THE INTERNATIONAL JOURNAL OF AEROSPACE PSYCHOLOGY
https://doi.org/10.1080/24721840.2025.2531746

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Anthropomorphic AI: Sociopathic AI Features as Predictors of Career Opportunities and Threats Perceived by Pilots in Commercial Aviation

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ABSTRACT

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Airline Captain (A320, A330/350)



Experienced Manager
Line Training Captain
Type Rating Instructor (TRI)
Type Rating Examiner (TRE)
Senior Examiner (SEN EASA and GCAA)
Aviation Safety Specialist
Evidence-Based Training Specialist

Scholar, Author, Lecturer
Doctoral Graduate Researcher

Co-Founder of HUMAI Research

Giacomo Belloni

HUMAI Research FZC

Empowering Human Performance with Advanced Technology

HUMAI develops human-centred **solutions** that integrate advanced and intelligent technologies with human resilience to enhance performance in complex, time-critical, and resource-constrained environments.

Human–Technology Integration focuses on seamlessly integrating advanced technologies and artificial intelligence with human capabilities to improve performance, behaviours, actions, and decision-making processes. The goal is to ensure that technology augments—rather than replaces—the human operator, especially in high-complexity operational contexts.

Cognitive Monitoring (Biometric and Biological). HUMAI employs non-invasive, real-time monitoring systems to assess operators' cognitive states. These tools enable technologies to adapt to human mental conditions and capabilities, supporting optimal performance and reducing cognitive overload.

Comprehensive Data Analysis. By collecting and analysing large-scale operational data in real time, HUMAI provides context-aware insights that account for dynamic and high-pressure conditions. This enables safer and more efficient solutions, supporting operators with accurate, timely, and actionable information throughout the full decision–action cycle.

Advanced Training Solutions. The solution leverages AI-driven tools to design innovative training methodologies, including competency assessment systems and adaptive training program generators. These solutions personalise training pathways based on individual performance, enhancing skill development and operational readiness.

Synergistic Ecosystem. By integrating training, decision-support tools, and intelligent technologies, HUMAI fosters a synergistic ecosystem where human expertise and advanced systems work in harmony. This approach enhances safety, efficiency, and overall operational effectiveness, representing a significant step toward next-generation, human-centred technological environments.

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The Autonomy Penalty: Understanding Commercial Pilots' Acceptance of Intelligent Technologies in the Cockpit

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encing commercial aviation pilots' acceptance of autonomous
logies, and to investigate whether resistance to increasing AI
of intelligent technologies or concerns about transferring
tems.
creasingly being integrated into commercial aviation cockpits,
sessment, operational performance, and an expanding range of
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Pilots and Advanced/Intelligent Technologies in Light of EASA's 2025 Reduced-Crew Operations Evaluation

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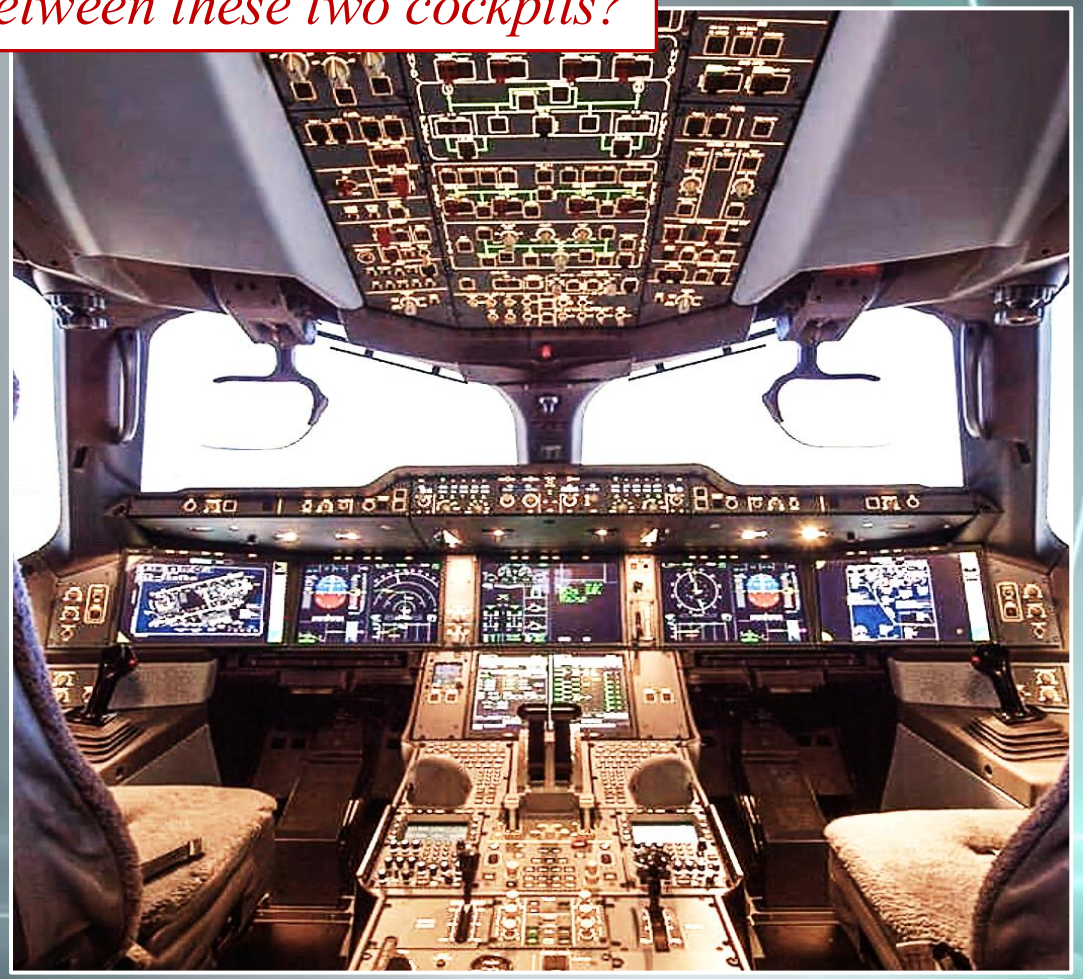
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What is the difference between these two cockpits?





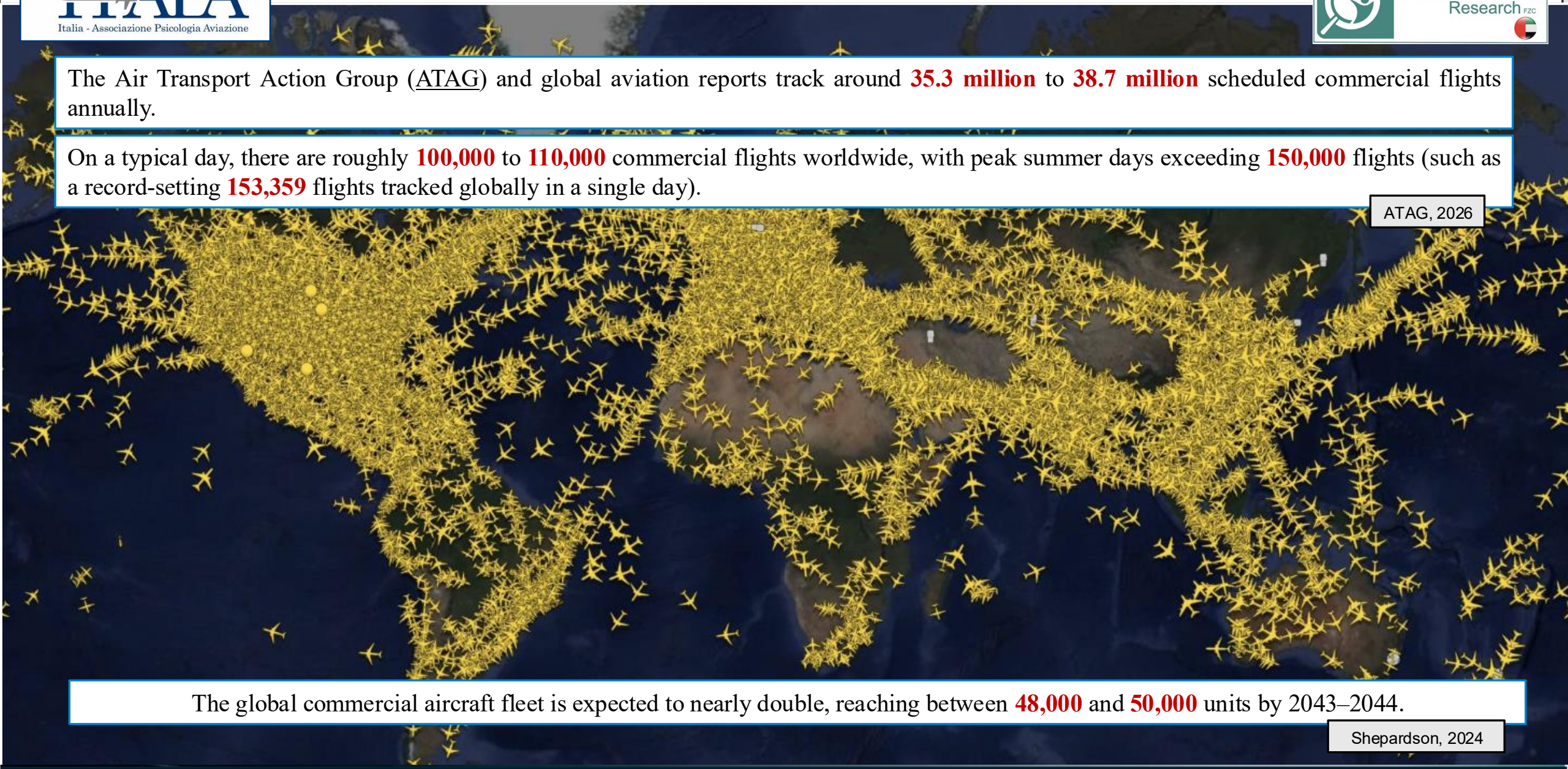


Why is it necessary this impressive level of technology?

The Air Transport Action Group (ATAG) and global aviation reports track around **35.3 million** to **38.7 million** scheduled commercial flights annually.

On a typical day, there are roughly **100,000** to **110,000** commercial flights worldwide, with peak summer days exceeding **150,000** flights (such as a record-setting **153,359** flights tracked globally in a single day).

ATAG, 2026

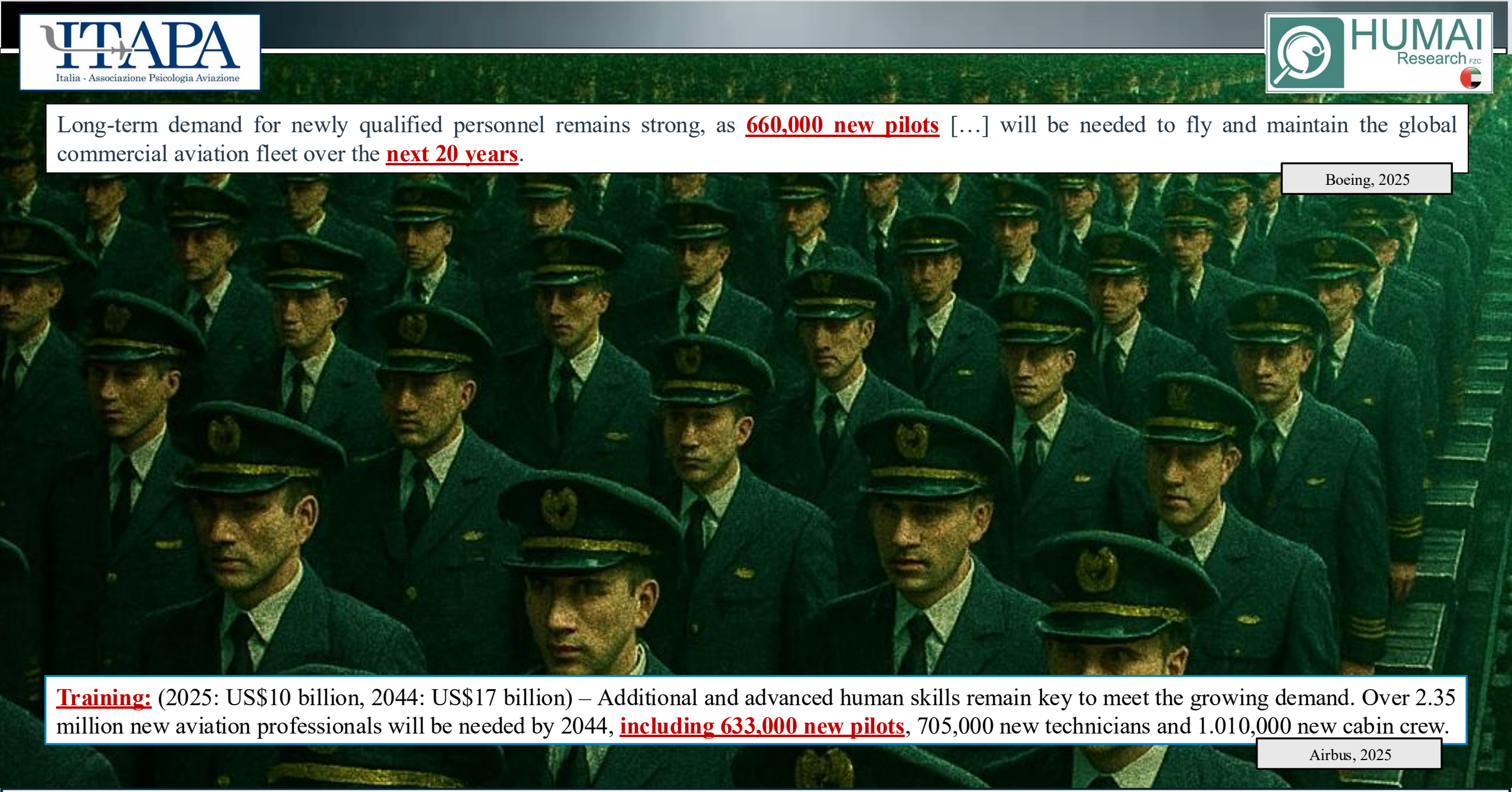


The global commercial aircraft fleet is expected to nearly double, reaching between **48,000** and **50,000** units by 2043–2044.

Shepardson, 2024

Long-term demand for newly qualified personnel remains strong, as **660,000 new pilots** […] will be needed to fly and maintain the global commercial aviation fleet over the **next 20 years**.

Boeing, 2025



Training: (2025: US$10 billion, 2044: US$17 billion) – Additional and advanced human skills remain key to meet the growing demand. Over 2.35 million new aviation professionals will be needed by 2044, **including 633,000 new pilots**, 705,000 new technicians and 1.010,000 new cabin crew.

Airbus, 2025

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MACH
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FLAP
TLU LO SPEED
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TQ %
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AUTO FTR
ITT °C
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FT 00 H 23
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FOB 2700 KG
GW 20360 KG
ENG 2 OUT
SINGLE ENGINE
ENG 2 FLAME OUT AT TAKE OFF
NORMAL CONDITIONS
GS 205 TAS 210
045 / 20
ILS27-W
CI366 124°
3.7 NM
13:38
WX+T
PATH
VOR2
CIA
15.3 NM
GS 429 TAS465 ILS APP
PAS 108°
No threat
Proximate
Potential
Threat (TA)
Collision
Threat (RA)
MOGON
102°
210 NM
06:46
ABNOTLI
ABTAMRO
SVA1393
OEHL
KNE121
ABGENON
ABDEDGI
WX+T
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         PLANNED FUEL
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TAXI                     750  0025
TRIP           KJFK    89592  1246
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ALTN           KEWR     2822  0027 DF
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T/O ALTN / TOBT / TSAT / CTOT
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     OPERATIONAL IMPACTS
WT UP 3.0     TRIP P 0700 KGS
WT UP 1.0     TRIP P 0234 KGS
WT DN 1.0     TRIP M 0227 KGS
WT DN 3.0     TRIP M 0687 KGS
FL UP 1.0     TRIP M 0239 KGS
FL DN 1.0     TRIP P 0926 KGS
FL DN 2.0     TRIP P 1968 KGS
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STEP      /320/KABAN/340/
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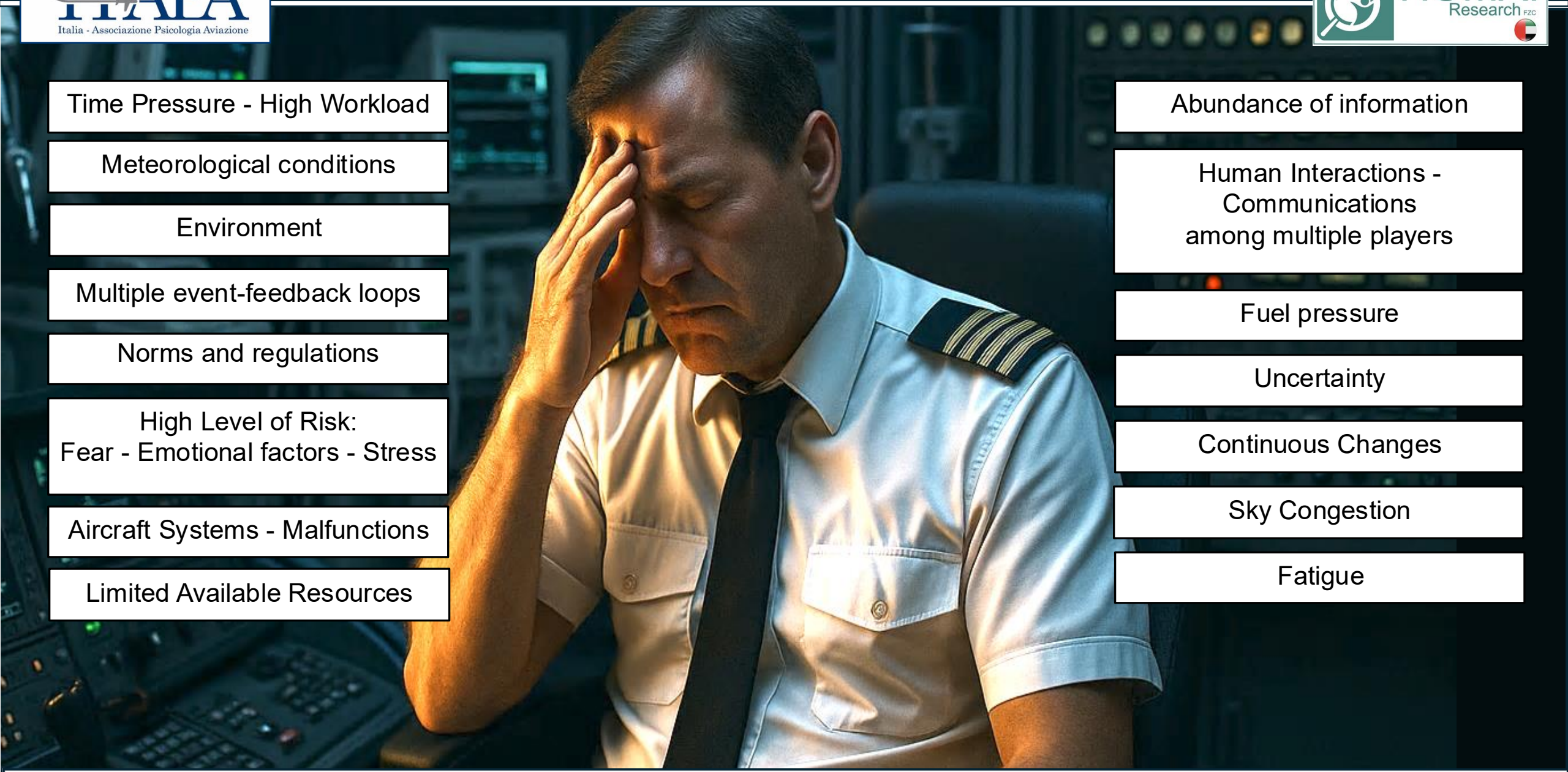
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Giacomo Belloni

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- Time Pressure - High Workload
- Meteorological conditions
- Environment
- Multiple event-feedback loops
- Norms and regulations
- High Level of Risk: Fear - Emotional factors - Stress
- Aircraft Systems - Malfunctions
- Limited Available Resources
- Abundance of information
- Human Interactions - Communications among multiple players
- Fuel pressure
- Uncertainty
- Continuous Changes
- Sky Congestion
- Fatigue

Empirical evidence indicates **that human error accounts for approximately 60–80% of aviation incidents**, rather than mechanical failures or aircraft malfunctions.

O'Hare et al., 1994; Shappell & Wiegmann, 1996; Shappell et al., 2006; Casner & Gore, 2010; IATA, 2013; Wagener & Ison, 2014



Errors predominantly stem from challenges of **operational complexity**, such as stress, cognitive load, difficulties making decisions under pressure.













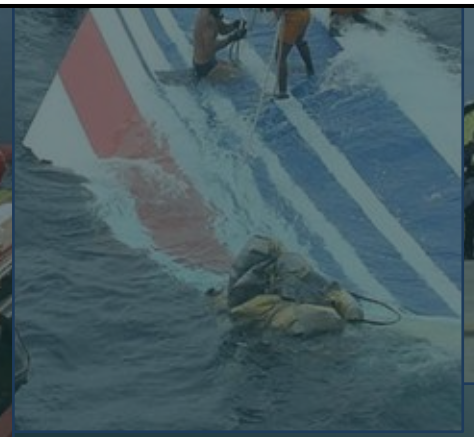
What do these incidents have in common?





Although the reliability and design of aeroplanes have steadily improved over time, by the end of the 1980s, the number of events was no longer declining, remaining at a constant rate. Notwithstanding *"the noteworthy technological advances in modern aircraft, devastating crashes continue to occur"* (Wagener & Ison, 2014), but in these cases, unlike in the past, on aircraft **without damage or malfunctions**.

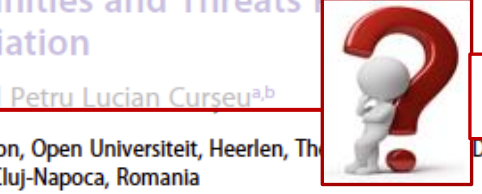
EASA
European Union Aviation Safety Agency


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Technology & Complexity



Why do we love technology?

THE INTERNATIONAL JOURNAL OF
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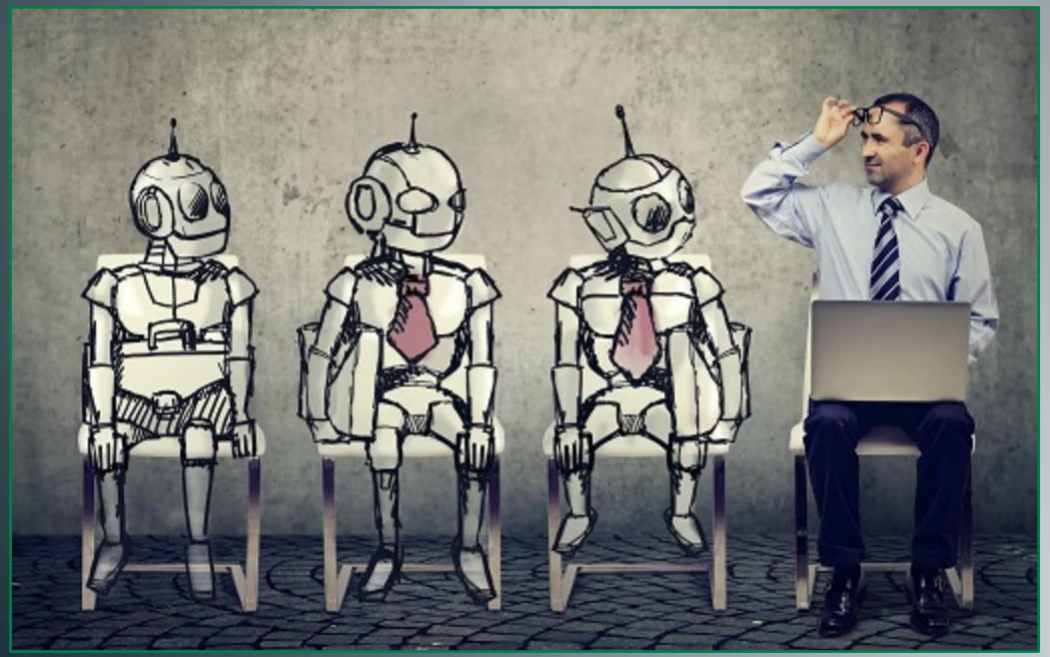
Man and technology, a symbiotic relationship











Our species identifies itself with the equipment it uses; man has always hybridised his nature with his tools. Technology development, together with humankind's evolution, is a dynamic co-evolutionary process; *"homo sapiens have always been homo technologicus, a symbiont of man and technology in perpetual transmutation"* (Longo, 2005, p. 5). Technology is so determinant today that it contributes to forming man's cognitive categories and influences their development. The distinction between man and technology is unclear because technology contributes to forming the essence of man. Technology's evolution has become man's evolution.

Longo, 2005, p. 5

"Technology progressed at a different pace, faster than man's ability to understand it. Pilots found themselves inexperienced in managing such an extreme degree of automation and the resulting intricacy. […] Automation has distorted the pilot's identity, who found himself unprepared to manage such a high degree of innovation".

(Belloni, 2019)

Pilots *"express growing concern about the complexity of advanced/intelligent technological systems and the difficulty in understanding their underlying functioning.*
This perception aligns with what was observed in many accidents: when technology becomes opaque or too complex, the risk arises not only from human error, but from a cognitive gap between humans and the system.
At that point, the effectiveness of recovery depends entirely on the pilots' level of training to be highly competent and resilient; therefore, on a system centred on humans, and not on machine technology".

(Belloni & Interlandi, 2025)

The Three Studies

1. **Anthropomorphic AI: Sociopathic AI Features as Predictors of Career Opportunities and Threats Perceived by Pilots in Commercial Aviation**

2. **Pilots and Advanced/Intelligent Technologies in Light of EASA's 2025 Reduced-Crew Operations Evaluation**

3. **The Autonomy Penalty: Understanding Commercial Pilots' Acceptance of Intelligent Technologies in the Cockpit**

Pilots do not necessarily reject artificial intelligence outright. Their willingness to accept it depends on **how they perceive** it, the benefits they attribute to it, and, above all, the degree of **operational authority** they are called upon to delegate to it. This distinction is fundamental to understanding the concept of the ***Autonomy Penalty***.

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This study analyses the **Anthropomorphisation** of AI, the tendency to attribute typically human characteristics to it, including negative ones.
The term **Sociopathic AI** does not imply that the AI is sociopathic; rather, it indicates that some pilots attribute to it traits such as:

1) ***lack of empathy,***
2) ***moral conscience,***
3) ***accountability,*** or
4) ***remorse***.

We have used a questionnaire completed by **363 commercial pilots** and analyses four main dimensions:

1) ***Perceived sociopathic characteristics,***
2) ***Professional opportunities,***
3) ***Career threats,*** and
4) ***Expected performance improvements.***

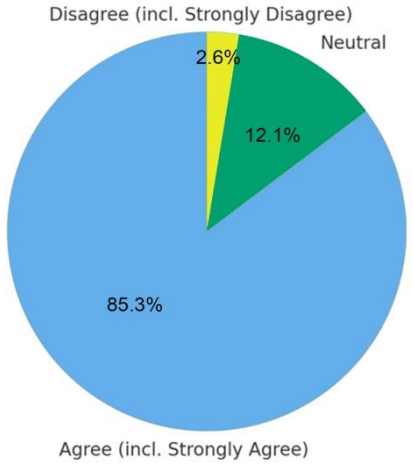
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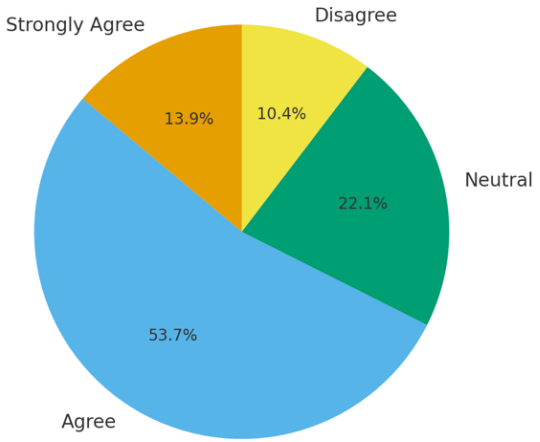
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1. Technology

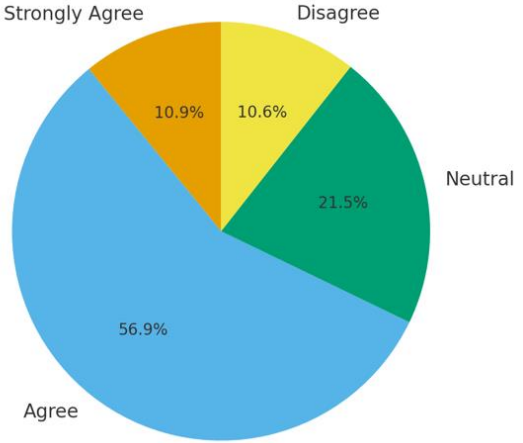
1) ***Technology*** *enables me to accomplish tasks more quickly, improves my performance, enhances the effectiveness and makes it easier to do my job.*



2) *Learning to operate* ***technology*** *is easy for me.*



3) **Advanced/Intelligent Technologies** learning programs can ultimately lead to an innovative way of learning and thinking.



(Belloni & Curșeu, 2025)

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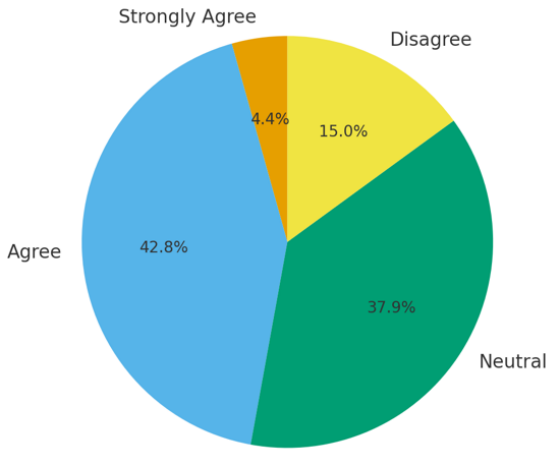
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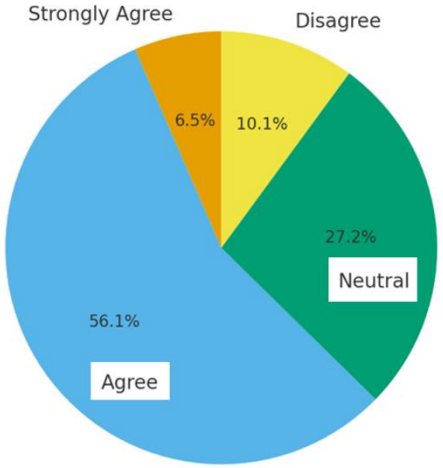
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2. Safety, Efficiency, Effectiveness

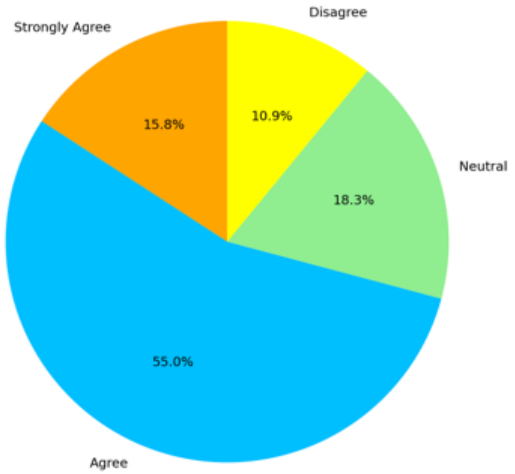
4) ***Advanced/Intelligent Technologies*** enhance flight operations **safety**.



5) **Advanced/Intelligent Technologies** provide innovative tools to perform my job **effectively**.



6) **Advanced/Intelligent Technologies** improve **efficiency** in commercial aviation.



(Belloni & Curşeu, 2025)

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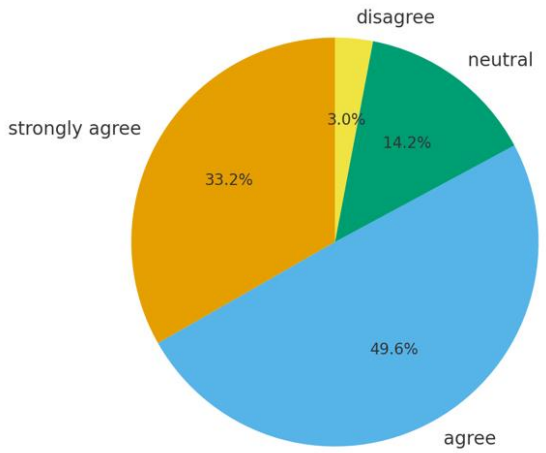
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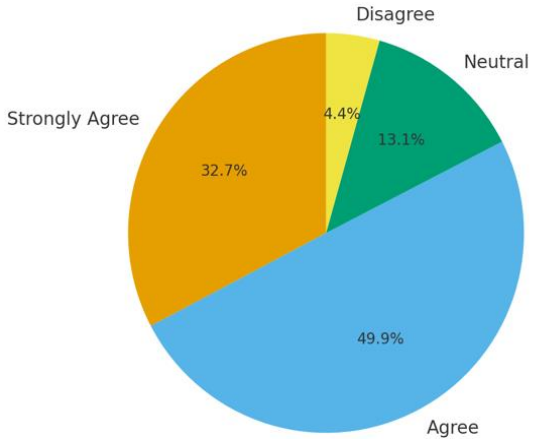
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3a. Advanced/Intelligent Technologies

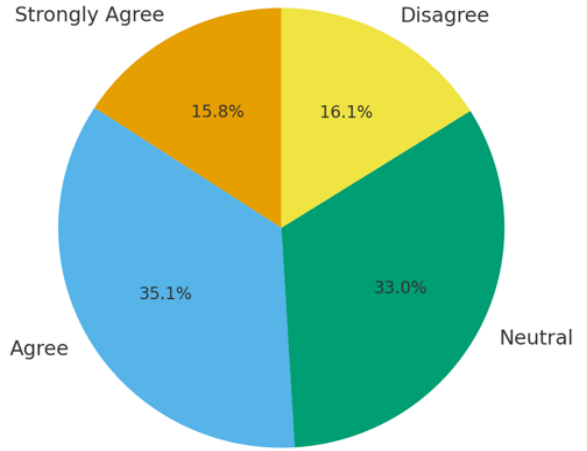
7) ***Advanced/Intelligent technologies*** *have risks that are discovered once people use them.*



8) *There should be caution in replacing people's tasks with* ***Advanced/Intelligent technologies*** *because new technologies can break down or get disconnected.*



9) *When* ***Advanced/Intelligent Technologies*** *have full control over operating systems, it can act against the best interests of humans.*



(Belloni & Curșeu, 2025)

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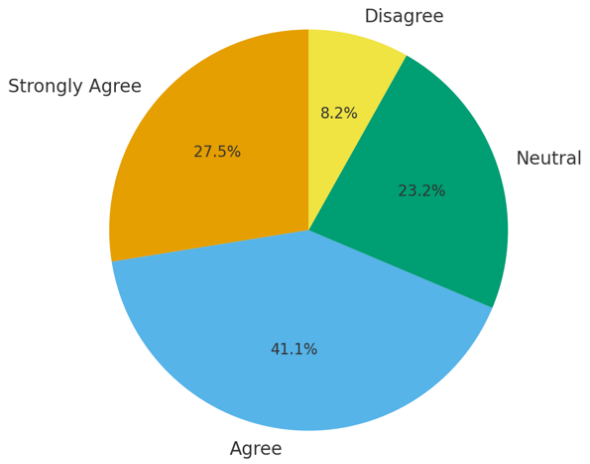
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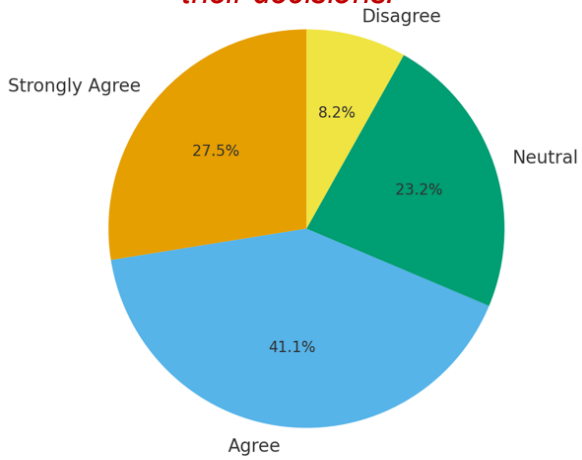
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3b. Advanced/Intelligent Technologies

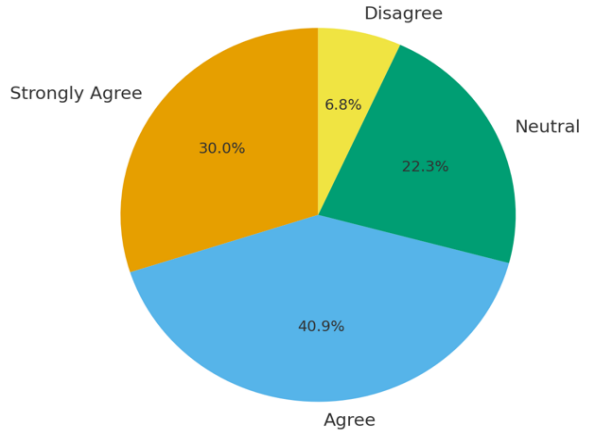
10) ***Advanced/Intelligent Technologies*** *cannot empathise with the human nature of complex*



11) ***Advanced/Intelligent Technologies*** *have no conscience that would make them accountable for their decisions.*



12) ***Advanced/Intelligent Technologies*** *have no feelings of guilt or remorse that could allow them to learn from mistakes and correct themselves.*

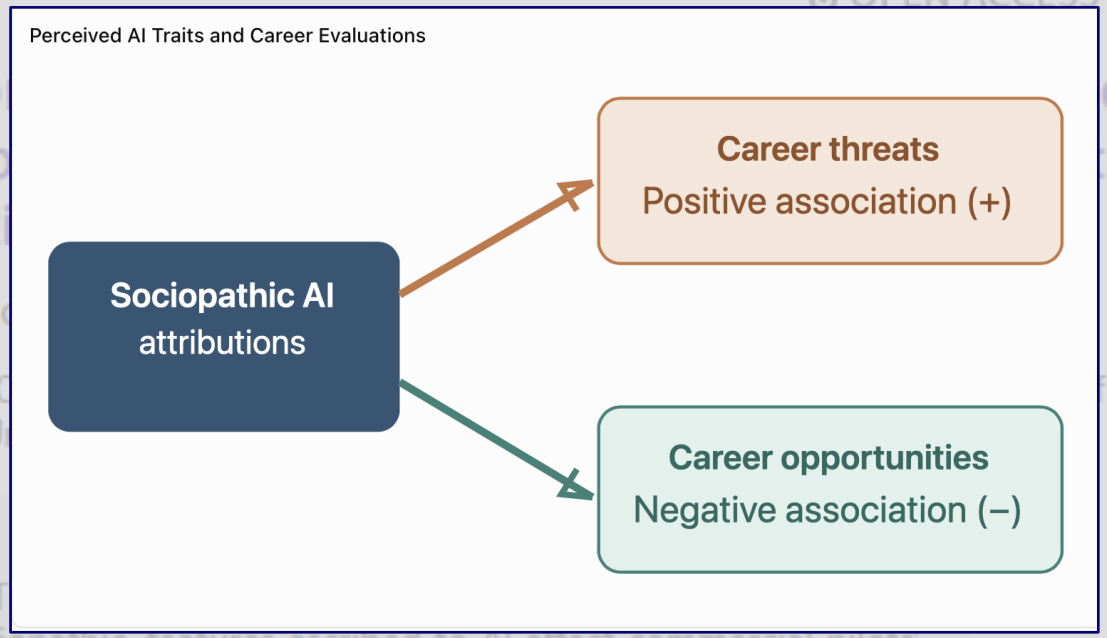


(Belloni & Curșeu, 2025)

of AI integration in the cockpit.
Background: Although technology has long been an irreplaceable, valuable ally for airline pilots, artificial intelligence (AI) differs significantly from previously used technologies and pilots perceive AI not only as a tool but as an [illegible]. These

1

Anthropomorphic AI: Sociopathic AI Features as Predictors of Career Opportunities and Threats Perceived by Pilots in Commercial Aviation



The results demonstrate that pilots who attribute sociopathic characteristics to artificial intelligence tend to perceive greater threats to their careers and fewer professional opportunities associated with its introduction.

2

Pilots and Advanced/Intelligent Technologies in Light of EASA's 2025 Reduced-Crew Operations Evaluation

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This second study involves **437 commercial pilots** and uses **three operational scenarios**: **normal**, **adverse**, and **emergency**.

The objective is to determine the extent to which the willingness to rely on advanced, intelligent technologies depends on three factors:

1) **Technological optimism**: *the belief that technology improves effectiveness, control, and performance.*
2) **Technological discomfort:** *uncertainty, anxiety, or a sense of losing control when interacting with technology.*
3) **Awareness of EASA assessments:** *knowledge of the Agency's conclusions regarding reduced-crew operations.*

intelligent systems, and whether awareness of recent European Union Aviation Safety Agency (EASA) evaluations of reduced-crew operations influences these judgments. A vignette-based survey of 437 commercial pilots assessed reliance decisions across normal, adverse, and emergency scenarios. Results show that technological optimism positively predicts reliance on

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Variable	Result
Technological optimism	Positively predicts reliance on intelligent technologies
Technological discomfort	Negatively predicts reliance on intelligent technologies
Technological optimism x discomfort	Significant interaction in normal and adverse conditions
Technological optimism x discomfort in emergencies	Not significant interaction
Awareness of EASA evaluation	No significant effect on reliance decisions

(EASA) evaluations of reduced-crew operations influences these judgments. A vignette-based survey of 437 commercial pilots assessed reliance decisions across normal, adverse, and emergency scenarios. Results show that technological optimism positively predicts reliance on

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Key Finding

Pilots' willingness to rely on advanced/intelligent technologies is primarily driven by **individual technological readiness**, particularly **technological optimism** and **discomfort**.

Their interaction varies across operational conditions, while awareness of EASA evaluations does not significantly influence reliance decisions.

These findings highlight **the importance of individual perceptions** in the adoption of intelligent technologies in safety-critical aviation contexts.

3

The Autonomy Penalty: Understanding Commercial Pilots' Acceptance of Intelligent Technologies in the Cockpit

This research examines the **psychological mechanisms** underlying **pilots' acceptance** of autonomous cockpit technologies.

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ABSTRACT

Objective: To examine the factors influencing commercial aviation pilots' acceptance of autonomous AI-based and intelligent cockpit technologies, and to investigate whether resistance to increasing AI autonomy reflects broader evaluations of intelligent technologies or concerns about transferring operational authority to autonomous systems.

Background: Artificial intelligence is increasingly being integrated into commercial aviation cockpits, supporting decision-making, situation assessment, operational performance, and an expanding range of cognitive and operational functions. However, highly autonomous systems may challenge professional expertise, operational control, and pilots' perceptions of their future professional role. Drawing on Threat Rigidity Theory and previous research on pilots' evaluations of AI and advanced/intelligent technologies, the present research examines the psychological mechanisms underlying pilots' acceptance of autonomous cockpit technologies.

Methods: Two complementary studies were conducted. Study 1 analysed responses from 183 commercial pilots participating in the European Union Aviation Safety Agency (EASA) Ethics for AI in Aviation survey, examining the effects of AI autonomy, personal-information intrusiveness, and confidence in maintaining pilot skills on acceptance. Study 2 involved 437 commercial airline pilots

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Study 1 – EASA Ethics for AI in Aviation Survey (183 pilots)

Examines how **AI autonomy** (low vs. high), **personal-information intrusiveness** (low vs. high), and **confidence in maintaining pilot skills** influence pilots' acceptance of AI-based systems.

Study 2 – Vignette-Based Study (437 pilots)

Examines pilots' **acceptance of intelligent cockpit systems** using two realistic flight scenarios with different levels of AI autonomy:

- Low AI autonomy (AIDeX): An AI-powered decision support system identifies a potential microburst risk and provides operational recommendations while pilots retain decision-making authority.
- High AI autonomy (AFSM): An Autonomous Flight Safety Module detects windshear and autonomously initiates a go-around, temporarily limiting pilot intervention.

The study investigates whether **perceived career opportunities**, **career threats**, and **expected performance enhancement** are associated with **pilots' acceptance** of intelligent cockpit systems with different levels of operational autonomy.

confidence in maintaining pilot skills on acceptance. Study 2 involved 437 commercial airline pilots

The Autonomy Penalty: Understanding Commercial Pilots' Acceptance of Intelligent Technologies in the Cockpit

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Results

In both studies, increasing **AI autonomy** consistently produced an **AI-autonomy acceptance penalty**: *a systematic reduction in pilots' acceptance of intelligent cockpit technologies as these systems assume greater operational authority.*

Personal-information intrusiveness had only limited effects, whereas confidence in **maintaining pilot skills** attenuated the negative impact of autonomy.

Career opportunities, **career threats**, and **expected performance enhancement** were associated with pilots' general evaluations of intelligent technologies but did not moderate the negative effect of increasing AI autonomy.

Methods: Two complementary studies were conducted. Study 1 analysed responses from 183 commercial pilots participating in the European Union Aviation Safety Agency (EASA) Ethics for AI in Aviation survey, examining the effects of AI autonomy, personal-information intrusiveness, and confidence in maintaining pilot skills on acceptance. Study 2 involved 437 commercial airline pilots

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