BAM
Bundesanstalt für Materialforschung und -prüfung

Sicherheit in Technik und Chemie

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THE PAST AND THE FUTURE OF HUMAN FACTORS: THE "UNCONTROLLABLE" ASPECT OF NDT RELIABILITY?

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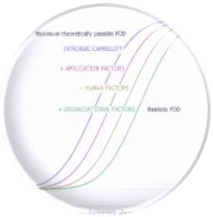
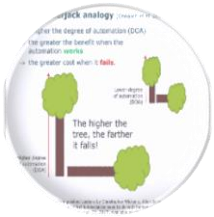
Outline



NDT reliability and the role of human factors



Preventing human error through automation

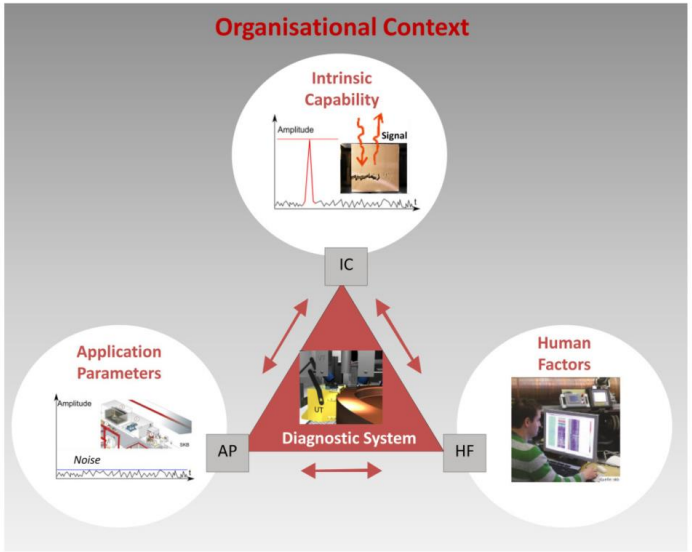
NDE paradigm change (the road to NDE 4.0)

THE PAST

THE PRESENT

THE FUTURE

Human factors affect the reliability of NDT



INFLUENCES ON RELIABILITY OF NDT (Müller et al., 2013)

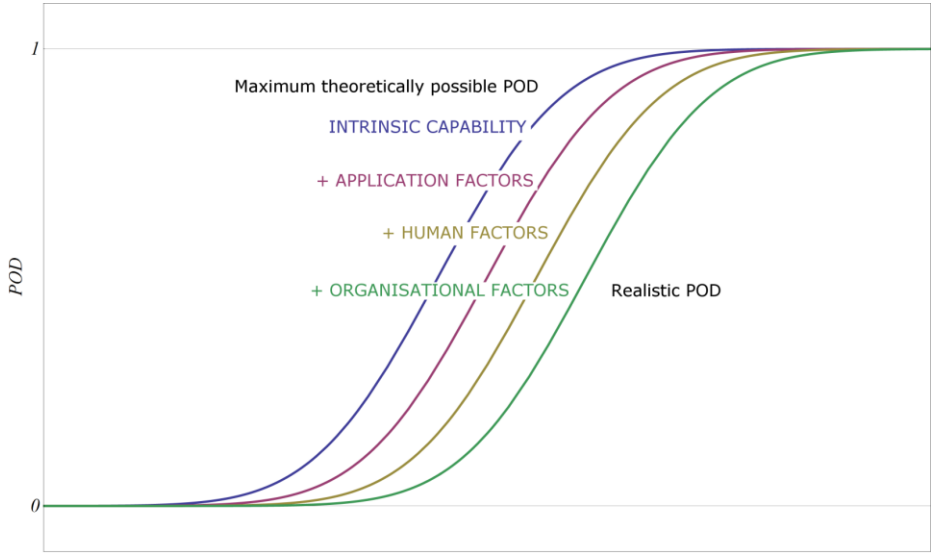


*Figure: M. Pavlovic, 2009

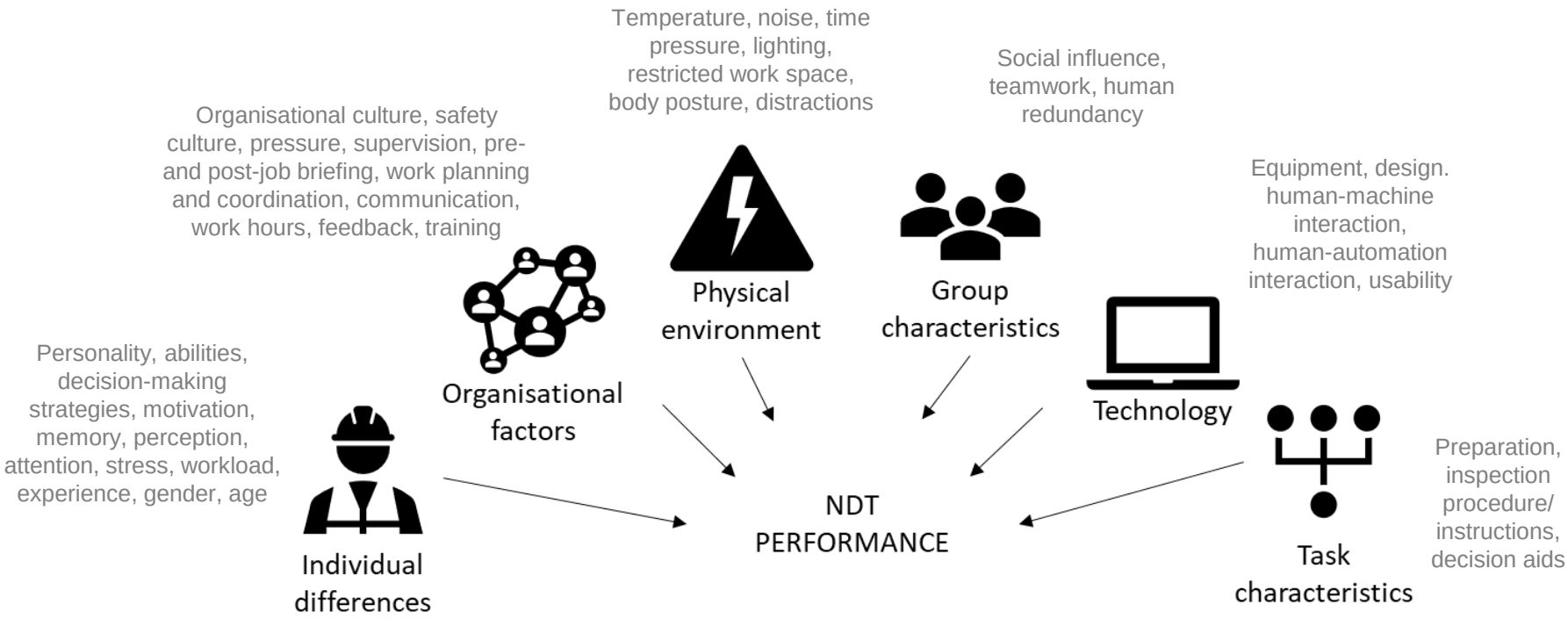
*Figure adapted from "Paradigm Shift in the Holistic Evaluation of the Reliability of NDE Systems", by C. Müller et al., 2013, *Materials Testing, 55*(4), p. 264 and reprinted with permission of the Hanser Verlag in "Human Factors in Non-Destructive Testing (NDT): Risks and Challenges of Mechanised NDT", by M. Bertovic, 2015, doctoral dissertation, Technische Universität Berlin.

What are human factors?

"Human factors refer to **environmental**, **organizational** and **job** factors, and **human** and **individual characteristics**, which influence behavior at work in a way which can affect health and safety"

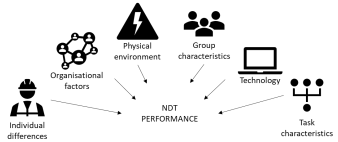
(HSE, 1999, *Reducing error and influencing behaviour)*

Categorising human factors considerations in NDT



D'Agostino, et al (2017). *Review of Human Factors Research in Nondestructive Examination*.
Bertovic (2016). *Human Factors in Non-Destructive Testing (NDT): Risks and Challenges of Mechanised NDT*.

Human factors: the uncontrollable aspect?



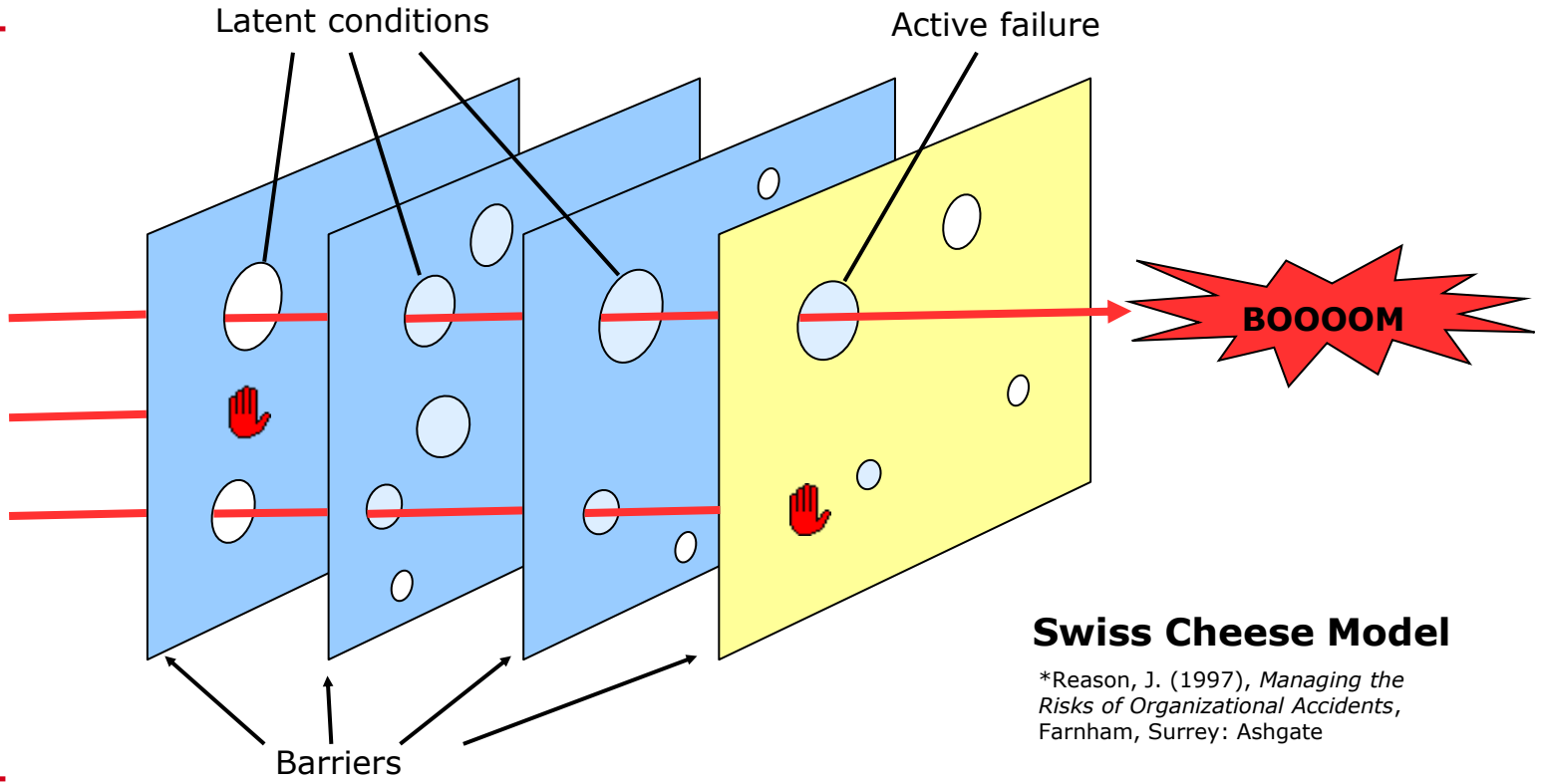
UNCONTROLLABLE

- current mental state
- subjective experiences
- mood
- expectations
- stress resistance
- some working conditions
- attentional resources
- etc.

CONTROLLABLE

- qualification & experience
- temperature
- duration of shifts
- distractions
- quality procedures
- some working conditions
- usability
- etc.

Preventing human error through design

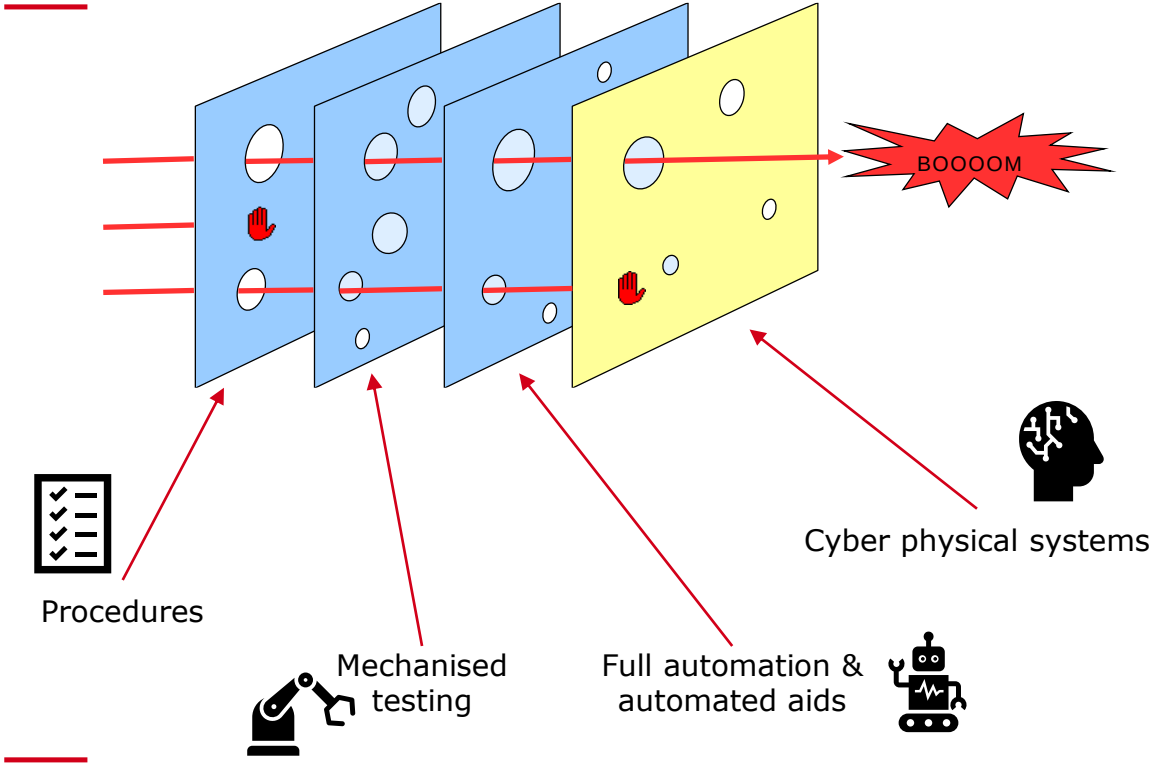


Swiss Cheese Model

*Reason, J. (1997), *Managing the Risks of Organizational Accidents*, Farnham, Surrey: Ashgate

*Figure adaptation: B. Fahlbruch

Preventing human error through automation



"It is human to err"
Reason, 1990, *Human Error*

Industry 4.0 / NDE 4.0

"The key is to understand that this technology is not about replacing people. It's about harnessing the strengths of humans and robots to achieve new levels of efficiency and productivity that neither can achieve alone"

– Prof. Julie Shah, Interactive Robotics Group, MIT

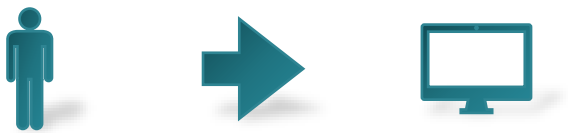
Distribution of tasks between people and technology

Which tasks remain with the **people**?

- Use, operation
- Design and development of new technologies
- Monitoring automated systems and processes
- Automation gaps (e.g. complex decision-making)

Which tasks are transferred to **computers or AI**?

- Complex computational tasks
- Routine, monotonous and repetitive tasks
- Time-consuming tasks
- Physical work
- Dangerous tasks



Ironies of automation (Bainbridge, 1987)

- Human as the primary source of error / operative errors
- Non-automatable / highly complex activities are transferred to humans
- Automation replaces people, but human beings constantly have to monitor technical systems and eliminate errors
- The higher the reliability of the automated systems, the more training required

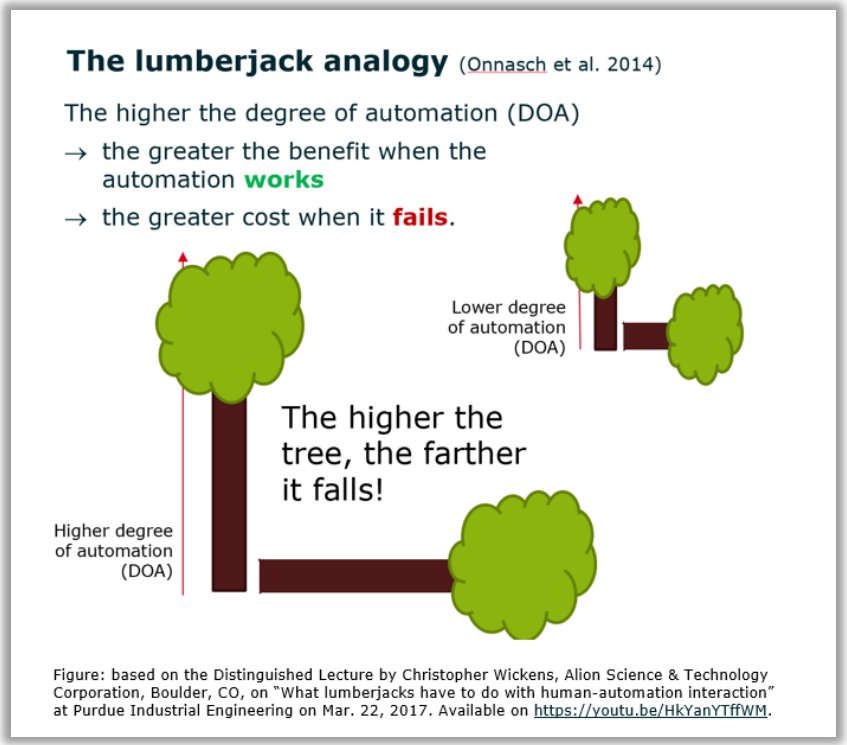


Figure: based on the Distinguished Lecture by Christopher Wickens, Alion Science & Technology Corporation, Boulder, CO, on "What lumberjacks have to do with human-automation interaction" at Purdue Industrial Engineering on Mar. 22, 2017. Available on https://youtu.be/HkYanYTfWM.

Main premise about human-automation interaction

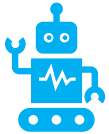
Automation does not eradicate human error, it rather changes the way we work, so that that we can expect new errors and error sources

Transitional systems pave the way to industry 4.0

Traditional system

Human interacting with a conventional manual, semi- of fully-automated device

NDE 3.0



Transitional system

Human interacting with cyber-physical systems in a conventional way

NDE 3.5

Industry 4.0 system

Human interacting with cyber-physical systems in a revolutionised way

NDE 4.0

*Bertovic, M., & Virkkunen, I. (2021; in review). NDE 4.0: New paradigm for the NDT Inspection Personnel. *Handbook of NDE 4.0*. Springer.

Different demands for the workers

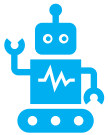
Traditional system

working according to well-defined procedures

high physical and cognitive demands

high influence of the environment and the organisation

responsibility at the hands of the operator at the sharp end



Transitional system

traditional training, qualification, procedures and design approaches meet new technologies

the task becomes more diverse and demanding – monitoring automation

implementing one technology can lead to improvement, implementing several requires a full redesign of current practices

Industry 4.0 system

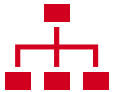
function allocation according to strengths and abilities

significantly changes the nature of the task

by putting the user in the centre of the design, the task becomes less demanding and the acceptance increases

*Bertovic, M., & Virkkunen, I. (2021; in review). NDE 4.0: New paradigm for the NDT Inspection Personnel. *Handbook of NDE 4.0*. Springer.

Definition of new roles



System developer

Dictates strategy

Develops the system and integrates it with other systems

Defines performance metrics

Responsible for reliability

Caretaker

Oversees the functioning of the system

Notices failures

Undertakes measures to repair or adapt the system

Responsible for the day-to-day deployment and operation of the system

Decision maker

Strategic decision maker and flexible problem solver

Know-how to diagnose more substantial problems in the systems use or to offer further explanation of the results and their meaning

High flexibility and adaptability to continuously changing conditions.

User experience (UX) designer

Creates the user interface and dictates user experience

Carried out by a multidisciplinary team (engineer, IT expert, designer, UX expert)

*Bertovic, M., & Virkkunen, I. (2021; in review). NDE 4.0: New paradigm for the NDT Inspection Personnel. *Handbook of NDE 4.0*. Springer.

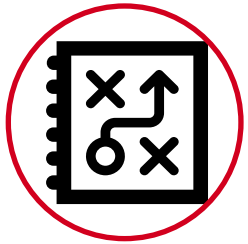
New paradigm is needed!

User-centred development of AI-based systems is crucial in order to achieve acceptance of new technologies

Careful consideration of the changes in tasks, tools, qualification, and responsibilities and a new allocation of tasks between people and AI-based systems is needed

Addressing the new challenges (chances and risks)

New demands for education and (re)training of the personnel



Development of a new conceptional model how to address the challenges effectively

Icons: Microsoft

Summary

Yes, by obtaining knowledge and implementing it in the practice

Yes, by including the users in the design

Yes, by acknowledging the people's central role in cyber-physical systems

What do you think?

"The highest form of technology is not full automation or full autonomy, but it is automation and autonomy that are very beautifully, gracefully, linked to the human operator."

- David Mindell, MIT Professor and pioneer of autonomous robotics

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