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Aviation in Europe – Innovating for Growth

The 7th European Aeronautics Days



L O N D O N



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The 7th European Aeronautics Days



Manual Operations of 4th Generation Airliners

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Dedicated to innovation in aerospace

Summary

Research into unexpected situations

- How do flight crew handle unexpected situations?
- How do automated aircraft systems play a role?

Exploratory experiments

- Experiments carried out with operational pilots
- Identify the behaviours and competencies
- Potential areas for improvement

Recommendations development & testing

- Concepts developed to address the problems identified in initial experiments
- Verification of the concepts in simulator tests



What is the situation?



- Aviation is extremely safe...
 - 4 accidents per million departures
 - 30+ million flights per year
 - Advanced 4th generation aircraft
 - However...
 - ...*what about when the systems fail?*
 - ...*what if something unexpected happens?*
 - ...*we rely on the **pilot**.*
- *Is the pilot ready to take control?*



Man4Gen approach

Identify the effects on the pilot behaviours

Develop methods to understand cognitive performance

Identify recommendations for improved procedures, training and design



Problem Statement

*Despite the substantial and proven safety benefits of automation systems in 3rd and 4th generation aircraft, evidence indicates that when faced with **unexpected** and **challenging** situations, pilots sometimes have difficulties in **quickly responding** to situations which require a **rapid transition** in their activity from monitors of very reliable systems, to **active and authoritative decision-makers** and which may involve exercising **manual control** of the aircraft.*



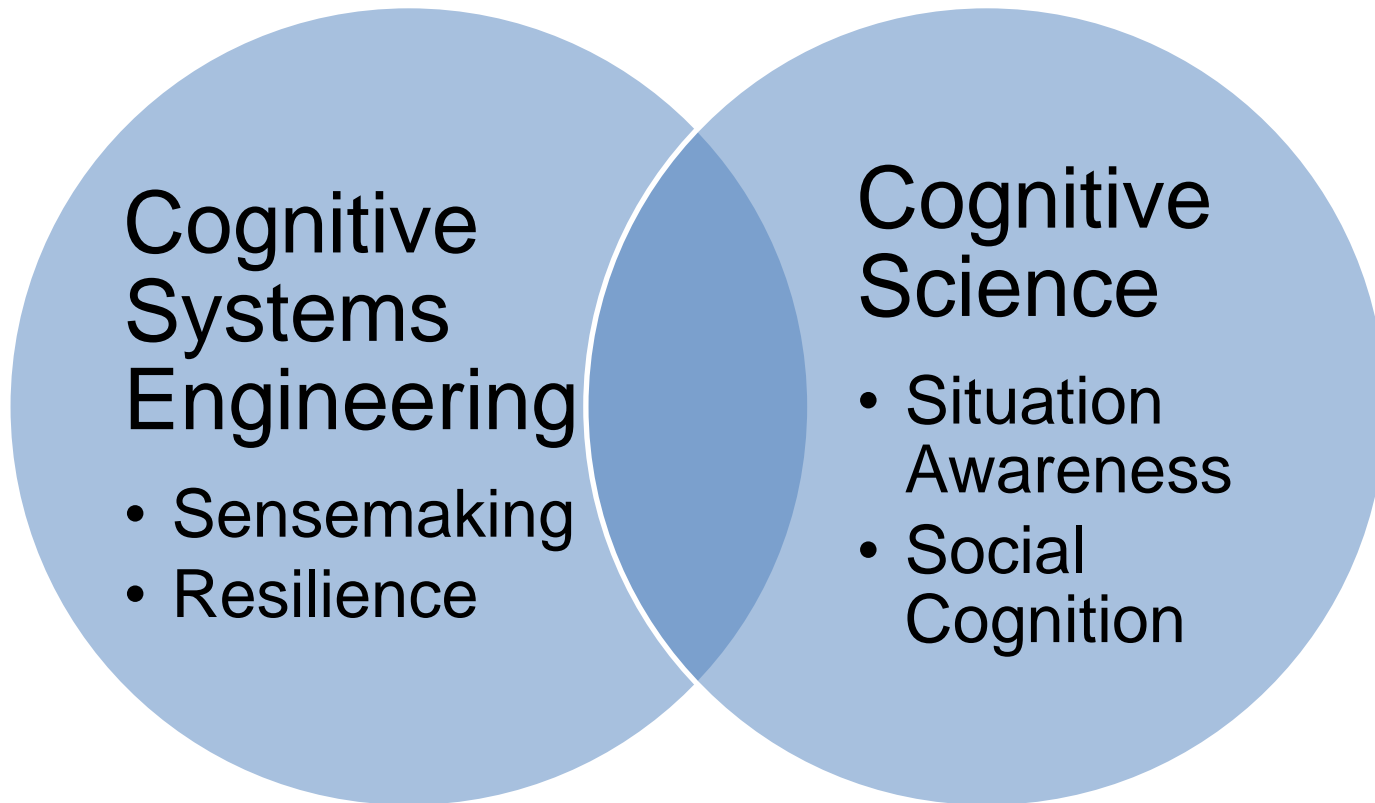


Research approach



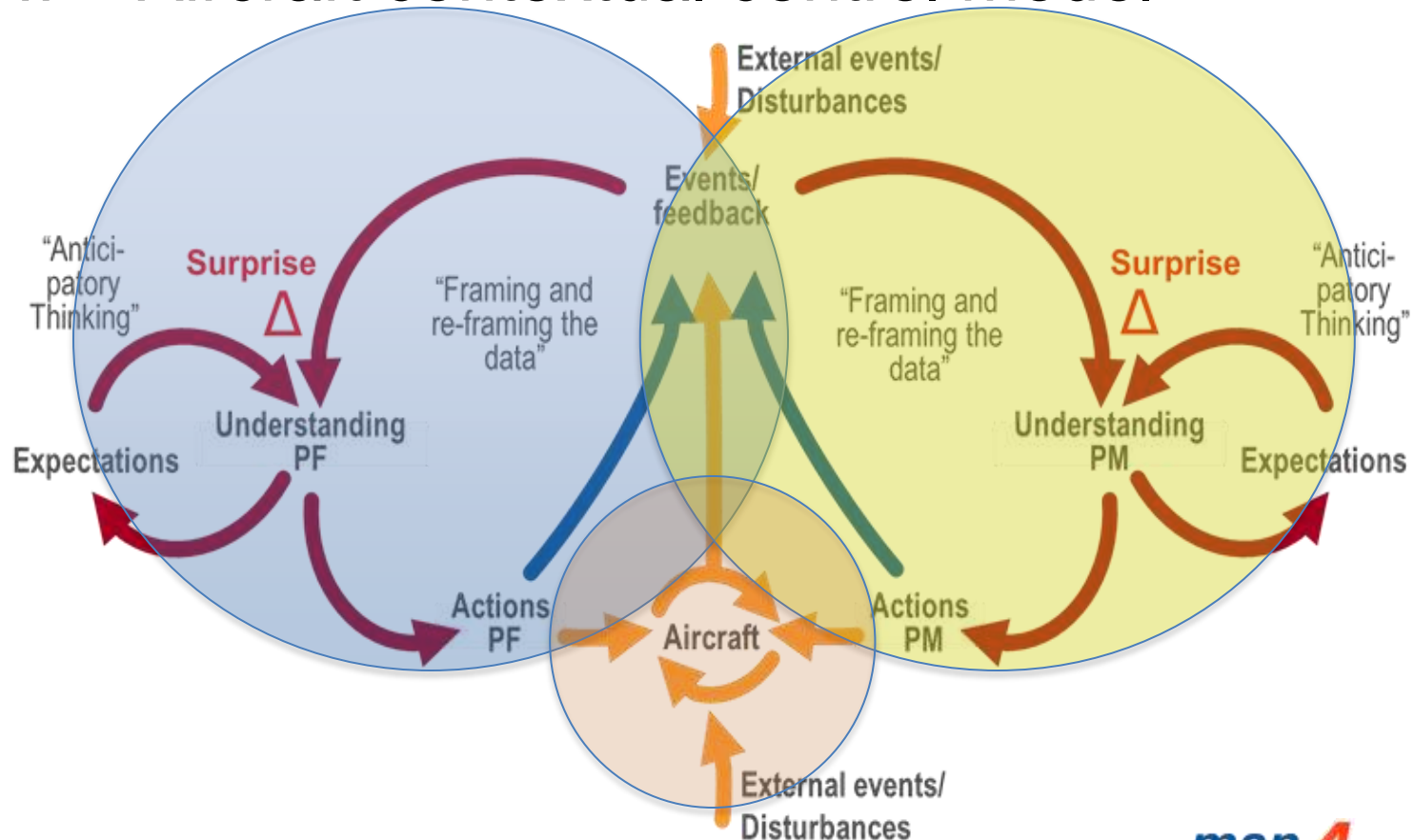
How are we examining the problem?

Two psychological research perspectives



Cognitive Systems Engineering

Crew – Aircraft contextual control model



Cognitive Science

SA related variables and methods:

Pilot functional state

- Heart rate
- Questionnaires

Pilot performance

- Expert observation
- Video analysis
- Simulator logging data

Pilot self-reported SA and workload

- Questionnaires

Pilot communication

- Expert observation
- Video analysis



Cognitive Science

fMRI experiments are executed to :

- Investigate SA on a fundamental neuronal level,
- Tackle fundamental aspects of the Man4Gen problem statement,
- Investigate the neurobiological correlates that can be considered central to piloting and monitoring an aircraft.



Exploratory experiments



How are we examining the problem?



Our experiment environments



B747 Simulator



A320 Simulator



fMRI



What are we investigating?

- Investigating crew behaviour
 - From an operational perspective
 - Understanding what is going on?
 - From a research perspective
 - Understanding why does the crew do this?



Behavioural Analysis



ICAO Pilot Core Competencies

- Application of procedures
- Communication
- Flight path management - automation
- Flight path management - manual
- Knowledge
- Leadership and teamwork
- Problem solving and decision making
- Situational awareness
- Workload management



Results from fMRI campaign

Cockpit style display used

Decision Making

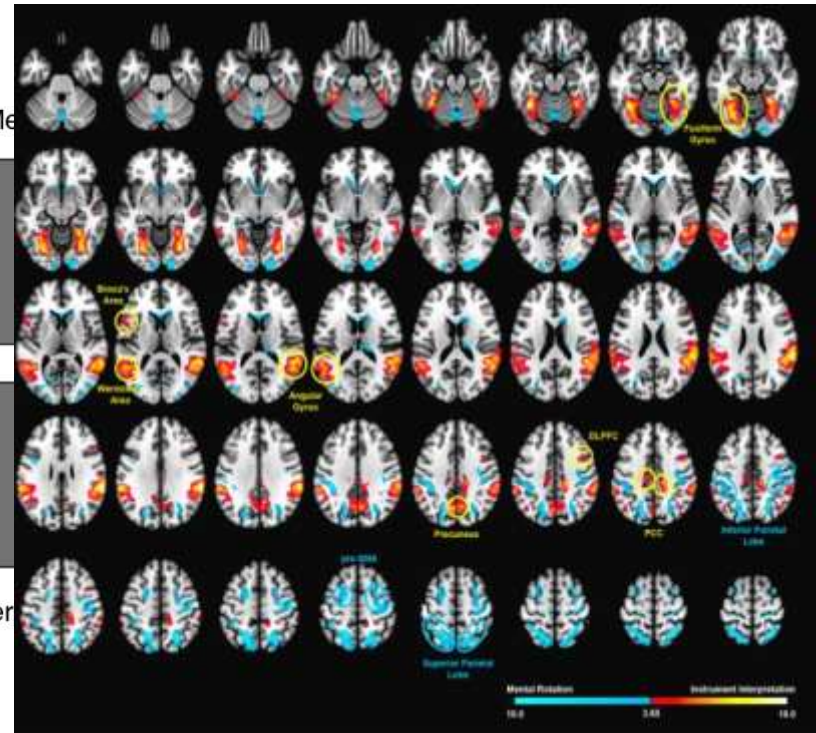
- Activation in visual areas during monitoring task

Mental rotation

- Significant activation differences between aviation and abstract mental rotation tasks

Anticipation

- Language, syntactical reasoning, communication are required for operations



Exploratory Simulator Campaign

Competency	P1_4	P2_4	P3_4	P4_4	P5_4	P6_4
Aircraft Flight Path Manage..	0.00	5.00	4.00	0.00	0.00	0.00
Aircraft Flight Path Manage..	0.00	2.00	1.00	4.00	0.00	4.00
Application of Procedures	0.00	1.00	1.00	2.00	0.00	2.00
Communication	26.00	10.00	17.00	22.00	10.00	10.00
Knowledge	0.00	0.00	0.00	5.00	0.00	0.00
Leadership and Teamwork	7.00	1.00	3.00	8.00	0.00	0.00
Problem Solving and Decisi..	5.00	1.00	0.00	14.00	0.00	0.00
Situation Awareness	8.00	2.00	2.00	4.00	0.00	0.00
Workload Management	3.00	3.00	0.00	10.00	0.00	0.00
Aircraft Flight Path Manage..	0.000	2.000	1.000	0.000	0.000	0.000
Aircraft Flight Path Manage..	0.000	0.000	0.000	0.000	0.000	0.000
Application of Procedures	1.000	1.000	0.000	2.000	0.000	0.000
Communication	0.000	0.000	0.000	2.000	0.000	0.000
Knowledge	0.000	0.000	0.000	0.000	0.000	0.000
Leadership and Teamwork	0.000	0.000	0.000	0.000	0.000	0.000
Problem Solving and Decisi..	0.000	0.000	0.000	3.000	0.000	0.000
Situation Awareness	2.000	0.000	1.000	2.000	0.000	0.000
Workload Management	0.000	0.000	1.000	2.000	0.000	0.000
Aircraft Flight Path Manage..	0.000	0.000	0.000	0.000	0.000	0.000
Aircraft Flight Path Manage..	0.000	0.000	0.000	0.000	0.000	0.000
Application of Procedures	0.000	1.000	0.000	1.000	0.000	0.000
Communication	0.000	2.000	0.000	1.000	0.000	0.000
Knowledge	0.000	0.000	0.000	1.000	0.000	0.000
Leadership and Teamwork	0.000	1.000	0.000	0.000	0.000	0.000
Problem Solving and Decisi..	0.000	0.000	0.000	0.000	0.000	0.000
Situation Awareness	2.000	0.000	0.000	0.000	0.000	0.000
Workload Management	0.000	0.000	0.000	2.000	0.000	0.000

Main Results

- High-performing crews were strong in:
 - Communication
 - Problem Solving and Decision Making
 - Leadership and Teamwork
 - Workload Management
- Low-performing crews showed weaknesses in:
 - Application of procedures under low-workload
 - Difficulties in manual flying



Defining the recommendations

- If competencies carry over to other scenarios, **focused training** is possible
- **Procedures** that reinforce required behaviours can be developed
- **Flight deck features** supporting essential competencies can be designed

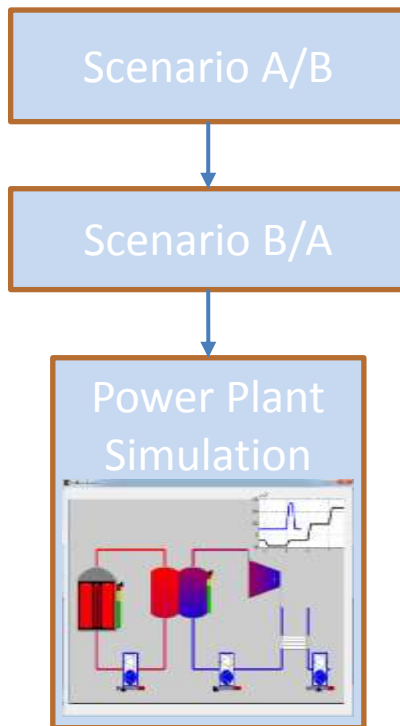


Concept development & verification

Training Concept Verification Campaign

Goals:

- Validate results from the first campaign
- Demonstrate that competencies transition between scenarios
- Measure competencies in desktop exercise/simulation



Scenario A:

- Approach, wind turning on tail, loss of visual contact, HDG fail during G/A, birdstrike, both engines in surge

Scenario B:

- Take-off, dual FMGC fail due to lightning strike, additional failures


Desktop Simulation:

- Crew nuclear power plant control task (requires same competencies)



“Just think!”

Strategy to support cognitive processes



“Just do the checklist!”

Procedure and Cockpit Display Concept

- Manage Time
- Manage (Un)certainities
- Manage contingencies

Step 1:

- **Fly the aircraft**
- **Confirm flight path control (or if semi-stable)**
- **Consider use of autoflight**
- **Assign PF/PM**

Stabilize flightpath & task management

Manage immediate threats

Short term planning

Identify situation

Perform appropriate actions

Long term planning



Procedure and Cockpit Display Concept



Risk LVL page
(XPDR Button 0)



Flight Phase Risk page
(XPDR Button 5)



Four Category subpages
(XPDR Button 1-4)



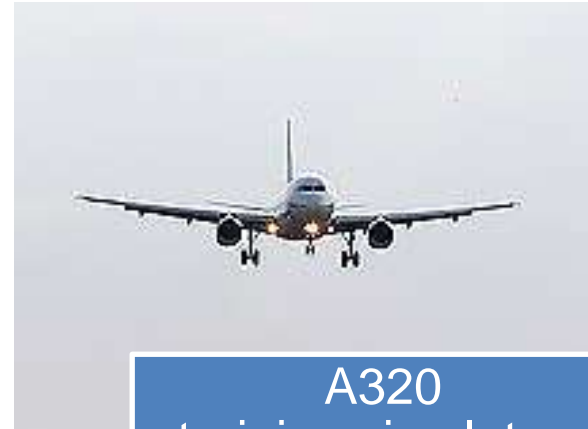
Verification campaign

Facilities

- A320-200 training simulator in xxxx
- A320-200 training simulator in Madrid, Spain
- GRACE research simulator NLR, A330, Amsterdam
- AVES research simulator DLR, A320, Braunschweig

Participants

- 30 flight crews in xxxx
- 12 flight crews in Madrid
- 12 flight crews in Amsterdam
- 8 flight crews in Braunschweig



A320
training simulators



A330
research simulator



To be continued...



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<http://man4gen.eu>



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