The MTO Safety Perspective and Selected Research Activities at the Halden Reactor Project

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Content

Purpose

• Introduction to the MTO perspective.¹)

• Selected research projects
  – Five examples on research projects performed by the OECD Halden Reactor Project (HRP).

• Practical implications and next step

¹) The views presented here are the views of the authors, not necessarily of IFE, OECD Halden Reactor Project.
IFE, OECD Halden Reactor Project

Institute for Energy Technology (IFE) hosts the OECD Halden Reactor Project.

The Halden Reactor Project:
- International co-operative effort
  - Affiliated to OECD NEA in Paris
- Aim:
  - Improve safety at operating NPP’s
- Project established in 1958
- Jointly funded by its Members:
  - 20 countries
  - > 100 nuclear organisations world wide
- Participant types
  - Utilities, Vendors, Licensing Authorities and R&D centres
- 3 year program periods.
OECD Halden Reactor Project (cont.)

**Signatory members:**
- the Institutt for energiteknikk (IFE), Norway,
- the Belgian Nuclear Research Centre SCK•CEN, acting also on behalf of other public or private organisations in Belgium,
- the Technical University of Denmark,
- the Finnish Ministry of Employment and the Economy (TYÖ),
- the Electricité de France (EDF),
- the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH, representing a German group of companies working in agreement with the German Federal Ministry of Economics and Technology,
- the Japan Nuclear Energy Safety Organization (JNES),
- the Korean Atomic Energy Research Institute (KAERI), acting also on behalf of other public or private organisations in Korea,
- the Spanish Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), representing a group of national and industry organisations in Spain,
- the Swedish Radiation Safety Authority (SSM), representing public and private nuclear organisations in Sweden,
- the Swiss Federal Nuclear Safety Inspectorate ENSI, representing also the Swiss nuclear utilities (Swissnuclear) and the Paul Scherrer Institute,
- the National Nuclear Laboratory (NNL), representing a group of nuclear licensing and industry organisations in the United Kingdom, and
- the United States Nuclear Regulatory Commission (USNRC).

**Associated parties:**
- the Czech Nuclear Research Institute (NRI),
- the French Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Commissariat à l’énergie atomique (CEA), France,
- EU JRC Institute for Transuranium Elements, Karlsruhe, Germany,
- the Hungarian Academy of Sciences, KFKI Atomic Energy Research Institute,
- the Italian National Agency for new Technologies, Energy and Sustainable Economic Development (ENEA), representing a group of Italian companies,
- Japan Atomic Energy Agency (JAEA),
- the Central Research Institute of Electric Power Industry (CRIEPI), representing a group of nuclear research and industry organisations in Japan,
- the Mitsubishi Nuclear Fuel Co., Ltd. (MNF)
- the Ulba Metallurgical Plant JSC in Kazakhstan,
- the JSC "TVEL" and NRC "Kurchatov Institute", Russia,
- All-Russian Research Institute for Nuclear Power Plants Operation (VNIIAES), Russia,
- the Slovakian VUJE - Nuclear Power Plant Research Institute,
- the Federal Authority for Nuclear Regulation (FANR), United Arab Emirates,
- and associated parties from USA:
  - the Westinghouse Electric Power Company, LLC (WEC),
  - the Electric Power Research Institute (EPRI),
  - the Global Nuclear Fuel (GNF) – Americas, LLC and GE-Hitachi Nuclear Energy, LLC, and
  - the US Department of Energy (DOE).
The MTO Labs

HAMMLAB
- Full-scale PWR & BWR simulators.
History: Humans as components

Early 20th century
- *Scientific Management* – may be seen as the first framework theory, which included a focus on *ergonomic* issues within an industrial setting.
  - Improve production effectiveness
  - Humans as components
  - Performance specification.

Around WWII
- Humans’ adaptability is not without limits → Human Factors.
  - Movement potentials, tolerance for environmental influences, sensory system, etc.

- Safety: Achieved largely as a result of repetitions of established routines.
- ‘Human errors’ explained with reference to the individual-
- Automation used to reduce the risk for ‘human errors’ - and increase production effectiveness.
History: Towards a systemic perspective

• In the late 1980s, it was increasingly accepted that human behaviour could not meaningfully be understood in isolation from the context in which it takes place (Reason, 1993)
  – Bhopal, Chernobyl, Zeebrugge, King's Cross, Piper Alpha and Clapham Junction
• Three Mile Island Accident in 1979
  – Nuclear industry
  – Several organisational factors were identified as contributors to the accident
• System accidents are normal and to be expected (Perrow, 1984).
History: MTO - The Systemic Perspective

- Systemic perspective
- MTO - interactions between ‘M’ (huMans), ‘T’ (technology), and ‘O’ (work organisation).
  - Scandinavia
  - Kerstin Dahlgren.
- Safety: a dynamic non-event (Weick, 1987).
- Humans contribute positively, if adequately supported.
- High-reliability organisations
  - Why do system accidents not happen more often?

- Resilience engineering
  - Goal: Enhancing organisations’ abilities to uphold safety, by creating processes that are flexible, yet robust.
  - Performance variability.
  - Four organisational abilities needed to operate safely: Respond, monitor, anticipate and learn (e.g. Hollnagel et al., 2013).

Five characteristics of HROs

1. Preoccupation with failures
2. Reluctance to simplify
3. Sensitivity to operations
4. Commitment to resilience
5. Deference to expertise
(Weick and Sutcliffe, 2001)
Five Research Projects

Operational culture
Alarm systems research
New technologies in CR
Teamwork competencies
Human automation

Main data collection source:

Main focus:
- Addressed
- Manipulated
- Generic
- Not manipulated
Operational Culture

MTO perspective
- A research area promoted by MTO.

Purpose
- Generalization of results across studies.

Does nuclear nations and organisations share a common culture, or do they have unique cultures?

Study
- Culture Profiles for control room operators in Swedish, Korean and US Plant units.

Main reference: HWR-1027.

Data collection using Hofstede's culture profiling questionnaire.
- 87 operators from 6 plants answered.

The anticipated variation in national culture based on Hofstede's (2001) data for Korea, Sweden and USA.
Operational Culture

Lessons learned
• Early evidence of common industrial/professional culture?
• Good news regarding the cultural validity of HAMMLAB experiments.

Main reference: HWR-1027.
Work practices:
Panel-based to Computer-based control rooms

MTO perspective

- Pre-systemic: Upgrade, always benefit from features of new technology.
- Systemic: Understand the impacts of technology on work practices.

Purpose:

- Provide insights into challenges and opportunities of computer-based control rooms on work practices.

Study 1:

Investigate whether or not Team Transparency (TT) is an important issue in computer-based control rooms.

Lessons learned:

- TT preferred
- Communication pattern differed.

Main reference: HWR-952.
Work practices: Panel-based to Computer-based control rooms

Study 2:
Explore whether iPad can be used as an information source to monitor process information for the shift supervisor when he/she is located outside the main CR

- HAMMLAB study – PWR
- 5 crews of 4 operators
- 4 scenarios
  - In two scenarios, SS had the iPad available when located outside the control room
  - In two scenarios, SS had NOT the iPad available outside the control room

Lessons learned
- With iPad, SS had:
  - Faster process update
  - Improved shared understanding
  - Reduced mental demand
- Overall:
  - Possible to make design solutions to overcome worries regarding challenges with computer-based systems, where operator activities can be visible for the whole team
  - Emerging technologies, like handheld devices, can support operator performance if designed right and focuses on supporting operator work.

Main reference: HWR-996.
Teamwork Competencies

MTO perspective
- Pre-systemic: Focus on procedure adherence.
- Systemic: Promote resilient collaboration.

Purpose: Contribute to the development of a taxonomy for teamwork competencies, required by nuclear power plant CR crews → promote training.

Study Part 1
What behaviors and attitudes do CR operators associate with high-quality and low-quality teamwork in a CR team?

Main reference: HWR-1035.
Teamwork Competencies (con)

Study Part 2:
What are the differences and similarities between the teamwork competencies needed by members of control-room (CR) crews in nuclear plants across three operational states: normal operation, outages and emergency operation.

Data collection and analysis
- Field observations
  - Normal operation, outage, emergency (simulator)
- Interviews
- Questionnaire survey

Thematic analysis.

Lessons learned

<table>
<thead>
<tr>
<th>Situation Awareness</th>
<th>Challenges</th>
</tr>
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<tbody>
<tr>
<td>Narrowing attention</td>
<td>Complacency</td>
</tr>
<tr>
<td>Abnormal</td>
<td>Normal</td>
</tr>
</tbody>
</table>

O’Connor et al. (2008) | Current Study
----------------------|------------------
Attitudes             |                  |
Communication         | Communication    |
Co-ordination         | Coordination     |
Team focused decision making | Decision-making & Planning |
Collaboration         | Leadership       |
                      | Learning and teaching, continuous improvement |
Building situation awareness | Situation Awareness, building and maintaining |

Teamwork competencies required by CCR crews.

Main reference: HWR-1107.
Human-Automation Interaction

(extract of study)

MTO perspective
- Pre-systemic: Automate all tasks that can be automated.
- Systemic: Humans must be able to take control when needed.

Purpose: Promote human-automation interaction.

Study
How do operators handle automation malfunctions using human-system interfaces, which contain either explicit or implicit information about the automatic system’s activity?

Automation: Interlocks, limitations, protections, controllers, programs

Main reference: HWR-659.
Human-Automation Interaction (cont.)

Lessons learned

Overall
- The study contributed to emphasize the need for informing operators about the automatic system’s activity.

When operating from the Experimental Interface, as compared to the Conventional Interface:
- Higher plant performance effectiveness
- Higher quality of human-automation cooperation
- Lower perceived workload
- Higher levels of trust in automation
- Improved detection of deviations.


Verbal feedback: Natural language feedback is helpful if it is:
- Specific
- Based on sound logic
- Easy to distinguish between feedback associated with the reactor and turbine sides.
Alarm Research

MTO perspective

- Pre-systemic: All devices should alarm when thresholds are exceeded.
- Systemic: Alarm in a way, which help humans to make sense of the situation.

Purpose

- How to improve alarm systems of today?
  - Too many alarms during disturbances
  - Difficult to detect secondary malfunctions.

Study

Is it possible to design alarm systems that are adapted to human needs?

- State Based Alarm (SBA) system developed in multilateral cooperation
  - Based on well-defined process states
  - Continuously adjusts to actual state
  - Only alarms relevant for the current state of the process
  - Add-on to an ordinary alarm system
  - Displayed in a separate list, and is warned by a separate alarm sound

- Usability study in HAMMLAB
  - 7 crews of 3 operators
  - 3 scenarios.

Main reference: HWR-1065.
Lessons Learned

- High usability score
- Manageable alarm rate
- Detected and corrected secondary disturbance faster and more often with the SBA
- Input to industry on how to design and development of advanced alarm system tools.

Detection of secondary disturbance during ongoing disturbance

<table>
<thead>
<tr>
<th></th>
<th>State based</th>
<th>Ordinary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage detected</td>
<td>100%</td>
<td>62%</td>
</tr>
<tr>
<td>Percentage corrected</td>
<td>100%</td>
<td>62%</td>
</tr>
</tbody>
</table>

Main reference: HWR-1065.
Rounding Off

HRP Research Projects
• A tiny subset of HRP projects illustrated.

MTO Summary
• Interactions between MTO
• Performance is underspecified
• Dynamic balance needed, continuous adaptations.

Practitioner perspective
• A research project provides only a (tiny) part of the knowledge needed.
• Short-term and longer-term perspective.

1. Are the MTO elements well-balanced, consider: “What will happen if ....?”
2. Are goals, roles and responsibilities (including leadership) clearly defined and communicated?
3. Are procedures, plans, processes, guidelines and checklists well-coordinated – and do they promote handling of both expected and unexpected events?
4. Are experiences recorded and shared to promote continuous development and learning?
5. Is the task/job/activity well suited for human capabilities (cognitive, emotional and physical) and to the characteristics of how humans work in a real life setting (e.g. performance variability)?
6. Has the individual adequate competence to perform the allocated task - considering both technical and teamwork competence?
7. Has initiatives been taken to promote the employees motivation to perform the job as intended (e.g. overcome resistance to change)?
8. Does the technology provide the information and control options needed by the operators (e.g. novice to expert) across all operational states?
9. Is the automatic system optimized for efficiency and human-automation collaboration?
10. Do the tools available support handling of both expected and unexpected events?

Ten questions to assist reflections on safety issues.
Next Step: Accident Management

- In 2015, HRP will initiate a series of projects addressing emergencies – reflecting the concern of HRP member organisations.
  - Accident at the Fukushima Daiichi plant in 2011.

- Research topics
  - Human-system interface
  - Training directed at accident management.
Project References


Note: HWR’s: Halden Work Reports. Reports can be obtained through the member organization in your country.