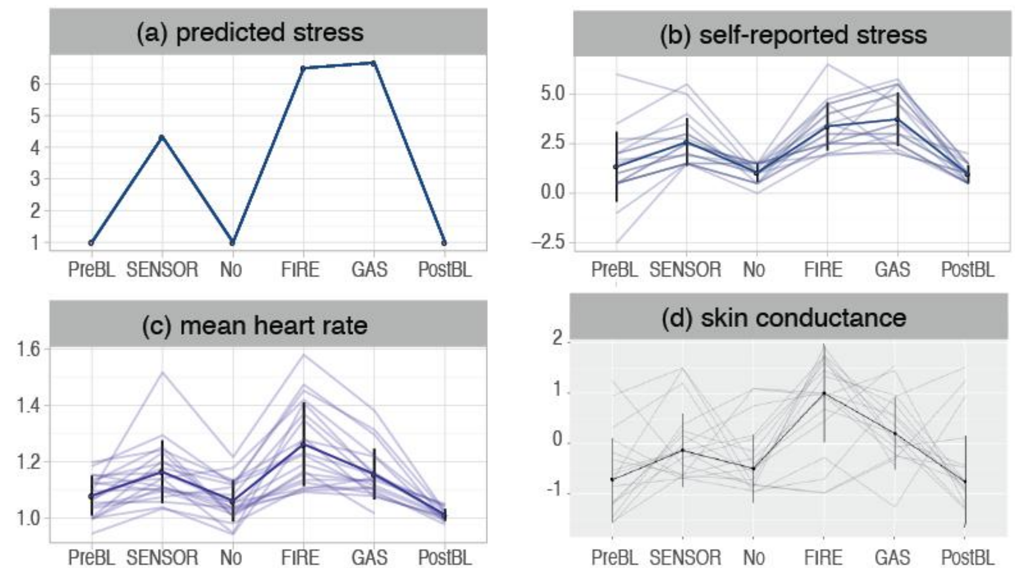
- Research questions
  - What is the stress level of the operator during incident and accident scenarios?
  - Does the experienced stress match the physiological state i.e. the physiological stress response of the operator?
  - Does the operator instructor's evaluation of stress match with the experienced and measures stress?

- Stress measurements in training simulator:
  - Three scenarios (routine testing, fire, radioactive steam leakage), normal operation, and baseline measurements (before and after scenarios)
  - 6 crews, with 3-4 operators each
  - The physiological stress response was measured with skin conductance and cardiac sensors
  - Perceived stress (operators)
  - Predicted load (operator instructors)

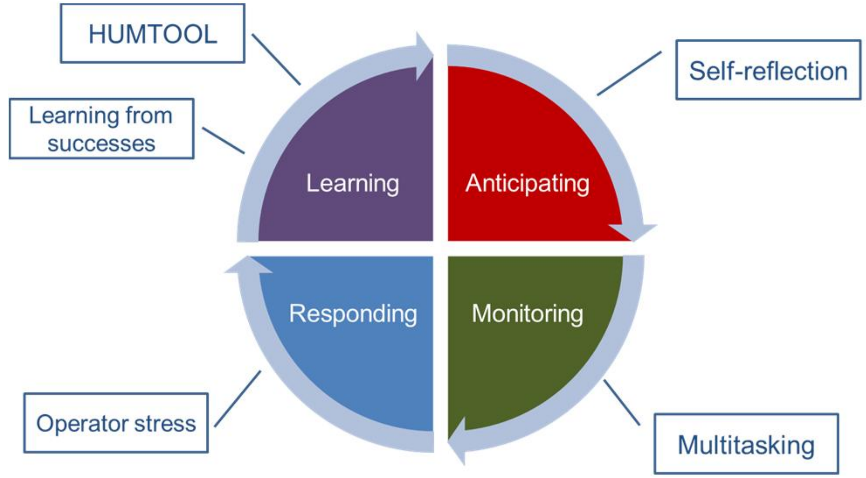


Results & Conclusions

- Operators do experience stress during simulated scenarios
- Stress is highest for the events with a possible radiation risk, moderate for the routine testing, and the lowest for normal operation and baselines
- Operators’ perceived stress is not always in line with the physiological stress response
  - Possibly due to individual differences in their sensitivity to perceive and ability to accurately report the stress at different phases of simulations
- Simulator instructor can predict the overall stressfulness of the different scenarios
  - Temporal resolution is limited



- **Physiological measurements of stress produce** detailed information on the individual’s stress at different time points, without interfering with the primary task
- **Information may be more reliable** as it is not dependent on participants’ memory for the events and not biased by interpretations, reasoning or motivational issues


HUMTOOL
Learning from successes
Self-reflection
Learning
Anticipating
Responding
Monitoring
Operator stress
Multitasking

Conclusion

Concluding remark

- There is increasing evidence that tools/practices/guidance/interventions/ procedures for

    1) gathering positive operating experiences from challenging operational situations

    2) promoting reflective thinking and learning and effective interruption management and troubleshooting among operators

    3) management of acute stress and fatigue

    4) promoting communication and coordination of activities in emergency exercises

    5) analysing human contribution to nuclear safety

  make the operative personnel work safer

  BUT: our work is still in progress, and more conclusions can be made in the near future

Key publications

Aaltonen, I., Kuula, T., Wahlström, M., Aikala, M., & Laarni, J. (2015) Challenges and training needs in NPP automation maintenance. *Proceedings of ANS NPIC&HMIT 2015*.

Koskinen, H., Laarni, J., Torkkeli, K. & Vesaoja, E. (2015). Pre-validation of a new interactive operating panel system for a nuclear power plant training simulator. *Proceedings of ANS NPIC&HMIT 2015*.

Laarni, J., Karvonen, H., Pakarinen, S. & Torniainen, J. (2016). Multitasking and interruption management in control room operator work during simulated accidents. In Proceedings of the HCI International 2016. Springer.

Liinasuo, M., Koskinen, H., & Porthin, M. (2016). Principles, practises and developmental needs of emergency exercises in Finland" In Proceedings of the Enlarged Halden Group Meeting (EHPG), May 8-13, Sandefjord, Norway.

Pakarinen, S., Leinikka, M., Torniainen, J., Henelius, A., Cowley, B., Lukander, K., & Huotilainen, M. (2015). Quantifying mental workload with minimally disruptive measurements of cardiac and electrodermal activity in real-life situations. *9th World Congress of International Brain Research Organization IBRO, Rio de Janeiro, Brazil, July 7-11, 2015.*

Pakarinen, S., Korpela, J., Torniainen, J., Laarni, J & Karvonen, H. (2016). Control Room Operator Stress and Cardiac Activity in Simulated Incident and Accident Situations. In Proceedings of Enlarged Halden Group Meeting (EHPG), May 8-13, Sandefjord, Norway.

Skjerve, A.B., Viitanen, K., Axelsson, C., Bisio, R., Koskinen, H. & Liinasuo, M. (2016). Learning from Successes in Nuclear Operations – A Guideline to be presented at ESREL2017 in 18.-22.6.2017.

Teperi, A.-M., Puro, V., & Ratilainen, H. (in press). Applying a new human factor tool in the nuclear energy industry. *Safety Science*.

Torniainen, J., Cowley, B., Henelius, A., Lukander, K., & Pakarinen, S., "Feasibility of an electrodermal activity ring prototype as a research tool." *37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society EMBC 2015, Milan, Italy August 25-29, 2015.*

Torniainen, J., Korpela, J. & Pakarinen, S. (2016). Control Room Operator Stress and Electrodermal Activity in Simulated Incident and Accident Situations. In Proceedings of the Enlarged Halden Group Meeting (EHPG), May 8-13, Sandefjord, Norway.

Viitanen, K., Axelsson, C., Bisio, R., Oedewald, P., & Skjerve, A. B. (2015). Enhancing Resilience by Introducing a Human Performance Program. Presented at *the 6th REA Symposium, Lisbon, Portugal,* June 22-25, 2015.

Viitanen, K., Koskinen, H.., Axelsson, C., Bisio, R., Linnasuo, M. & Skjerve, A. B. (2016). Learning from Successful Experiences: An Undeveloped Potential in the Nuclear Industry? In Proceedings of the Enlarged Halden Group Meeting (EHPG), May 8- 13, Sandefjord, Norway.

Wahlström, M. & Kuula., T. (2016). Organizational self-determination and new digital self-study applications as means for developing nuclear power plant operation training" In Proceedings of HCI International 2016.