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Ethics as a Human Factor in Flight Safety: Developing a Training Tool for the Prevention of Ethics-Related Aviation Accidents and Critical Incidents

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ABSTRACT

The integration of emerging technologies with human factors research has reshaped the way aviation safety is understood and managed. While advances in smart materials enhance aircraft resilience by adapting to external pressures and mitigating physical risks, this study argues that the ethical dimension of human performance functions as an equally adaptive safeguard in complex socio-technical systems. By conceptualizing ethics as a human factor, this research explores how inclusive human-system integration requires not only technical robustness but also ethical resilience across individuals, organizations, and regulatory frameworks. Traditional approaches to aviation safety emphasize physiological, psychological, and cognitive dimensions, yet overlook the ethical decisions that underpin operational outcomes. Systematic analysis of aviation accidents reveals recurring ethical deviations—such as concealment of errors, tolerance of procedural violations, or organizational pressures—that directly compromise safety. Like smart materials that redistribute stress to prevent catastrophic failure, ethically resilient systems redistribute responsibility and accountability, ensuring transparency, communication, and procedural adherence. Positioning ethics as a structural layer of resilience connects the material and human dimensions of safety in a unified framework. The research employs a three-phase, mixed-methods methodology. First, accident reports and safety databases are reviewed to identify and classify ethical lapses as causal or contributory factors. Second, a conceptual model is developed that maps the pathways through which individual moral choices and organizational culture interact with technical and procedural constraints to influence safety outcomes. Third, this model informs the design of an interactive digital training tool—an e-learning platform that integrates realistic scenarios, simulations, and reflective exercises. Inclusive human-system design requires not only that aircraft adapt to stresses but also that humans and organizations adapt ethically to pressures of efficiency, hierarchy, and cultural diversity. Smart technologies and ethically resilient human systems create a synergistic model that enhances safety, prevents preventable accidents, and fosters trust in aviation as a global, inclusive enterprise.

Keywords: Aviation safety, Ethics, Smart systems, Human factors, Inclusive human systems, Training, Organizational culture

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INTRODUCTION

Aviation has achieved historically low accident rates, yet preventable events persist when organizations drift toward normalized deviance, when teams are reluctant to speak up, or when poor design and ambiguous rules leave crews without ethically sound options. The aviation ecosystem has long modelled physiological, psychological, and cognitive contributors to error, but less attention has been paid to the ethical substrate of performance—the moment-to-moment judgments about honesty, responsibility, fairness, and courage that shape reporting, coordination, and compliance. Treating ethics as a human factor reframes safety as a moral-technical enterprise: one that depends on robust equipment and procedures, and also on trustworthy, transparent behaviour supported by Just Culture principles and systemic learning.

In this paper, ethics is analysed as an adaptive capability that helps human–system teams maintain control under uncertainty, consistent with systems perspectives on human performance and accident causation. Systems approaches—including Reason's layers of defence, Rasmussen's socio-technical hierarchies, Human Factors Analysis and Classification System (HFACS), System Theoretic Accident Model and Processes (STAMP) - Causal Analysis based on System Theory (CAST), and Safety-II—show that accidents emerge from interactions across people, tools, organizations, and regulators (Reason, 1997). Within this view, ethical decisions are not private or incidental; they are shaped by interface design, work-as-done, incentives, and oversight, and they, in turn, influence data integrity, communication, and recovery. Investigations repeatedly surface latent conditions such as ambiguous responsibilities, performance pressure, or inadequate training—conditions that also drive ethical drift. Integrating ethics with established models connects moral judgement to control structures, feedback loops, and performance variability seen in investigations and safety management.

METHODOLOGY

The presented research follows a three stage methodology, based on Safety II philosophy (Hollnagel, 2014). Phase 1 synthesizes accident and incident reports to identify ethics-relevant precursors and contributory factors (e.g., concealment of errors, tolerance of procedural workarounds, misreporting, or retaliation fears). The review is structured using a hybrid taxonomy aligned with HFACS and STAMP-CAST so that ethical deviations can be traced through individual acts, team dynamics, supervision, and organizational influences (Ziakkas & Henneberry, 2025).

Phase 2 elaborates a conceptual model of ethical resilience that maps how moral awareness, judgement, motivation, and courage interact with cockpit interfaces, training, and organizational incentives.

Phase 3 translates the model into an interactive training tool (e-learning and scenario-based simulations) piloted in civil and military contexts with pre/post measures of ethical reasoning, speaking-up intentions, and safety behaviour.

The following table (Table 1) presents elements of the selected methodology.

Table 1: Research methodology overview.

Category	Operational Definition	Aviation Examples	Primary Data Sources	Preventive Controls
Concealment/ withholding	Intentional omission or alteration of safety-relevant information.	Non-reporting of unstable approach; selective cockpit voice recorder recollection;	Cockpit voice recorder/flight data recorder concordance, aviation safety reporting narratives, maintenance logs, European Risk Classification Scheme trend signals.	Just Culture policy, non-punitive reporting, independent debriefs.
Workaround normalization	Routine violation of a procedure perceived as efficient or benign.	Bypassing checklist verification; habitual late briefings; Minimum Equipment List interpretation.	Line observations, Line-Oriented Flight Training notes, findings, safety management systems occurrence data.	Human-centred Standard Operating Procedure redesign, explicit risk assessments, with feedback.
Undue pressure	Explicit or implicit incentives that prioritise throughput over prudence.	Gate departure targets overriding pressure; rostering beyond fatigue limits.	Scheduling records, fatigue risk management data, rostering systems, grievance logs.	Balanced Key Performance Indicators, Fatigue Risk Management System governance, union–management safety dialogue.
Retaliation and silence	Discouraging speaking-up or dissent through formal or informal sanctions.	Criticism of refusal to accept Minimum Equipment List; negative appraisal after go-around.	Human resources files, anonymous surveys, whistle-blower reports.	Confidential reporting channels, anti-retaliation, leadership walkarounds.
Design-induced ambiguity	Interface logic or alerts that make correct action ethically unclear.	Mode confusion in automation handover with contradictory cues; alert prioritization conflicts.	Flight data monitoring flags, simulator notes, Human Machine Interface usability tests.	Human-centred design reviews, pilot-in-the-loop trials, certification checklists.

Conceptual Model: The Ethical Resilience Pathways

The proposed conceptual model (Figure 1) treats ethics as a distributed capability spanning four coupled levels: individual (moral awareness and judgement under workload), team (communication and speaking-up), organization (Just Culture, incentives, training, and Safety Management Systems), and regulator (reporting frameworks, oversight, and harmonised guidance, Airbus, 2024). Information and accountability flow bi-directionally across these levels. When one level is weakened—for example, when an interface obscures system state—other levels compensate by clarifying expectations, managing workload, or creating protected time to think. The model supports traceability from ethical micro-decisions to safety outcomes and back to design and policy levers (AAIASB, 2006).

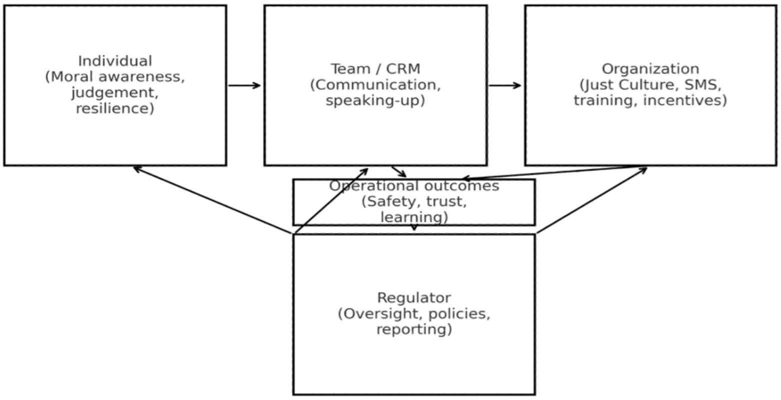

Figure 1: The conceptual model presentation.

Training Tool Design and Implementation

The training tool is an e-learning platform that integrates narrative cases, interactive branching scenarios, Simulated Air Traffic Control Environment (SATCE) - style communication vignettes, and reflective prompts (Ziakkas et al., 2022). The scenarios are derived from anonymised investigation narratives and aligned with competency frameworks so that communication, workload management, and judgement under uncertainty are practised together (BEA, 2012). Features include adaptive feedback, debrief transcripts that contrast work-as-imagined with work-as-done, and prompts for articulating ethical justifications. To encourage transfer, learners annotate decisions with the policy clauses, Standard Operating Procedures (SOPs) steps, or human factors principles they are invoking; the tool then visualises how choices affect team workload and system margins.

Validation and Evaluation

Evaluation uses a pre/post mixed-methods design. Quantitative measures track gains in moral awareness, intention to speak up, risk recognition, and rule-use under time pressure. Qualitative data from debrief interviews examine reasoning quality and barriers to ethical action (e.g., workload, ambiguity, fear of repercussions). Flight departments and ATC units pilot the tool in recurrent training, with follow-up checks of reporting volume and quality, European Risk Classification Scheme (ERCS) risk profiles, and simulator performance on ethics-inflected Line-Oriented Flying Training (LOFT) scenarios.

Table 2: Evaluation metrics and success criteria for the ethics training tool.

Dimension	Measures and Instruments	When Measured	Success Criteria
Moral awareness & judgement	Multidimensional Ethics Scale short form; scenario-based judgement rubric.	Pre, immediate post, +3 months	≥0.5 SD improvement sustained; qualitative reasoning shows richer justification.
Speaking-up intention & behaviour	Situational judgement tests; anonymous reporting rates (normalized).	Pre/post; quarterly trend	↑ reporting volume and specificity without punitive spikes.
Risk recognition & rule-use	Time-pressured micro-scenarios; correct rule identification; reaction times.	Pre/post	Faster, more accurate rule invocation with maintained SA.
Team climate & psychological safety	Brief climate survey on just culture and inclusion; debrief content analysis.	Pre/post; +3 months	Meaningful gains in climate indicators and openness to dissent.
Operational signals	ERCS distribution for ethics-linked events; LOFT debrief ratings; FDM weak-signal flags.	Baseline, +6 months	Shift toward lower ERCS risk bands; fewer repeat patterns.

POLICY AND EDUCATION IMPLICATIONS

Integrating ethical resilience into aviation policy requires a fundamental shift from compliance toward proactive governance that recognizes moral decision-making as a systemic factor in safety performance. International Civil Aviation Organizations' Annex 19 (4th edition) underscores that Safety Management Systems (SMS) are not only technical but also moral frameworks that depend on trust, fairness, and transparent learning processes (ICAO, 2023). Embedding ethical key performance indicators (KPIs) into SMS audits ensures that accountability and fairness are measured alongside incident rates and risk scores. Regulators such as European Union Aviation Safety Agency (EASA) have begun operationalizing this shift through the European Risk Classification Scheme (ERCS), which now integrates cultural and organizational precursors into risk evaluation. Policies that institutionalize moral reasoning—such as ethical audits of decision boards and fair accountability reviews—encourage learning before failures rather than punishment after them. At the organizational level, the integration of Just Culture and ethical resilience can be realized through three policy levers: ethical reporting incentives, leadership evaluation tied to transparency, and cross-functional ethics committees that review high-risk operational decisions. Incorporating these measures into SMS documentation aligns policy, culture, and human performance objectives (Dekker, 2011). The approach mirrors the adaptive properties of smart systems—absorbing pressure through distributed structures—where moral load-sharing prevents the isolation or scapegoating of individuals after incidents. The relationship between moral agency and resilience thus becomes codified within safety policy.

Education policy must support this transformation by embedding ethics into competency frameworks across aviation disciplines. At Purdue University, USA and the Hellenic Air Force Academy, Greece, curricular initiatives now position ethics as a measurable competency within Competency Based Training Assessment (CBTA) frameworks. Scenario-based training replicates real dilemmas—such as balancing fuel efficiency with environmental responsibility or procedural compliance with operational tempo—prompting reflective decision-making under stress. This builds on the SATCE-CBTA-SiPO methodologies demonstrated in prior research (Ziakkas et al., 2022).

In military training environments, ethics is further linked to leadership accountability, emphasizing integrity in command decisions, operational transparency, and respect for international humanitarian obligations. Culturally inclusive ethics education also addresses bias and hierarchy in multinational operations. Training that fosters ethical dialogue across cultures enhances communication in mixed crews, mitigates misunderstanding, and promotes shared situational awareness (Wiegmann and Shappell, 2017). By equipping personnel to recognize and navigate moral tension points, such programs extend the reach of Just Culture beyond legal compliance into moral competence. Ultimately, ethical education and policy converge on a shared outcome: resilient human-system integration in which decisions are both safe and just.

DISCUSSION

Viewing ethical resilience through the lens of smart systems reframes the human as an intelligent, adaptive material within socio-technical architectures. Smart materials prevent structural failure by redistributing load; similarly, ethical systems prevent organizational collapse by redistributing responsibility and reinforcing moral communication. In aviation, this manifests through self-correcting feedback loops that connect cockpit behaviours, team interactions, organizational policies, and regulatory learning cycles. Ethical resilience ensures that weak signals—ambiguous concerns, subtle doubts, or procedural drift—are not silenced but transformed into actionable intelligence through transparent dialogue. The analogy extends further: as smart materials possess sensors that monitor stress and trigger adaptive responses, ethically mature systems embed sensing mechanisms in their culture—confidential reporting, safety observation programs, and reflective debriefs—that detect ethical fatigue before it manifests as operational failure. These adaptive loops parallel the system-theoretic principles of STAMP (Leveson, 2012) and Safety-II, emphasizing the flow of feedback and learning over linear causality.

The integration of AI into this architecture introduces a new dimension: ethical resilience must now account for algorithmic transparency, data integrity, and bias mitigation. EASA's AI Roadmap 2.0 (2023) calls for 'explainability' as a human-centric design imperative, positioning moral traceability as a safety requirement, not a philosophical ideal (EASA, 2023). In this context, human-AI collaboration becomes a co-evolutionary process where both entities learn from each other's ethical signals. AI systems capable of explaining not only what decision is made but why it aligns with safety and fairness principles extend moral cognition into the digital domain. By integrating ethical constraints within machine logic, designers reinforce human agency rather than replace it. This notion resonates with Dekker's (2019) view that learning and accountability must evolve together if organizations are to remain resilient under complexity. The aviation sector's move toward Advanced Air Mobility (AAM) and autonomous operations further elevates ethical resilience to a societal level. Public acceptance of these technologies will hinge not only on reliability metrics but on perceived fairness, inclusivity, and accountability in automated decision-making. Hence, ethical resilience becomes a strategic enabler of legitimacy—a source of public trust in intelligent transportation systems. Just as fatigue management matured from compliance to science, ethical resilience must evolve from policy statement to operational capability. Embedding ethics as a performance variable—measurable, trainable, and reviewable—ensures that the human factor continues to serve as the conscience of smart systems.

CONCLUSION

Ethics, treated as a human factor, provides practical leverage for preventing accidents in complex socio-technical systems. A taxonomy of ethics-related deviations, a pathways model of ethical resilience, and a validated training tool together translate moral intent into operational capability. This human-centred approach complements technical robustness, builds inclusion and trust, and aligns with contemporary investigation methods that seek learning over blame.

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