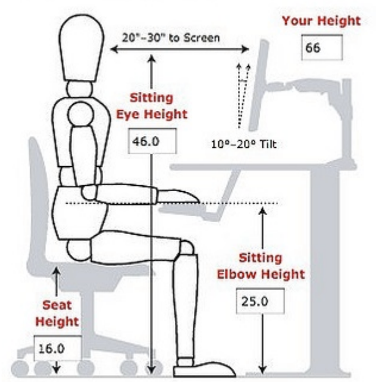
Human Factors & System Safety

"People in Control"

Human Factors – as "Imagined"



Erik Hollnagel, Ph.D.
Professor, Institute of Regional Health Research, University of Southern Denmark
Senior Professor, Jönköping Academy, Sweden
Email: hollnagel.erik@gmail.com

Agenda-as-Imagined

14.00 **Work-as-Imagined and Work-as-Done: The Nitty Gritty of Human Factors**

Prof. Erik Hollnagel – University of Southern Denmark

The first question for human factors is how to provide a work environment allow as much work as possible to go well, which means that it is both safe c environment are designed by someone to be used by someone else. The desig e.g. tools, interactions, interfaces, roles and functions etc. both as single issue good design requires more than an understanding of work-as-imagined, of l requires and understanding of work-as-done, of what people do when the what the design assumed. While there are many guidelines and design theoretical approach to human factors and specific models of human function account for recurrent patterns of performance that are characteristic of ever to capture work-as-done and to reconcile that with work-as-imagined shoul human factors in a rapidly changing world.

15.30 *Coffee Break*

16.00 **"Work-as-Imagined and Work-as-Done – Improving Runway Operatio**

Sebastian Daeunert – Incident Investigator – FRA Tower DFS

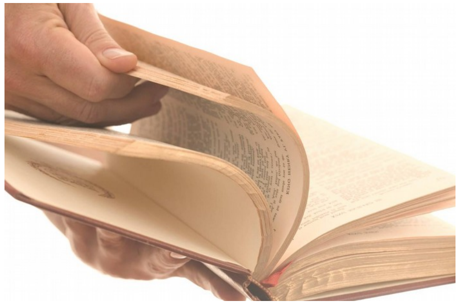
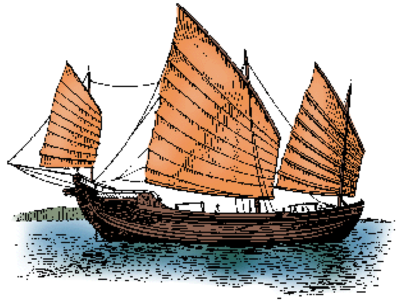
The way that we adapt to our environment in everyday life can teach us about hov In his presentation, Sebastian Daeunert describes how Frankfurt tower contemplate operations, ultimately giving controllers responsibility for their way of working.

17.00 **End of Day 2**

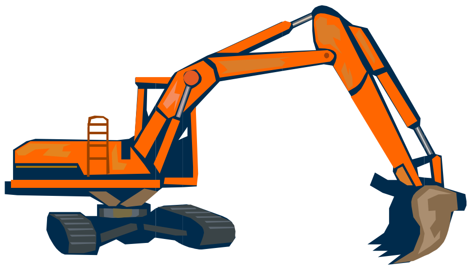
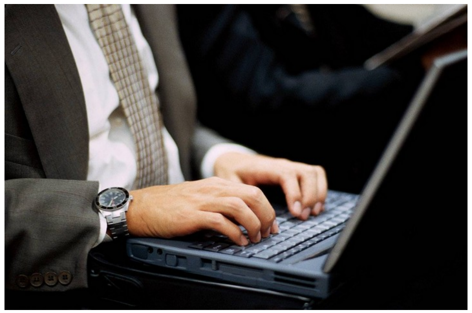
14:00	WAI and WAD – HF as "Imagined" Erik Hollnagel
15:00	WAI and WAD – Improving Runway Ops Sebastian Daeunert
15:45	Coffee break
16:15	WAI and WAD – HF as "Done" Erik Hollnagel
17:00	End of Day 2

When did Human Factors begin?

Why was human factors not considered as a problem then ....

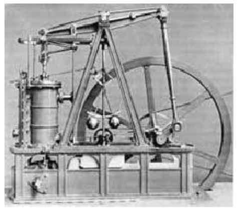
... and why is it considered as a problem now?


The pre- and post-industrial period

SafetySynthesis

Natural “fit” with simple technology



Industrial revolution

1698

1783

Pre-industrial | Post-industrial

Individuals | Trivial (linear) systems

The human factor was not an issue because:

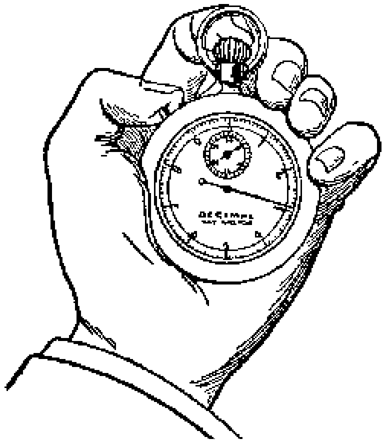
- Systems were limited in size and number of parts
- Technology was uncomplicated (linear)
- Work was mainly manual
- “Processes” were slow
- Artefacts were few and usually only loosely coupled
- System integration was non-existent or limited

1910: Scientific management

Scientific management was formulated in the late 19th and early 20th in order to increase efficiency of work and decrease waste. It introduced empirical methods to study work as it actually took place (WAD) – with the intention of prescribing the "**one best way**" of doing it (WAI).

Principles of scientific management (1911)

- Analyse tasks to determine most efficient performance
- Select people to achieve best match between task requirements and capabilities
- Train people to ensure specified performance
- Insure compliance by economic incentives



Aviation 1910 – without HF or ATC

Safety Synthesis

Attendance at the Dominguez Aviation Meet reached and surpassed all expectations. During the ten day event, from the 10th to the 20th of January 1910, an estimated 226,000 spectators converged on Dominguez Field and gate receipts totalled over $137,500. The meet was considered a phenomenal success and helped to alleviate a perceived economic drought in the Los Angeles area. It is generally believed the Dominguez Aviation Meet launched the aviation industry in California.

What was work like in the 1920s?

Industrial work in the beginning of the 20th Century was very different from what it is today.

<u>Comprehensibility</u>: system functions were easy to understand, independent and work was manual.

<u>Stability</u>: work activities were regular and stable (orderly).

<u>Descriptions</u>: simple (few elements and relations).

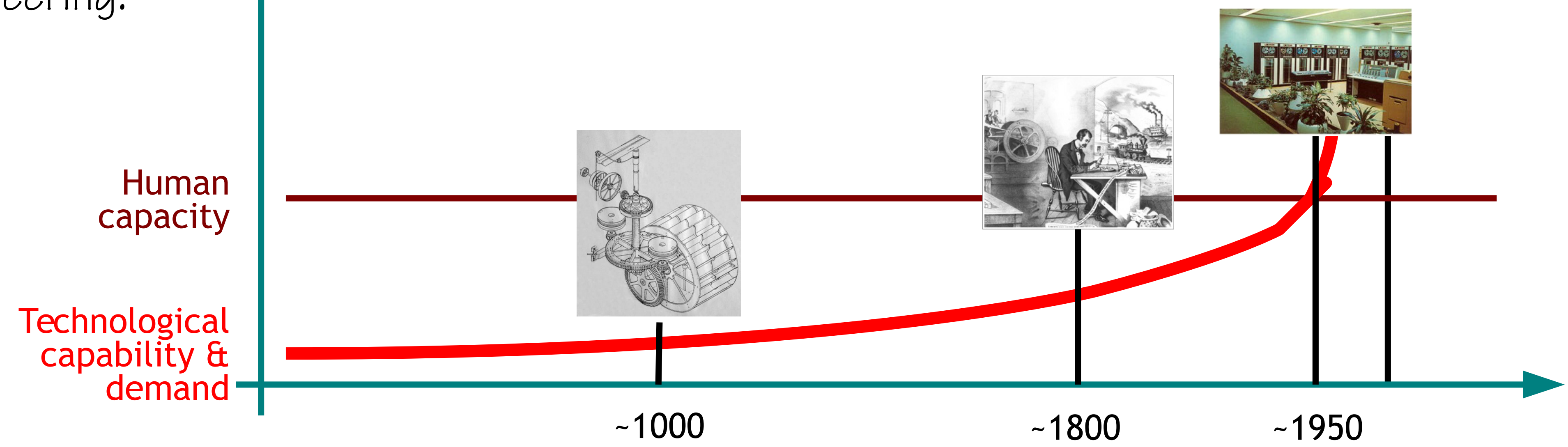
Systems were loosely coupled and linear. Explanations in terms of simple (“root) causes were good enough.

1945: Beginning of demand-capacity gap

SafetySynthesis

The use of information technology, beginning in the 1940s, rapidly increased machine capabilities. The demands to the operators who should control them soon exceeded what humans could do.

This created a demand-capacity gap and started the development of human factors engineering.



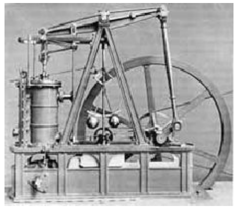
Humans came to be seen as imprecise, variable, and slow.

The post-IT period

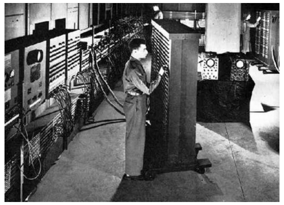
Human factors became an issue because:

Humans were seen as too imprecise, variable, and slow.

Human performance capacity limited system productivity.



Industrial revolution



IT revolution

1698

1945

Pre-industrial

Post-industrial

Post-IT

Individuals

Trivial (linear) systems

Human as a liability

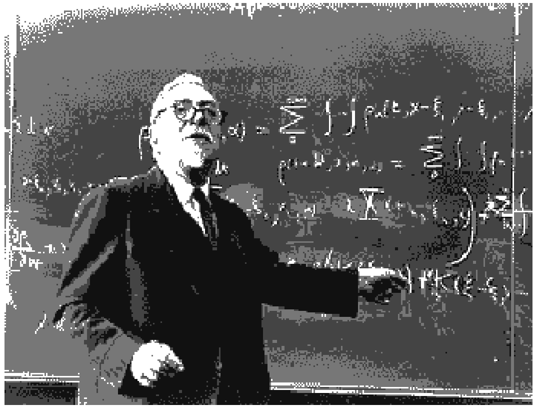
Humans are too imprecise, variable, and slow.

Human performance variability is cause of accidents.

Automation is used to overcome specific limitations

Automation is used to take over human tasks

Training + Design + Automation



Gadget worshippers, who "regard(ed) with impatience the limitations of mankind, and in particular the limitation consisting in man's undependability and unpredictability"
Norbert Wiener, 1964.

Solutions: training – design - automation

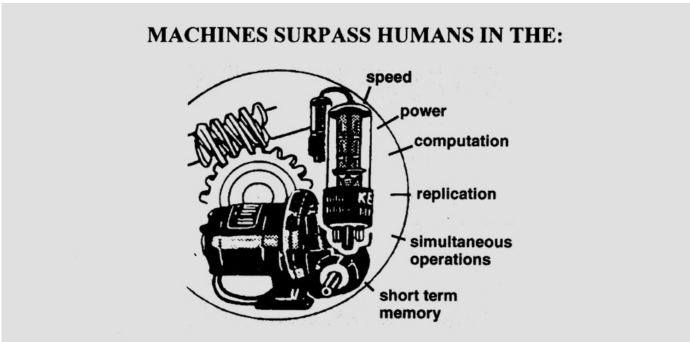
Training (1) Train the operator, to adjust the human component to the requirements of the system.
(2) Enhance system performance by adjusting the mechanical elements to fit the man.

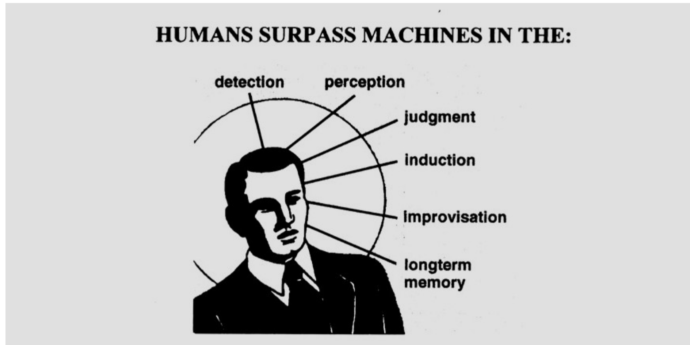
Taylor, F. V. and Garvey, W. D. (1959). The limitations of a 'Procrustean' approach to the optimization of man-machine systems. Ergonomics, 2, 187-194.

Design Design the workplace so that human limitations (perceptual, motor, cognitive) do not become a hindrance for system performance.

Automation We begin with a brief analysis of the essential functions … We then consider the basic question: Which of these functions should be performed by human operators and which by machine elements?

Fitts, P. M. (1951). Human engineering for an effective air navigation and traffic control system. Ohio state University Foundation Report, Columbus, OH





Theory X and Theory Y (1957)

In theory X, management assumes employees are inherently lazy and will avoid work if they can. People need to be closely supervised with comprehensive systems of hierarchical controls. People will show little ambition without an enticing incentive program and will avoid responsibility whenever they can.

In theory Y, management assumes employees may be ambitious, self-motivated, anxious to accept greater responsibility, and exercise self-control, self-direction, autonomy and empowerment. People enjoy their mental and physical work duties and that they have the desire to be creative and forward thinking in the workplace, if given the chance. People should be given the freedom to perform at the best of their abilities without being bogged down by rules.

McGregor (1906-1964)

If people are treated consistently in terms of certain basic assumptions, they come eventually to behave according to those assumptions in order to make their world stable and predictable.

What was work like in the 1980s?

Industrial work towards the end of the 20th Century had changed dramatically due to computerisation.

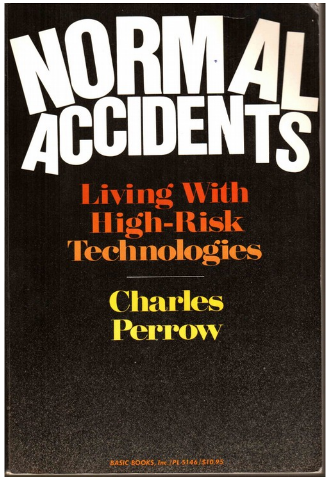
Comprehensibility: system functions could be hard to understand, they were dependent and work was automated.

Stability: less stable, affected by demands-resources, coping with unexpected situations.

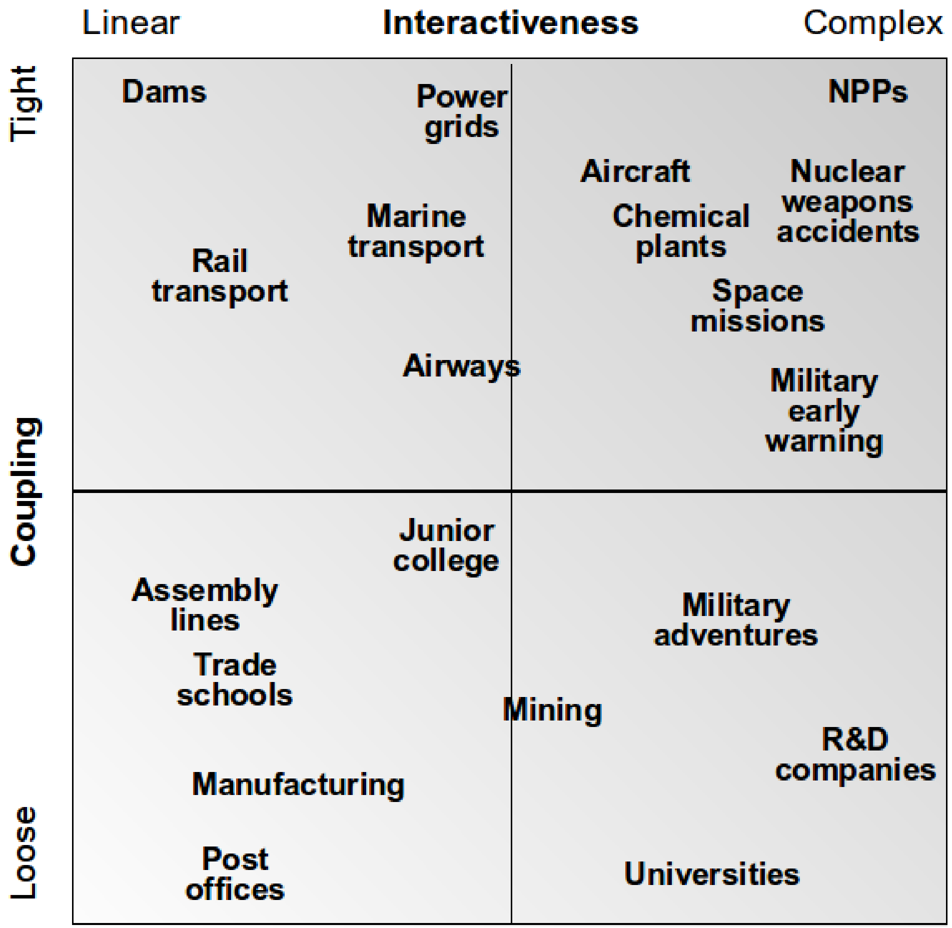
Descriptions: complex (many elements and relations).

Systems were tightly coupled and increasingly non-linear. Multiple interacting causes.

Complex, socio-technical systems



"On the whole, we have complex systems because we don't know how to produce the output through linear systems."



Tight couplings:

Delays in processing not possible
Invariant sequence
Little slack (supplies, equipment, staff)
Buffers and redundancies designed-in
Limited substitutability

Complex systems / interactions:

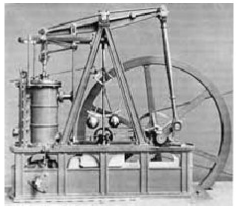
Tight spacing / proximity / Many feedback loops
Common-mode connections / Interconnected subsystems
Indirect information / Limited understanding

The post-NAT period

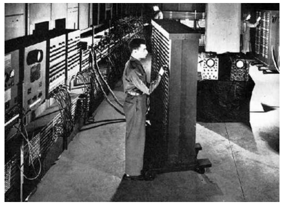
Problem: Humans were seen as failure prone and unreliable, hence a challenge to system safety ("weak link")

Solution; Eliminate (automate) or constrain human performance

The human factor as a liability



Industrial revolution



IT revolution

Normal accident theory (NAT)

1698

1945

1984

Pre-industrial

Post-industrial

Post-NAT

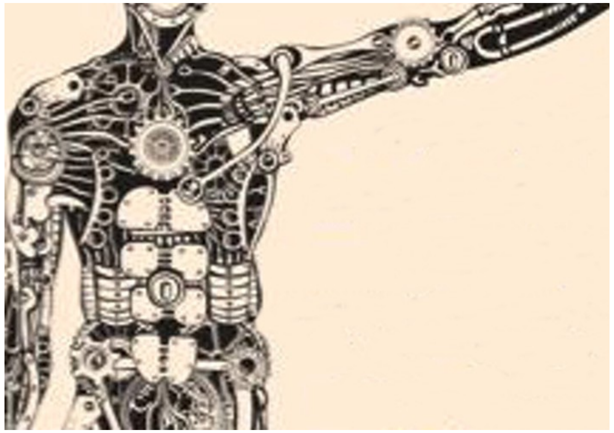
Post-IT

Individuals

Trivial (linear) systems

Non-trivial systems

Humans are variable and fallible



Classical HF limitations (Sensory, Motor, Cognitive)
Fitts' List (1951):
Speed, memory, sensing, perceiving, reasoning, consistency, computation, power output, information capacity

Human as a biological machine → Human as an information processing machine

Limited attention (span and focus)
Lack of situation awareness
Workload
Error prone ("human error mechanisms")
Non-compliant
Overconfident
Unpredictable

Overcoming variability by constraints

Individual, team, organisation

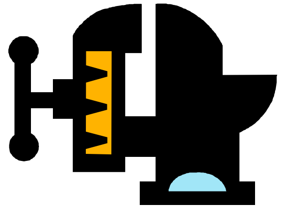
Barriers, regulations, procedures, standardization, norms

Function → Success (accident free)

Slow drift, abrupt transition

↓

~~Malfunction (root cause)~~ → ~~Failure (accidents, incidents)~~



Safety is achieved by constraining performance

Growing complexity

1910 Complexity: due to "economy of scale" of work, rather than to technology.
Solution: decompose tasks into basic (simple) activities, optimise locally.

1945 Complexity: due to new information technology (embedded logic).
Solution: train, design, automate.

1981 Complexity: due to process complexity.
Solution: use computers for analysis and display support.

1984 Complexity: due to increased use of IT.
Solution: intelligent support systems (= more IT).

2017 Complexity: rampant technology development
Solution: new and better technology.

What will work be like tomorrow?

Industrial work at present is in a state of transition driven by technological advances – and hopes.

Comprehensibility: system functions are partly hidden, automation is ubiquitous and obscure.

Stability: system performance changes dynamically and autonomously, environments are partly unpredictable.

Descriptions: intractable – complex with ill-defined boundaries.

Systems will be non-trivial and non-linear. Consequences emerge from complexity.

The ideal = Zero harm

OUR VISION

ZEROHarm

The [redacted] Vision is to achieve Zero Harm through the effective management of safety at all its businesses and operations. This means simply that we do not accept that it is necessary for people to be injured while working for us and that all employees should be able to return home fit and well at the end of each shift. We believe that our operations should have fundamentally safe, well-designed plant, equipment and infrastructure with robust risk-based safety management systems driving desired outcomes and behaviours.

OUR SAFETY PRINCIPLES

Underpinning this Vision are three fundamental Safety Principles:

ZEROMindset

We believe that all injuries and occupational illnesses are preventable.

We are responsible for preventing and correcting unsafe behaviour and work conditions.

NORepeats

All unsafe practices and incidents will be investigated to determine what happened and why.

All necessary steps will be taken to prevent recurrence.

SIMPLE Non-negotiable standards

We will adopt a common, simple set of non-negotiable standards and rules throughout the Group.

Divisional line management at all levels has the responsibility of implementing and maintaining the standards and rules.

The [redacted] Safety Principles set out the foundation of the desired culture, expected behaviours and performance standards within the organisation. Each Principle has two supporting elements which, we believe, will assist us in leading us on the journey towards Zero Harm.

Summary: Human Factors as imagined

Safety Synthesis

1. The common idea about the "human factor" implies that problems can be solved by dealing with a single factor (decomposition).

2. The "human factor' was first seen as a hindrance for the full use of technology. The solution was to overcome this limitation by training, design, and automation.

3. The "human factor" was next seen as an unreliable component (a liability). The solution was to eliminate or constrain unreliable performance.

4. Looking at the "human factor" by itself is an oversimplification that creates more problems than it solves. It assumes that humans can be "engineered" to function as reliable machines.

We can keep people in control – and be safe – if we can control people!