Human Performance Envelope: Overview of the Project and Technical Results

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What are we aiming at?

Automation  Human Operator

Operational Environment

Performance

https://emojiterra.com/de/gehirn/
https://emojiterra.com/de/pilot-hauttyp-1-2/
https://emojiterra.com/de/pilotin-hauttyp-6/
https://emojiterra.com/de/landung-eines-flugzeugs/
How to automate? Human Centered!

Automation

Operational Environment

Human Operator

Performance

Safety

Efficiency

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Performance is dependant on Human Factors

- Situation Awareness
- Workload
- Stress
- Attention
- Vigilance
- Fatigue
- Trust
- Communication
- Teamwork

Human Factors

Human Operator

Performance

Safety

Efficiency

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Situation Awareness

Workload

Stress

Attention

Fatigue

Vigilance

Communication

Teamwork

Trust
Decline in performance: is an interaction of Human Factors, even if these factors are only slightly impaired!
Decline in performance: it happens gracefully, not abruptly.
How to automate now? Human Centered! ... enabled by Human Performance Envelope
1. Detect operator’s state on time
2. Develop automation which is capable to adapt to the state of the operator.
Situation Awareness

Workload

Stress

Attention

Vigilance

Fatigue

Trust

Communication

Teamwork
Situation Awareness ↔ Workload ↔ Stress
Moving toward the edges of the envelope by events.
Frankfurt Approach

Task: manual approach
- AP off
- A/THR off
- FD on

Duration:
Approx. 15 - 20 min
High turbulence whole scenario

Approach & RWY change during initial approach

Medium turbulence whole scenario
Low fuel whole scenario

Delay vectors during initial approach

Loud noise during final approach
Low visibility whole scenario

Localiser interference during final approach

Wind shift during final approach
Measurements
Measurements

Eye Tracking Data
- Point of Gaze
- Blink Rate
- Areas of Interest
- Pupil Diameter
Measurements

Physiological Data
• Heart Rate (HR)
• HR Variability (HRV)
  • RR Intervals
  • Breath Rate
• Perfusion Index
Measurements

Performance Data
- Speed
- Heading
- Altitude
- Vertical speed
- Localiser glideslope deviations
- Point of touchdown
Measurements

Subjective Data
• Self assessed performance
  • ISA
• NASA-TLX
• SAACL
• SART
• Samn-Perelli
Exploratory Simulations

Operational Environment

- **N=10 first officers**
  - major European airline
  - A320 type rated
- **Age**
  - M = 31
  - SD = 3.28
- **Experience (total flight hours)**
  - M = 4045
  - SD = 1569
- **Captain**
  - from same airline
  - complemented crew
If workload increases...

Very high WL

High WL

Baseline WL

Pupil Ø ↑

Heart Rate ↑
Heart Rate Variability ↓

Localiser / Glideslope Deviation ↑

Self assessed Performance ↓

NASA TLX / ISA ↑
If stress increases

- Pupil Ø
- Heart Rate
- Heart Rate Variability
- Localiser / Glideslope Deviation (less compare to WL)
- SACL

Baseline St

High St

Self assessed Performance
If situation awareness decreases...

Baseline SA

Impaired SA

Localiser / Glideslope deviation (higher compared to WL und St)

Pupil Ø

Heart Rate
Heart Rate Variability

Self assessed Performance

SART

Baseline SA

Impaired SA
Results: combined factors

Pupil Ø

Low Frequency HRV

Localiser / Glideslope Deviation

HPE more severely reduced by combined factors
Design Philosophy

Pilots need to have information about:

- The status
- The limitations
- The consequences of the limitations for operation and the impact of the limitations on safety
  - To be aware about the risks
  - To understand the risks
  - To understand the options
- The options
- The consequences of the options
- How to implement the options
Development of New HMI

Fuel

- Pilots need a better understanding of the remaining flight time available.
Development of New HMI

Indication of reachable airports with 30 min and 0 min remaining fuel.
Development of New HMI

Weather
Indication of available airports and runways taking into account the actual weather situation and aircraft performance and limitations.
Development of New HMI

Technical failure:

Indication of limitations of the aircraft according to flight phase
Indication of operational consequences of the limitations
Measurements
Second Simulator Experiments

Operational Environment

- N=20 first officers
  - major European airline
  - A320 type rated

- New HMI were integrated in Thales Avionics 2020 Cockpit Simulator

- Same aircraft model as in first simulator experiments (A320)
- Same scenario as in first simulator experiments
Consortium

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Office national d’études et de recherches aérospatiales
Centro para a Excelência e Inovação na Indústria Automóvel
Centro Italiano Ricerche Aerospaziali
Centre Suisse d’Électronique et Microtechnique SA
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Airbus Operations SAS
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Thales Avionics SAS
Thales Air Systems SA
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