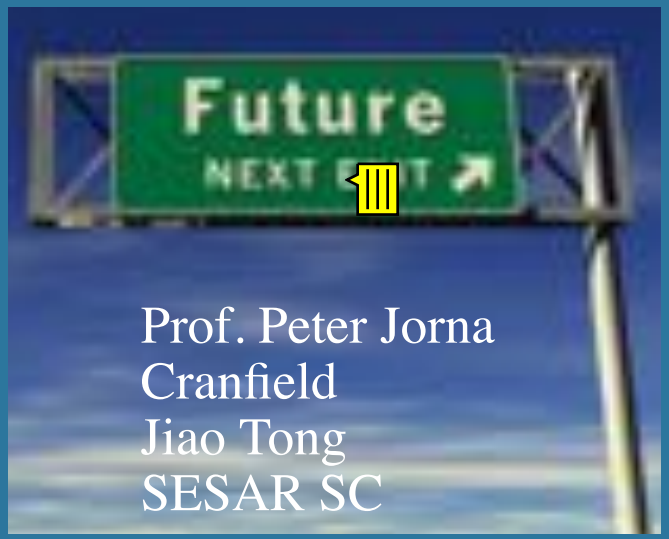
Human-Computer Interaction in Aviation

Some Bottlenecks and Next steps



Agenda

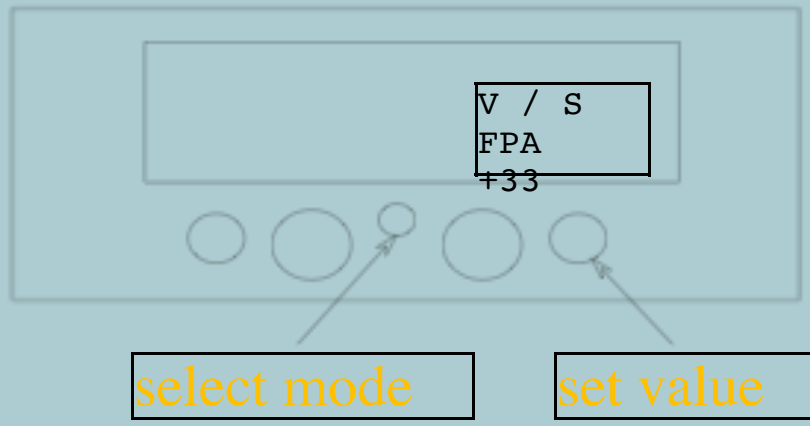
- Bottlenecks in HCI some examples
  - Accidents/ incidents
  - Overrated human abilities: *'Inattentional blindness'*
  - Slow acceptance of new technologies

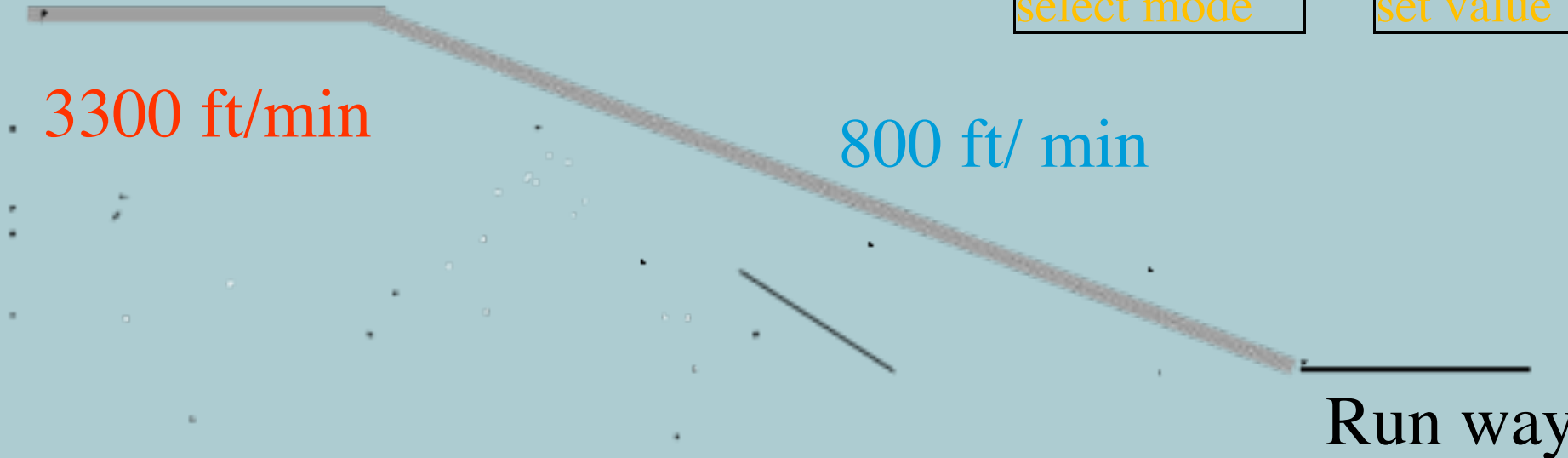
- Improvements in Human Factors considerations
  - Regulation 25.1302
  - Validating new designs
  - Education (thank you HUFAG!)

- Innovation of HCI: towards the next level
  - 'Humanising' automation or Replacing human (again…)
    - Computers with a 'Vision'
    - Backing humans for a change…

Missing details can kill you……..

Expectancy ≠ actual flight mode





many……

XPDR Standby/TCAS OFF NOT noticed for 54 minutes

By Pilots on a new Legacy Jet

location XPDR control & PFD TCAS OFF *(Map optional)*

Transponder in STBY for some reason

RMU in TA/RA vs STANDBY

Technical status XPDR = ok, Operational status aircraft= unprotected!!

PFD with TCAS OFF text White

Over rating Human Abilities…..

Distraction + Selective attention= inattentional blindness D.Simons

- You only see what you are looking for….
- **Looking is not Seeing!**

Like my wife……checking lights

Walk back **again** to check the license plate…

Tribunal: Human factors recognised but pilots still responsible for the law……They need help!

From ‘Ergonomics’ to ’System’ logic

All of it together in reality:

Crew problem or computer?

- The cause of the incident was a quirk in the Airbus A320′s flight computer. On the first near-landing, it switched to ground mode — which, among other things, limits the power of the ailerons and restricts the pilots' power to move them. They had to look on powerlessly as the flight computer took control and put the plane at the mercy of the storm…. Only when the pilot started to ascend again did the flight computer return to flight mode and free the aileron.

- BFU Germany: during this investigation, the manufacturer stated that the system switches from Flight Mode to Ground Mode as soon as one main landing gear touches the ground, and that the effect

Computers act differently depending on context:
MODES……!!!…NOT TELLING….!!!

Automation and confusion(s)

- AF 447
  - Pitot data compromised
  - Do it yourself mode…
  - Pilots confused

- Asiana 214
  - Thrust into ‘Idle’
  - Disconnects protection
  - Pilot expectation = system state

Were pilots happy with automation?

ECOTTRIS EU project (1996-1998): no!

rank	need for more and better training
1	knowledge of automation
2	decision making
3	Crew Resource Management
4	manual flying
5	determination of appropriate SOP's
6	standard cockpit handling
7	knowledge of SOP's.

FAA investigations on HCI…..

EASA cockpit automation survey
pilots happy 15 years later (2013)?

- Improve training (MPL, evidence based training etc.) to better address automation management

And insight in technolog

EASA cockpit automation survey 2013

- Manufacturers to publish automation philosophies and policies, generic and specific to aircraft types for training and operations

many, complex, bit secret… & sneaky

Reverse-Engineering Autopilot Behavior on the A340-200/300.
The Anatomy of a Modern Autopilot

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Abstract

A rigorous and accurate method for reverse-engineering autopilot behavior from its description in the aircraft operational manual (FCOM) has been developed. The method has been applied to the A340-200/300 in the framework of a contract with Airbus Industrie whose goal was to study pilots' knowledge of autopilot behavior.

Introduction

There has been a growing need in the HF automation community to gain access to high-level descriptions of automation behavior. These descriptions are required for various purposes such as studying pilots knowledge of automation (Javaux and Olivier 2000), comparing autopilot specifications against plausible mental models (Rushby 2002), validating minimal safe mental models of autopilot behavior (Crow, Javaux and Rushby 2000), examining autopilots for consistent behavior (Degani 1996), looking for error-prone designs (Degani 1996, Leveson and Palmer 1997) and predicting automation surprises (Crow, Javaux and Rushby 2000, Javaux 2002, Rushby 2002) or reducing automation complexity (Vakil and Hansman 2002).

Method

The reverse-engineering method presented here is general and can be applied to any past or present autopilot, provided an operational manual is available. It draws on ideas first introduced by (Sherry et al 1997). It consists of eight steps that must be performed sequentially (fig. 1). Each step outputs information that is used by the next ones. Guidelines have been defined for each step.

Figure 2 below shows an example of output from step 2, where a small paragraph of the A340-200/300 FCOM (autoflight chapter) has been segmented into 3 informational zones that contain information relevant to autopilot behavior (205 such paragraphs were found in the 156 pages of the A340-200/300 autoflight chapter and segmented into 555 informational zones).

Figure 1. The 8 steps of the reverse-engineering method

Figure 2. Segmentation into informational zones

The information found in the informational zones is then translated into accurate logical expressions. The expressions for the informational zones of fig. 2 are shown in table 1. 736 such elementary logical expressions were found in the A340-200/300 FCOM autoflight chapter.

Table 1. Logical expressions for the information found in figure 2.

The reverse-engineering process then continues by normalizing the logical expressions (i.e., ensuring they all rely on the same basic set of predicates and arguments) and integrating them into independent mode or autopilot state transition scenarios. Transition scenarios correspond to single, independent and operationally meaningful autopilot behaviors such as 'ALT engagement when reaching the target altitude' or 'OP CLB engagement with the ALT selector knob'. 302 such independent transition scenarios (or autopilot behaviors) were found on the A340-200/300.

Reverse engineered flight modes

A340 flight manual based (n=302) mode behaviour (Javaux, 2002)

VERTICAL	arm	disarm	eng	diseng
SRS			2	3
OP CLB			4	4
OP DES			1	4
CLB	4	7	3	6
DES	3	6	2	6
V/S FPA			13	5
ALT*			1	3
ALT CSTR*			1	4
ALT CRZ*			1	4
ALT	1	2	2	1
ALT CSTR			1	3
ALT CRZ			1	3
G/S*			1	4
G/S	1	4	1	5
FINAL	1	6	1	7

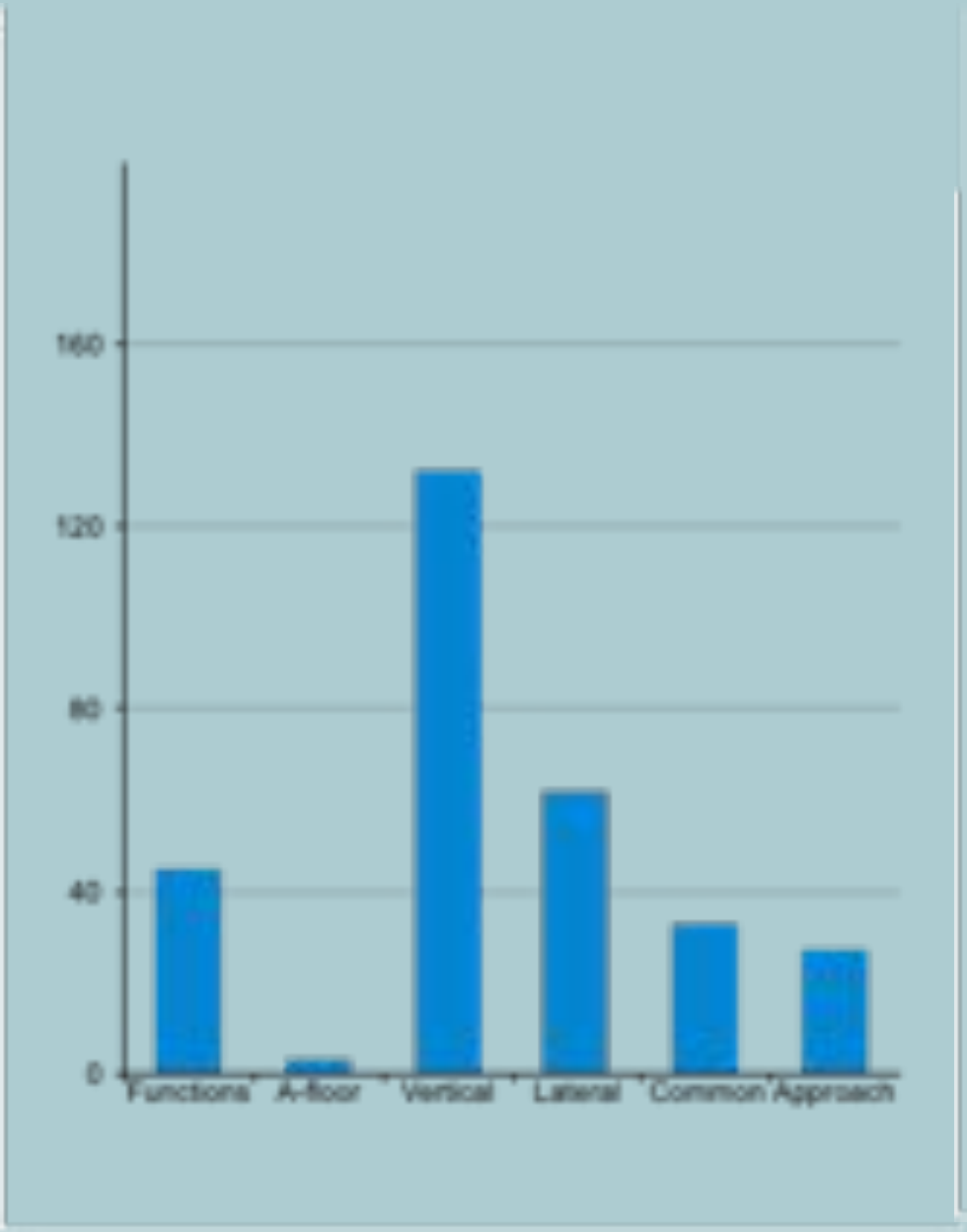
SYSTEMS	arm	disarm	eng	diseng
AP			3	11
FD			3	4
A/THR	5	6	4	6

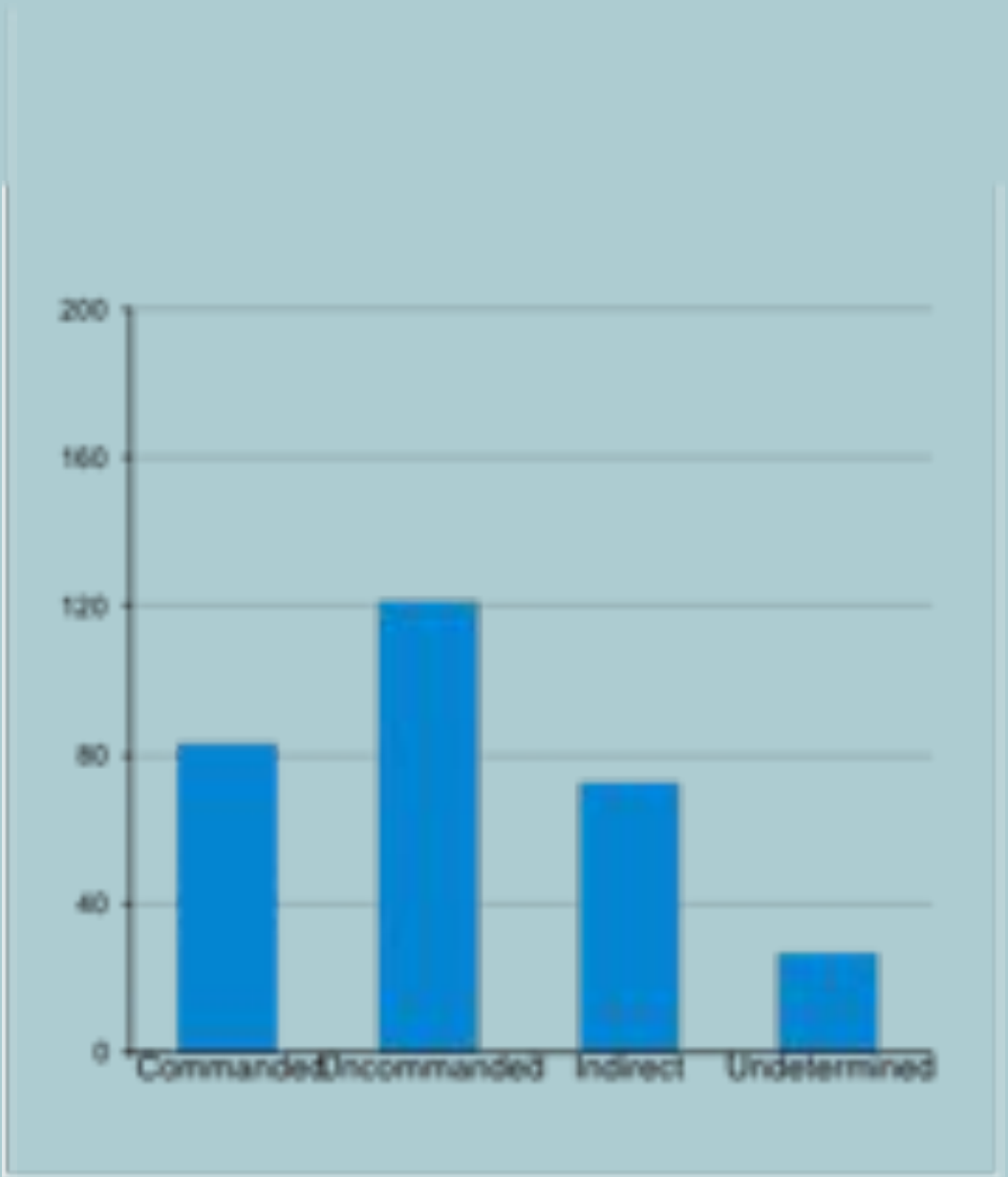
LATTRAL	arm	disarm	eng	diseng
HDG TRK			7	1
NAV	3	6	4	3
LOC*			1	4
LOC	2	4	1	5
APP NAV	1	5	2	7
GA TRK			1	1
RWY			1	1
RWY TRK			1	1

COMMON	arm	disarm	eng	diseng
TAKE OFF			1	5
GO AROUND			1	4
LAND			1	2
FLARE			1	1
ROLL OUT			1	
FINAL APP	1	6	1	8

APPROACH	arm	disarm	eng	diseng
PREC. APP	1	4	1	5
N.PREC APP	1	6	1	8

Mode families & transitions

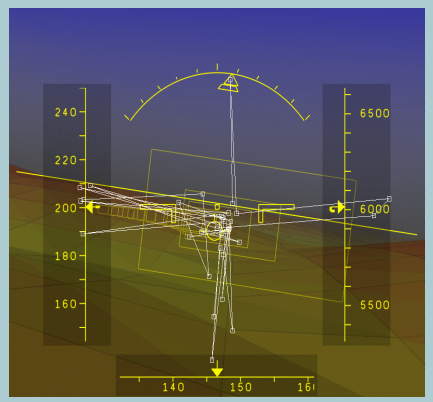


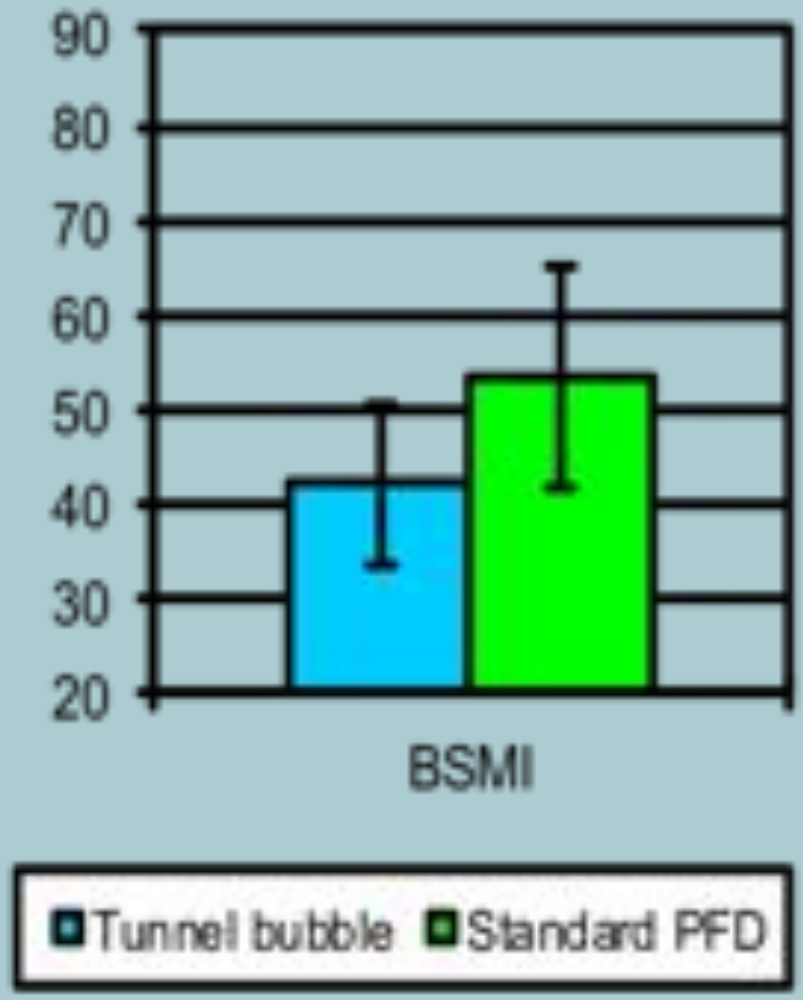


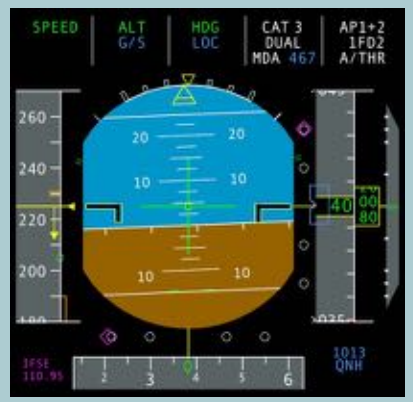
Slow Acceptance of technologie

WE DON'T KNOW WHAT IT DOES BUT IT WAS A MANDATORY MODIFICATION

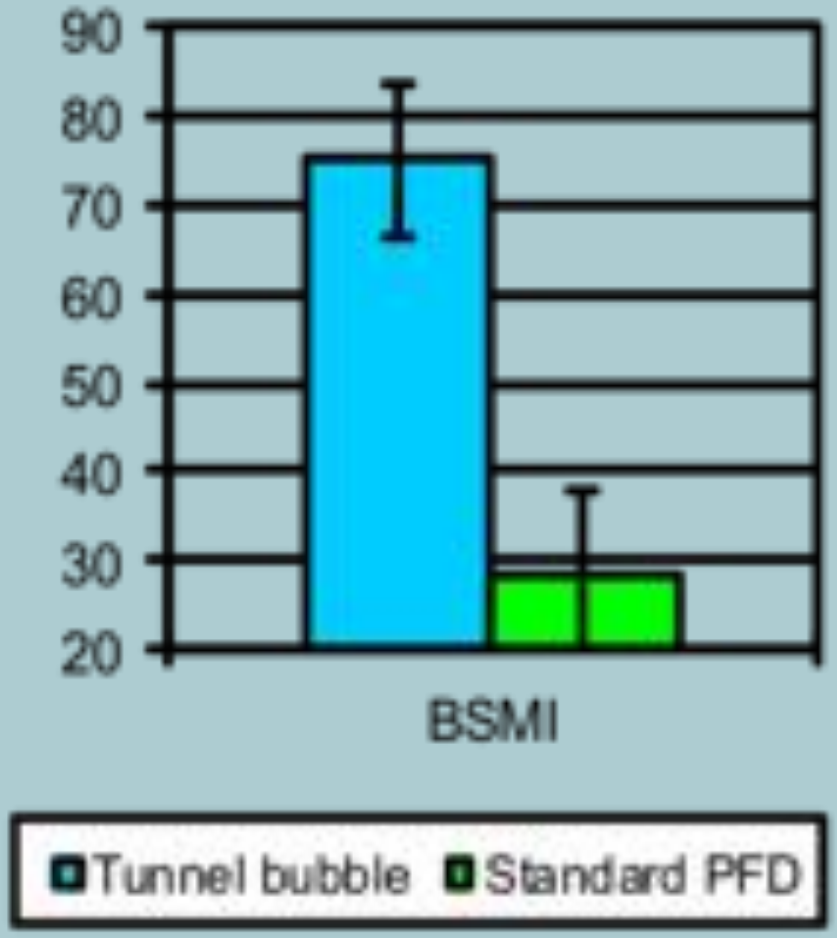
Workload ratings by civil pilots
favouring **new** technologies







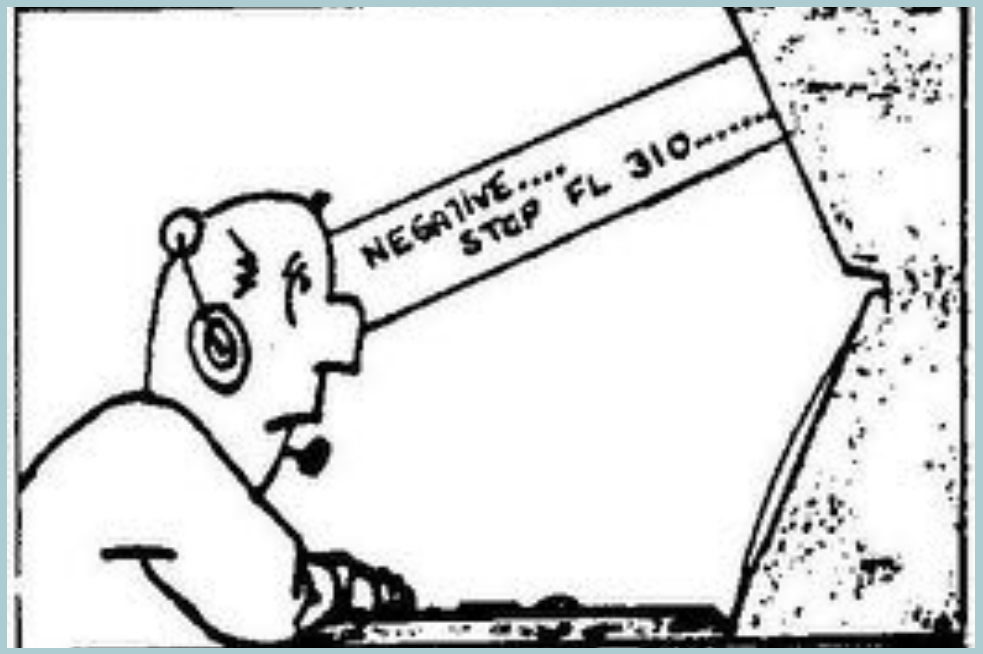
Workload ratings by pilots
favouring **familiar** technologies (30%)



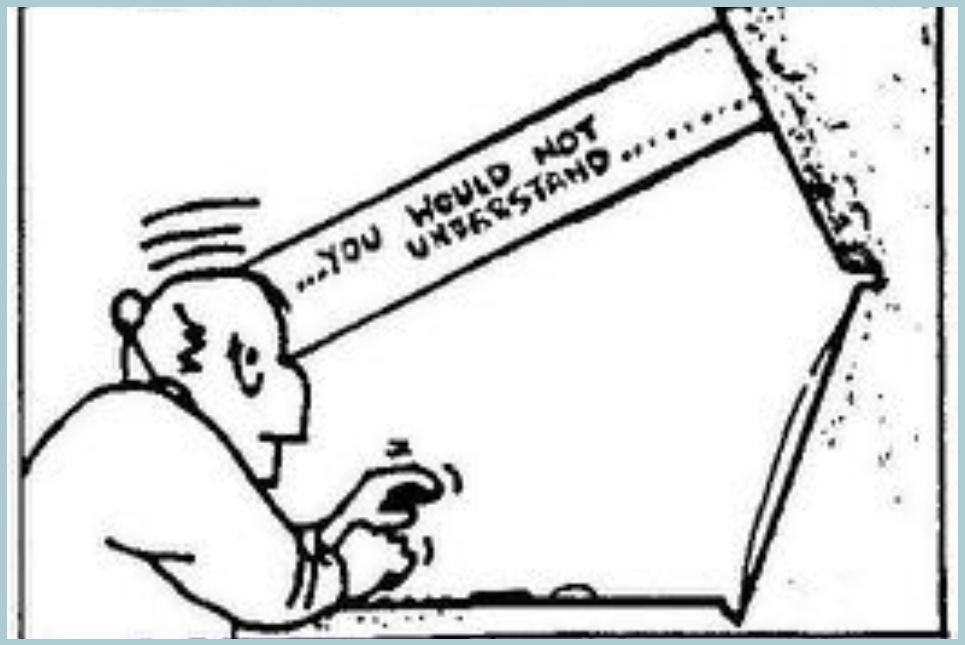
Users opinion has limited validity!

accepted?


REQUEST CLIMB
BA 123 FL 350.


NEGATIVE....
STOP FL 310.....


WHY FL 310?


...YOU WOULD NOT
UNDERSTAND.....

Improvements (Hilburn et al. 2016) WP-E SESAR project

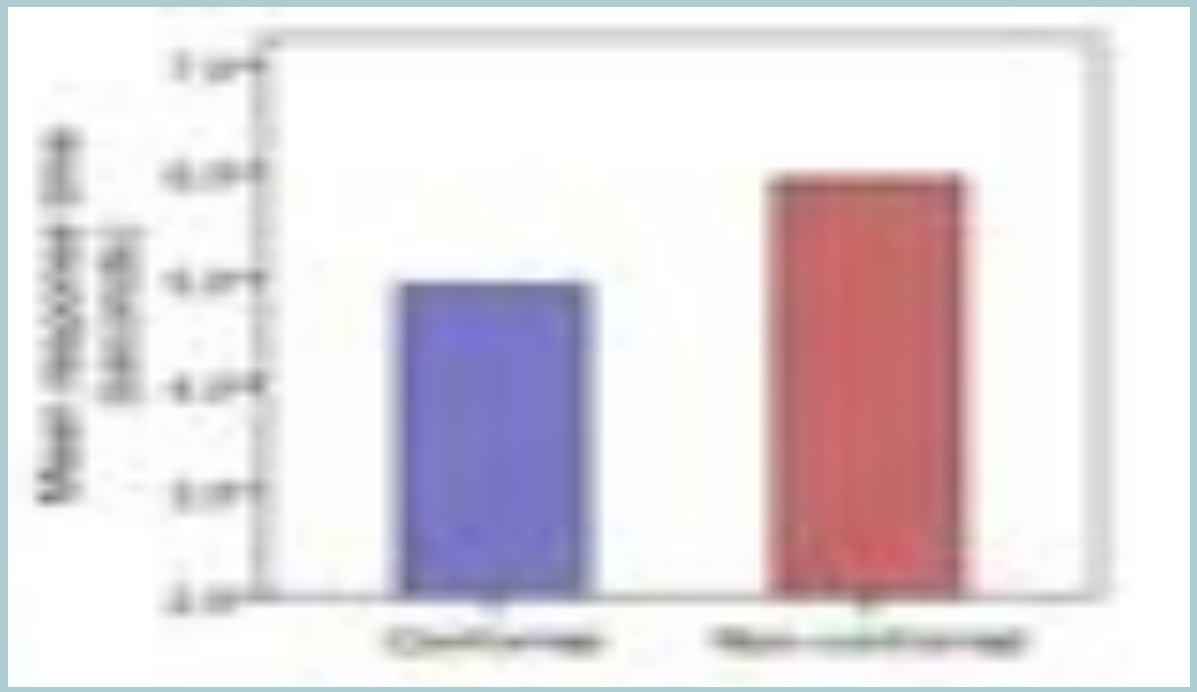
*Will controllers accept automation that thinks **exactly** like they do?*

CHPR

The big deception applied in the MUFASA project

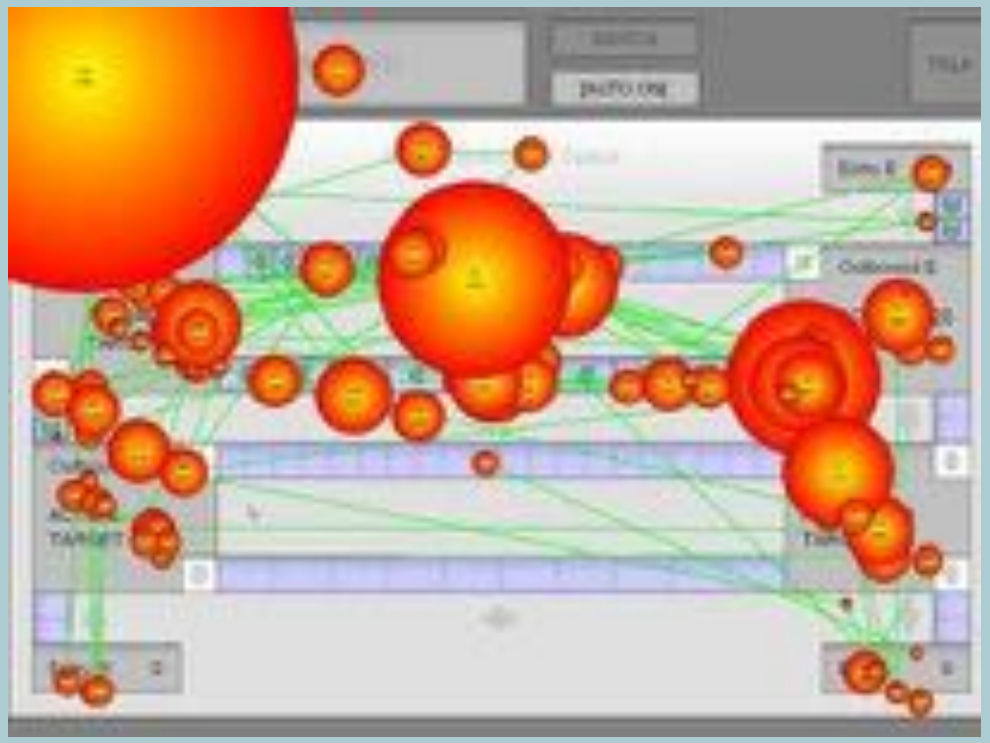
"Automation" advice was actually an unrecognisable replay of their own (or colleague's) previous performance

Accept/ Reject and response times



Improvements- Aviator 2013 select

monitor automation the planned wo



OMA

Operators Monitoring Appropriately

OMA is ‘Grand mother’ or ‘Granny’ in dutch…

Improvement: new HF Certification

devices versus *tasks*

HF certification is now Task(s) based

(Installed systems for use by the flight crew-25.1302)

FAR/CS§ 25.1302 Installed Systems and Equipment for Use by the Flight Crew

This section applies to installed equipment intended for the flight crewmembers' use in the operation of the airplane from their normally seated position on the flight deck. This installed equipment must be shown, individually and in combination with other such equipment, to be designed such that qualified flight crewmembers trained in its use can safely perform their tasks associated with the intended function by meeting the following requirements:

a) Flight deck controls must be installed and information necessary to accomplish these tasks must be provided,

b) The flight deck **controls and information** intended for the flight crew use must:

(1)Be presented in a clear and unambiguous form, at resolution and precision appropriate to the task, and

(2) Be accessible and usable by the flight crew in a manner consistent with the urgency, frequency, and duration of their tasks, and

(3) Enable flight crew awareness, if awareness is required for safe operation, of the effects on the aircraft or systems resulting from flight crew actions.

C) Operationally-relevant **behaviour of the installed equipment** must be:

(1) Predictable and unambiguous and

(2) Designed to enable the flight crew to intervene in a manner appropriate to the task.

d) To the extent practicable, the installed equipment must enable the flight crew to **manage errors** resulting from flight crew interaction with the equipment that can be reasonably expected in service, assuming flight crews acting in good faith. This subparagraph does not apply to skill-related errors associated with manual control of the airplane.

Frequent Safety show stoppers…

- **M** (issing information)
- **A** (ssumptions, Alternative strategies)
- **D** (esign induced troubles, Distractions)

Missing information

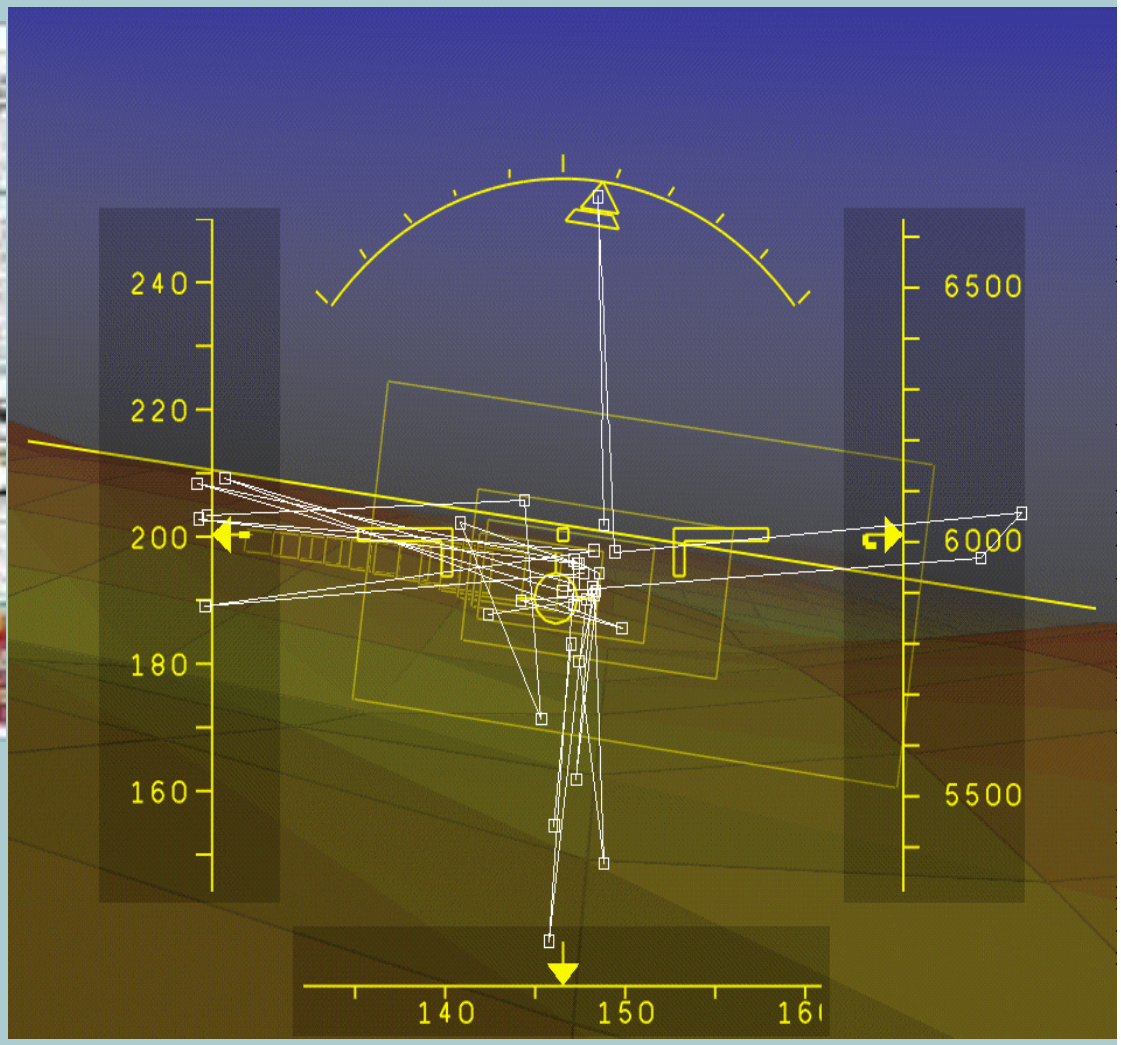
Assumptions made

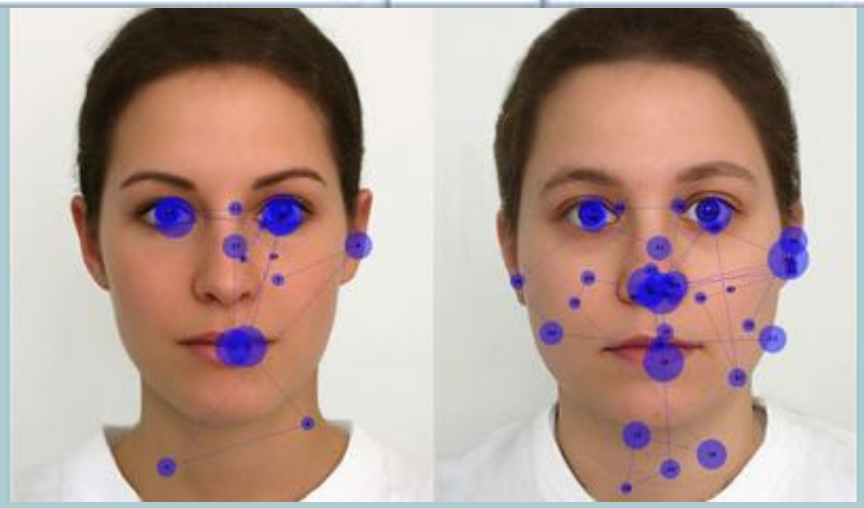
Design induced trouble

Objective', **realistic** design validation

EPOG gaze area's (A380 example)

Eye tracking trajectories





To the next level: USE THE EYE Trackers

tell the avionics…….Hé, you seem to be missing something…

‘COMPANION’ cockpit

Eye point of gaze & mental processing data into Avionics

the pilot looking?

e Operator State

s the new data attended?

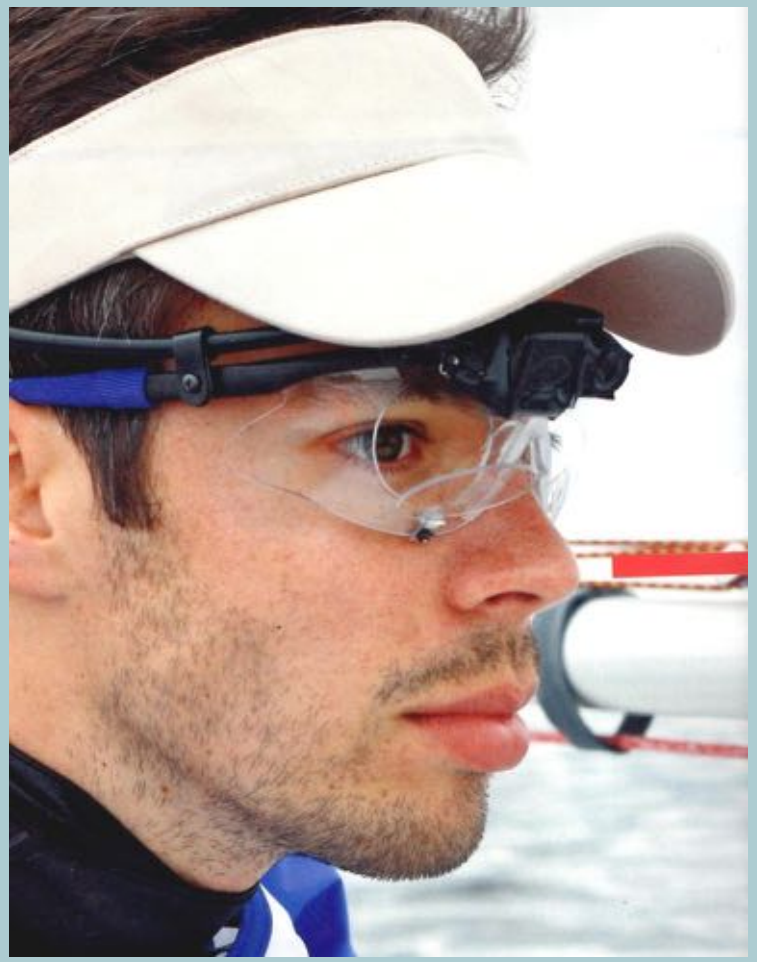
No? Alert or Change *location*

Too busy? adapt *timing* or use easy *format*.

Flaw in scan or strategy? Provide *feedback & training*

Feasibility?

Smaller equipment to wear



Face tracking by video imagery

Classification of Emotional states

Humanisation of automation

Companion and beyond: it is underway…….

Gaat de automation Robot ons helpen?

Of vervangen? (alweer…..)

De toekomst zal het zeggen..

Eerst maar een bakkie koffie?