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Implementation of Human–AI Teaming in the Aviation Industry: The Turkish Airlines Case Study

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ABSTRACT

Human–AI teaming is emerging as a defining paradigm in next-generation aviation, fundamentally reshaping pilot roles, cockpit task distribution, and decision-making processes. As AI systems evolve into adaptive and semi-autonomous agents, aviation training faces new challenges that extend beyond technical proficiency to include trust calibration, cognitive adaptation, workload redistribution, and ethical responsibility. This paper examines the shifting cognitive and operational landscape introduced by AI-enabled technologies such as adaptive automation, predictive analytics, and mixed-initiative systems. While these innovations enhance situational awareness and safety, they also introduce risks including automation complacency, over-reliance, and degradation of manual skills. Consequently, training frameworks must evolve to ensure pilots can effectively monitor, evaluate, and, when necessary, override AI systems. The study further explores the pedagogical complexities of developing human–AI decision-making capabilities, emphasizing the need for shared situational awareness, transparent communication, and alignment of mental models. It highlights the importance of training strategies that enable pilots to critically assess AI outputs, recognize system limitations, and integrate machine insights with human judgment. Finally, the paper addresses organizational and regulatory challenges, including the lack of standardized competency frameworks and ambiguities in accountability. It argues for the extension of competency-based and evidence-based training models to incorporate human–AI interaction skills. These issues are examined through a case study of Turkish Airlines, illustrating how technological innovation, training systems, and organizational context interact in the implementation of human–AI teaming.

Keywords: Human–AI teaming, Aviation training, Adaptive automation, Pilot competencies, Human factors, Situation awareness, Cognitive workload, Aviation safety

INTRODUCTION

Commercial aviation is undergoing a profound digital transformation driven by advances in data analytics, machine learning, and artificial intelligence. Airlines increasingly rely on algorithmic systems to support operational decision-making, optimise resource allocation, and enhance safety performance (Ziakkas & Vink, 2023). This shift reflects both economic

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pressures and safety imperatives within a highly competitive and tightly regulated industry. However, the introduction of artificial intelligence does not merely add new tools to existing workflows; it fundamentally alters how work is performed, how decisions are distributed, and how responsibility is understood within complex socio-technical systems (Reason, 1997).

Within this evolving landscape, human–AI teaming has emerged as a central operational paradigm. Rather than functioning as passive automation, AI systems increasingly act as collaborative agents that generate probabilistic forecasts, adaptive recommendations, and real-time decision-support inputs (EASA, 2023). While such systems promise efficiency gains and enhanced anticipatory safety, they also introduce challenges related to trust, transparency, skill adaptation, and organisational accountability (Reason, 2008). Training systems that remain grounded in deterministic automation logic are therefore increasingly misaligned with AI-mediated operational environments.

This paper examines these dynamics through an in-depth case study of Turkish Airlines. As one of the world's fastest-growing network carriers, operating across diverse cultural, regulatory, and operational contexts, Turkish Airlines provides a particularly relevant setting for examining how human–AI teaming is implemented in practice. The case-study approach enables a nuanced exploration of how technological innovation interacts with human performance, training systems, organisational culture, and regulatory oversight (Saunders et al., 2019).

CONCEPTUAL FOUNDATIONS OF HUMAN–AI TEAMING

Human–AI teaming represents a departure from traditional automation paradigms that emphasised predictability and procedural control. Contemporary AI systems operate probabilistically, learning from large datasets and adapting outputs based on contextual variables. This characteristic challenges classical human factors assumptions regarding stable mental models and deterministic system behaviour (Hollnagel, 2014). Effective teaming therefore requires mutual adaptation, where humans understand system limitations and AI systems are designed to support human cognitive strengths rather than replace judgement (Ziakkas & Vink, 2023).

From a human factors perspective, successful teaming depends on calibrated trust, shared situational awareness, and aligned mental models. Excessive trust may lead to automation complacency and skill erosion, while insufficient trust can result in under-utilisation of valuable decision-support capabilities (Reason, 2008). These risks are amplified in aviation environments characterised by time pressure, uncertainty, and high operational consequence. Training systems must therefore cultivate interpretive and evaluative skills rather than relying solely on procedural compliance.

Regulatory developments increasingly acknowledge these challenges. The European Union Aviation Safety Agency's Artificial Intelligence Roadmap 2.0 explicitly promotes a human-centric approach to AI, emphasising transparency, explainability, and human oversight (EASA, 2023). Similarly, ICAO's performance-based training philosophy and IATA's Evidence-Based

Training framework provide mechanisms for embedding human–AI competencies within existing training architectures (ICAO, 2013; IATA, 2024).

Turkish Airlines Digital Transformation Context

Turkish Airlines has pursued an extensive digital transformation strategy to support rapid network growth, operational complexity, and competitive positioning within the global aviation market. Operating a large and diverse fleet across short-haul, long-haul, and ultra-long-haul routes, the airline must manage variability arising from weather, airspace constraints, crew availability, maintenance demands, and heterogeneous regulatory environments. In response, Turkish Airlines has invested in advanced data analytics and artificial intelligence (AI) capabilities designed to enhance operational predictability, efficiency, and safety performance (Ziakkas & Vink, 2023).

Key initiatives include predictive maintenance systems that analyse aircraft health and sensor data to anticipate component degradation, flight operations optimisation tools that support fuel efficiency and trajectory planning, advanced crew rostering algorithms that balance regulatory compliance with fatigue risk considerations, and data-driven safety analytics platforms that enable proactive identification of trends and weak signals (Hollnagel, 2014). While these systems remain under explicit human oversight, they increasingly function as collaborative cognitive partners by providing probabilistic forecasts, prioritised recommendations, and real-time decision-support inputs rather than deterministic outputs.

From a human factors perspective, this shift has redefined operational roles and cognitive demands. Dispatchers, for example, must interpret optimisation outputs that integrate multiple competing constraints, requiring contextual judgement and cross-checking rather than procedural confirmation. Crew planning personnel interact with algorithmic rostering solutions that necessitate trust calibration and ethical consideration of human wellbeing. Safety analysts rely on pattern-recognition algorithms that augment, rather than replace, expert sensemaking. These interactions are presented in Table 1 and illustrate how human–AI teaming emerges organically within daily operations, reshaping responsibility allocation and decision authority (Reason, 1997).

Table 1: Human–AI teaming implementation dimensions observed at Turkish airlines.

Dimension	Operational Example	Human Factors Implication
Flight operations optimisation	AI-supported dispatch planning	Increased interpretive and cross-checking demands
Crew rostering algorithms	AI-assisted schedule generation	Trust calibration and fatigue risk awareness
Predictive maintenance	Aircraft health monitoring	Shift from reactive to anticipatory judgement
Safety analytics	Weak-signal detection	Enhanced sensemaking and organisational learning

METHODOLOGY

The study adopts a qualitative case study methodology to examine the implementation of human–AI teaming within Turkish Airlines. This approach is well suited to the investigation of complex socio-technical systems where organisational context, human experience, and cultural factors play a decisive role (Saunders et al., 2019). Data sources include internal policy documents, training materials, system descriptions, and semi-structured interviews with personnel involved in flight operations, dispatch, training, and safety management.

The research approach is interpretivist and abductive, integrating empirical observations with established human factors theory to generate analytically grounded insights (Hollnagel, 2014). Saunders' research onion provides the overarching methodological structure, while the ICAO Analysis–Design–Development–Implementation–Evaluation (ADDIE) framework is used as an analytical lens to examine how training systems evolve in response to AI-enabled operational demands (ICAO, 2013, 2020).

The following table (Table 2) presents the THY case study methodology.

Table 2: Research methodology overview - alignment of addie phases with THY human–AI teaming competencies.

Methodological Dimension	Framework / Approach	Purpose in the Study
Research philosophy	Interpretivist	Capture human experience, trust dynamics, and meaning-making in human–AI interaction
Research approach	Abductive	Integrate empirical observations with human factors theory
Research strategy	Qualitative analytical study	Examine training, organisational, and regulatory implications
Data sources	Literature, regulatory documents, operational reports	Ground analysis in evidence-based aviation practice
Instructional design lens	ICAO ADDIE framework	Structure analysis of training adaptation to AI-enabled operations
Training paradigm	CBTA / EBT	Map human–AI competencies to observable behaviours
Safety perspective	Safety-II & FAIR 3	Frame variability, adaptation, and resilience as safety enablers

FINDINGS

The introduction of AI-enabled systems at Turkish Airlines has prompted a fundamental reassessment of training philosophy, extending beyond traditional emphases on system operation and procedural compliance. Operational personnel consistently report that while AI-driven tools enhance efficiency and anticipatory decision-making, they also introduce increased cognitive demands related to interpretation, validation, and management of uncertainty. These demands are particularly salient in time-critical domains such as flight dispatch, crew planning, and safety risk assessment, where AI outputs shape, but do not determine, final decisions (EASA, 2023).

From a competency-based training and assessment (CBTA) and Evidence-Based Training (EBT) perspective, the core challenge lies in translating these demands into observable and assessable behaviours. Effective human–AI teaming at Turkish Airlines is characterised by behaviours such as active interrogation of AI-generated recommendations, explicit verbalisation of uncertainty, cross-checking of algorithmic outputs against operational context, and timely intervention when system behaviour diverges from intent (IATA, 2024). These behaviours align with existing EBT competency domains—including situational awareness, decision-making, communication, and workload management—but require reinterpretation within AI-mediated operational environments.

Scenario-based training has emerged as a critical pedagogical mechanism for developing these competencies. Training scenarios that deliberately introduce ambiguous, conflicting, or degraded AI outputs support the development of adaptive expertise and calibrated trust. Structured debriefings informed by Safety-II principles further reinforce learning by examining how successful adaptations occur during normal operations, rather than focusing exclusively on deviations or error (Hollnagel, 2014). Viewed through the International Civil Aviation Organization (ICAO) Analysis–Design–Development–Implementation–Evaluation (ADDIE) framework, these findings indicate a need to strengthen the design, development, and evaluation phases of training programmes to explicitly address AI-related cognitive and ethical demands (ICAO, 2013, 2020).

The alignment between CBTA/EBT competencies and human–AI interaction behaviours investigated at Turkish Airlines is summarised in Table 3, illustrating how existing training frameworks can be extended to accommodate AI-enabled operations.

Table 3: Alignment of CBTA/EBT competencies with human–AI teaming behaviours.

CBTA/EBT Competency	Observable Behaviour in AI Context
Situation awareness	Recognition of AI uncertainty and system drift
Decision-making	Critical evaluation of algorithmic recommendations
Communication	Clear articulation of disagreement with AI outputs
Workload management	Balancing monitoring and manual intervention

Furthermore, Turkish Airlines operates within one of the most culturally diverse organisational environments in commercial aviation, employing multinational flight crews, dispatchers, engineers, and operational managers across a rapidly expanding global network. This diversity represents a strategic asset but also introduces complexity in the implementation of human–AI teaming. Cultural norms related to authority gradients, communication styles, uncertainty tolerance, and attitudes toward automation significantly influence how AI-generated recommendations are perceived, challenged, or accepted during operations (Ang & Van Dyne, 2008).

Cultural Intelligence (CQ) therefore plays a critical moderating role in the effectiveness of human–AI collaboration. Interview data indicate that personnel from different cultural backgrounds may interpret identical AI outputs differently, particularly when algorithmic recommendations conflict with experiential judgement or established operational practices. In higher power-distance contexts, AI systems may be perceived as authoritative extensions of organisational intent, increasing the risk of uncritical acceptance. Conversely, in contexts characterised by greater scepticism toward automation, valuable AI insights may be discounted prematurely. Training systems that fail to address these dynamics risk misaligned trust, degraded teamwork, and reduced resilience (Ziakkas, Pechlivanis, & Plioutsias, 2026).

Organisational culture further shapes implementation outcomes. Turkish Airlines' commitment to Just Culture principles supports open discussion of AI limitations and encourages reporting of unexpected or ambiguous system behaviour (Reason, 1997). However, organisational interviews suggest that ambiguity regarding accountability for AI-informed decisions can inhibit challenge behaviours, particularly in hierarchical environments. Aligning technological innovation with explicit responsibility boundaries, cultural awareness, and safety values is therefore essential for sustaining effective human–AI teaming.

The implementation of human–AI teaming at Turkish Airlines is shaped by a complex regulatory landscape encompassing International Civil Aviation Organization (ICAO) standards, European Union Aviation Safety Agency (EASA) guidance, and national aviation authority oversight. While existing regulatory frameworks permit the use of advanced decision-support systems, explicit requirements for human–AI teaming competencies remain underdeveloped. This creates both flexibility and uncertainty for multinational carriers seeking to integrate AI across operational domains (ICAO, 2013).

Performance-based approaches such as Competency-Based Training and Assessment (CBTA) and Evidence-Based Training (EBT) provide a pragmatic pathway for integrating AI-related competencies within approved training frameworks. However, the absence of harmonised definitions for observable human–AI interaction behaviours complicates standardisation and assessment across regulatory jurisdictions (IATA, 2024). From a regulatory perspective, this places increased responsibility on operators to demonstrate that training programmes adequately address emerging cognitive, ethical, and cultural risks associated with AI use.

The Turkish Airlines case highlights the importance of proactive engagement with regulators to align innovation with oversight expectations. Embedding explainability, human oversight, and continuous learning within training and operational processes supports compliance with evolving EASA human-centric AI principles while remaining consistent with ICAO's performance-based philosophy (EASA, 2023). These considerations underscore the need for collaborative regulatory development to ensure that human–AI teaming enhances, rather than compromises, aviation safety.

DISCUSSION

The Turkish Airlines case study demonstrates that human–AI teaming constitutes a systemic transformation rather than a discrete technological upgrade. AI-enabled systems reshape cognitive work, redistribute authority, and surface latent assumptions about decision-making and responsibility across the organisation. Training systems that remain anchored in deterministic automation paradigms risk producing technically proficient yet cognitively brittle operators, ill-equipped to manage probabilistic and adaptive system behaviour.

From a CBTA and EBT standpoint, effective human–AI teaming is evidenced through observable behaviours: timely interrogation of AI outputs, clear communication of uncertainty, calibrated trust, and decisive intervention when required. These behaviours align with existing competency domains such as situational awareness, decision-making, communication, and workload management, but require reinterpretation within AI-mediated contexts. The Turkish Airlines experience suggests that embedding these behaviours within training and assessment criteria enhances resilience and supports consistent performance across diverse operational scenarios.

Safety-II and Functional Analysis and Risk Integration (FAIR) 3 perspectives further illuminate how risk and success emerge from interactions between humans, intelligent systems, and organisational context. Rather than treating AI-related confusion or disagreement as error, these frameworks legitimise examination of variability, adaptation, and recovery. Cultural Intelligence reinforces this approach by making culturally mediated decision pathways visible and discussable, thereby strengthening shared situational awareness and trust within multicultural teams.

Proposed Human–AI Teaming Implementation Model

Drawing on the Turkish Airlines experience, the paper proposes an implementation model emphasising four interdependent principles: transparency through explainable AI, integration of AI-focused competencies within training frameworks, alignment with human cognitive strengths, and organisational cultures that promote shared responsibility. The Turkish Airlines Human–AI Teaming Implementation Model (Table 4) illustrates how technological, human, and organisational elements are deliberately aligned to support resilient and accountable collaboration between human operators and AI-enabled systems.

Table 4: Turkish airlines human–AI Teaming implementation model.

Core Dimension	Turkish Airlines Implementation Focus	Human Factors Implication
AI role	AI used as decision-support partner, not autonomous authority	Preserves human accountability and calibrated trust
Transparency	Emphasis on interpretable, contextualised AI outputs	Supports sensemaking and situational awareness
Training integration	AI competencies embedded within CBTA/EBT frameworks	Enables observable, assessable human–AI behaviours
Cultural intelligence	Recognition of multicultural authority and communication dynamics	Enhances challenge behaviour and teamwork
Safety and risk approach	Application of Safety-II and FAIR 3 in data-driven safety	Strengthens resilience and adaptive performance
Organisational culture	Alignment with Just Culture principles	Encourages reporting and shared responsibility

CONCLUSION

The Turkish Airlines case study illustrates that successful implementation of human–AI teaming in commercial aviation is not driven by technological sophistication alone, but by the organisation's capacity to adapt training systems, cultivate trust, and align cultural, regulatory, and operational practices. AI-enabled systems introduce new cognitive demands and ethical considerations that cannot be addressed through procedure-centric training models. Instead, preparation for AI-mediated operations requires deliberate development of adaptive expertise, critical evaluation skills, and culturally informed judgement. By integrating AI-related competencies within CBTA and EBT frameworks, aligning instructional design with the ICAO ADDIE model, and grounding organisational practice in Safety-II, FAIR 3, Cultural Intelligence, and Just Culture principles, airlines can foster resilient and ethically aligned human–AI collaboration. The Turkish Airlines experience offers transferable lessons for the wider aviation industry, demonstrating that human–AI teaming becomes a source of sustained safety and performance only when technological innovation is matched by investment in human capability, training design, and organisational culture.

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