Het modeleren van mens-machine interfacing: nieuw denken over luchtvaart veiligheid

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Dutch Aviation Group
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Delft University of Technology
Growth and change

Michael O’Leary

Flightpath 2050
Europe’s Vision for Aviation
Report of the High Level Group on Aviation Research
Contextual changes in aviation

- Growth: 2.5 traffic volume increase in 2050, dramatic reduction in emissions, less than 1 accident per 10 million movements
- By 2050, passengers and freight should enjoy efficient and seamless travel services, based on a resilient air transport system thoroughly integrated with other transport modes and well connected to the rest of the world.
New entrants on the market
New concepts
"These are issues that we have seen time and time again, and unfortunately it has taken 50 lives for us to focus additional attention on these issues that have not been addressed," NTSB chairwoman Hersman said on Colgan Air 3407.

Not inherently dangerous
A phenomenal safety record

First flight 27 April 2005: no hull losses

First flight 15 December 2009: no hull losses
Evacuation, rescue and emergency

Icecold water and drowning

Red hot brakes, fuel leaks, fire hazards
Air crash investigation: so far, so good, so safe

US airlines, 1 fatality in:
- 24 months
- $45 \times 10^6$ flights
- $5 \times 10^9$ passengers

Non Plus Ultra Safe: Beyond $10^{-7}$ systems
System deficiencies or knowledge deficiencies?

Gedoemd tot afwachten?
• Black Swans?
• Unknown/unknown?
• Emergent properties?
• Serendipity: *Finding out by accident the unpredicted and unforeseen*

Of:
Aanpassen van systeemeigenschappen?
Verbeteren van modellen en theorieën?
Groter verklarend vermogen?
The man-machine coupling
fly by wire: aero elastics, flight dynamics
The man-machine coupling
Fly by wire: aero elastics, flight dynamics

What's the autopilot doing now? It's supposed to do that. Why is it doing that? I don't know. But it knows, doesn't it?!!
Designing Manned or Machined systems
Who is to blame?

This will lead us nowhere
The BEA Report on AF447: real life conclusions

- Operating circumstances only clarified by flight recorder retrieval
- Sequence of events:
  - temporary loss of airspeed indications
  - followed by airplane exiting flight envelope
  - followed by crew losing situational awareness
  - no understanding of stall situation
  - no application of recovery manoeuvres
- Occurrences in both classic and high automation level a/c designs
- Flight path control requires perfect situational awareness
- Safety depends on adequacy between cognitive capacities and signals provided
- Hypotheses used for safety analysis are not always relevant, procedures not always applied, warnings not always perceived
- Improving quality of feedback enables detection of weaknesses in safety models
- Identify similarities by sharing recommendations/lessons learned
- **Combination of ergonomics of warning design, training conditions, recurrence training process**

**DID NOT GENERATE EXPECTED BEHAVIOUR**
**SHOWED LIMITS OF CURRENT SAFETY MODELS**
Main sources for failure or success

Identified from case descriptions:

-The available time window was critical

-The system state was critical

-Understanding the complexity and dynamics of the event consumed many resources.

-The availability of resources, redundancy and flexibility in responses determined the outcome of the events to a very high extend.
Kleine kans op grote gevolgen
Een apart aandachtsgebied?

Optimal versus limit state design?
Pre-crash versus post-crash?
Physical versus virtual?
Top-down versus bottom-up?
Qualitative versus quantitative?

Rampenbestrijding en hulpverlening
Een Nieuwe Kijk op Menselijk Falen
Ook niet-rationele benaderingen meenemen
Nieuwe modellen en theorieën
Human stall: flight, fight or freeze
Freeze is no option
Flight is no option
Bring back the whole plane

Go ballistic

Envelope protection

Basic flying skills
Physical safety: dynamic energy management?

Riding the roller coaster
Potential energy \( E = mgh \)
Kinetic energy \( E = \frac{1}{2}mv^2 \)

Braking curve protection
Tunnel in the sky
The machine
A Knowledge based engineering design perspective
The controls
A knowledge based engineering design perspective
Als onze studenten dit kunnen

Nuna, Electrische raceauto
Delfly, Satelliet, Submarine,
High tech fiets
Studenten breken wereldrecord 0-100 acceleratie

En er eerste prijzen mee weg slepen

Nuna7 - World Solar Challenge 2013
Is dit dan het gereedschap voor de volgende generatie?
Zijn we gehouden aan Hypertaylorsisatie en full automation?
Driehoek
Mens machine interface

A failsafe flight envelope?
Combine physical and virtual realities
Reflex level of response
Competence based training

Knowledge Based Interface Design?
Total energy management
Human Centered Design
Temporal logic
Neurosciences
Ecological Design

Vliegmachine
Fysieke werkelijkheid

Mens als handelend wezen
Mentale werkelijkheid

Operating envelope

Computerbesturing
Virtuele werkelijkheid
Een vierde mental control level: naast skill, rule en knowledge based *het reflex level*

**Proactive:**
- Energy cone control

**Reactive:**
- Procedural flight

**Emergency:**
- Resources
- Competences

**Reflex:**
- Panic, fight or freeze
- Flight
- Basic flying skills
- Conditioned reflexes

**Checklists**
- Pilot training
- Flight envelope protection

**Flight energy management**
- Crew resource management

**ETTO**
- Compliance based performance
- Flight performance optimization
Pilot: error, hero, top gun or avatar?
Subconscious/conditioned reflex?

Ivan Petrovitš Pavlov (1849 - 1936)

One of Pavlov's dogs, preserved at The Pavlov Museum, Ryazan, Russia

Simplified human models

Gestalt therapy

Daniel Kahneman

Thinking, Fast and Slow

‘A lifetime's worth of wisdom’

Steven D. Levitt, co-author of Freakonomics

The International Bestseller
A shared human centered design perspective: neurosciences?

**Fight-or-flight Response**

- **Hypothalamus**
  - activates sympathetic nervous system
  - activates adrenal-cortical system by releasing CRF
- **Pituitary gland**
  - secretes hormone ACTH
- **Adrenal medulla**
  - releases norepinephrine
  - releases epinephrine
- **Bloodstream**
  - ACTH arrives at adrenal cortex and releases approximately 30 hormones
  - neural activity combines with hormones in the bloodstream to constitute fight-or-flight response

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Perspectief op verbetering

Behoefte aan kennisontwikkeling:
• Scholing, forensische bekwaamheden
• Innovatief vermogen: systeemintegratie, samenwerking
• Nieuwe begrippen en methoden: resilience engineering, neurowetenschappen

Terugkoppeling van kennis met als motto:
• Kijkend naar het verleden
• Leren hoe we de toekomst kunnen inrichten
• Op grond van een reality check: to learn from the field

Opties:
• Precompetitieve samenwerking: Platform transportveiligheid
• Scholing, voorlichting, innovatie: Themapark transportveiligheid
Transportkenniscentrum Nederland?

Educatie, informatie, innovatie

Technik Museum Speyer

Verkehrshaus Luzern

'Fyra' heet straks geen Fyra meer

AnsaldoBreda geen inzage in technische rapporten Fyra
Have a safe flight