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Investigating Human Errors – Mistakes and Violations in Just Culture Transportation Operations

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ABSTRACT

Human error remains a persistent and influential factor in transportation safety, yet its interpretation and management have evolved significantly through the adoption of Just Culture frameworks across aviation, rail, maritime, and road transportation systems. This paper examines the nature of human errors—specifically mistakes and violations—within operational environments governed by Just Culture principles, analysing how organisations can distinguish between human fallibility and unacceptable behaviour while fostering learning, accountability, and systemic resilience. As transportation systems grow more complex through automation, AI-driven decision-support, and multicultural team structures, the accurate investigation of human errors has become increasingly essential to ensuring safety, fairness, and continuous improvement. The analysis begins by conceptualising human error within contemporary human factors theory, emphasising the distinctions between mistakes (errors of judgement, planning, or interpretation) and violations (intentional deviations from rules or procedures). Mistakes are framed as manifestations of cognitive limitations, contextual ambiguity, poor interface design, and systemic pressures. Violations, however, often emerge from misaligned incentives, organisational drift, complacency, or poorly designed procedures that do not align with operational realities. A Just Culture environment must therefore provide the analytical tools to differentiate between these error types in a manner that is transparent, fair, and constructive. The paper further explores how Just Culture influences error reporting, investigation quality, and organisational learning. A well-implemented Just Culture encourages open reporting by reassuring employees that honest mistakes will not result in punitive action. This transparency allows organisations to capture weak signals, identify system vulnerabilities, and detect latent conditions before they escalate into incidents. However, the investigation of potential violations remains complex, requiring careful consideration of intent, situational pressures, cultural influences, fatigue,

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workload, and the design of procedures. The study argues that without a disciplined, evidence-based approach, Just Culture frameworks risk drifting toward blame avoidance or, conversely, punitive tendencies that undermine trust. Human factors methodologies—including task analysis, cognitive interviews, workload assessment, and systemic accident models such as HFACS or FRAM—are examined as critical tools in differentiating between mistakes and violations. These methods provide the structure necessary to identify whether behaviour was shaped by system design, training gaps, cultural norms, or individual decision-making. The paper highlights how emerging technological contexts, such as automation dependency and algorithmic decision-support systems, introduce new forms of error, including automation complacency, misinterpretation of AI-generated guidance, and system-induced violations due to poorly harmonised procedures. Organisational and regulatory implications are addressed, emphasising the need for robust governance structures, transparent decision criteria, and competency-based training programmes that incorporate Just Culture principles. Multimodal transportation case studies illustrate how inconsistencies in enforcement, cultural differences, and operational pressures can either strengthen or erode Just Culture foundations. The paper concludes by proposing an integrated investigative framework that combines human factors science, Just Culture principles, and systemic analysis to support fair accountability and meaningful learning. The findings underscore that effective management of mistakes and violations requires more than distinguishing human behaviour types—it demands an organisational commitment to understanding context, improving system design, and cultivating an environment where safety and fairness coexist.

Keywords: Human error, Mistakes, Violations, Just culture, Transportation safety, Human factors, Systemic investigation, Accountability, Safety culture

INTRODUCTION

Human error remains one of the most consistently cited contributors to accidents and serious incidents across transportation systems, including aviation, rail, maritime, and road operations. Despite significant advances in technology, automation, and safety management, human performance continues to shape operational outcomes, particularly in complex, time-pressured, and safety-critical environments. Historically, accident investigation and safety governance frameworks approached human error primarily through a person-centred lens, attributing failure to individual negligence, procedural non-compliance, or inadequate skill. While such approaches offered a clear mechanism for accountability, they often failed to capture the systemic and contextual factors that shape human behaviour in operational settings (Reason, 1997; Rasmussen, 1997).

Over the past three decades, safety science has progressively shifted from individual blame toward system-oriented interpretations of human error. Contemporary human factors theory conceptualises error as an emergent property of socio-technical systems, arising from the interaction between human cognition, task demands, organisational pressures, and technological design (Hollnagel, 2014; Dekker, 2014). Within this perspective, error is not

viewed as an anomaly but as a predictable consequence of operating within complex systems characterised by uncertainty, competing goals, and limited cognitive resources. This shift has fundamentally altered how safety-critical industries understand responsibility, learning, and prevention.

The concept of Just Culture has emerged as a central mechanism for operationalising this systemic understanding of human error. Just Culture frameworks seek to balance learning and accountability by recognising that humans are fallible while maintaining clear boundaries for unacceptable behaviour (Reason, 1997; Dekker, 2016). In transportation operations, Just Culture is intended to foster open reporting, protect individuals from punitive responses to honest mistakes, and enable organisations to identify latent conditions before they escalate into adverse events. Regulatory authorities across multiple domains have formally endorsed Just Culture principles, embedding them within Safety Management Systems (SMS) and occurrence reporting requirements (ICAO, 2018; EASA, 2022; FAA, 2020).

Despite widespread adoption at the policy level, the practical implementation of Just Culture remains uneven. One of the most persistent challenges lies in the investigation and interpretation of human behaviour, particularly in distinguishing between mistakes and violations. These categories, while conceptually well defined within human factors literature, are frequently conflated in operational practice. Highway crash analyses reveal this conflation: approximately 49.2% of fatal crashes involve skill-based errors while 51.6% involve violations, yet investigations often fail to distinguish intent from outcome (Iden & Shappell, 2006). Investigations often default to outcome-based judgments, where the severity of consequences influences accountability decisions rather than a structured analysis of intent, context, and system contribution (Dekker, 2014). Such practices undermine trust, discourage reporting, and erode the very learning mechanisms that Just Culture seeks to promote.

Mistakes and violations represent fundamentally different behavioural phenomena. Mistakes are unintentional errors of planning, judgement, or interpretation, typically associated with flawed mental models, ambiguous information, or inadequate system feedback (Reason, 1997). Violations, by contrast, involve intentional deviations from rules or procedures, yet are frequently adaptive responses to operational pressures, impractical procedures, or misalignment between work-as-imagined and work-as-done (Hollnagel, 2012). Treating these behaviours as morally equivalent obscures their underlying causes and leads to inappropriate organisational responses. The challenge of accurate error classification is further intensified by the increasing complexity of transportation systems. Advanced automation, algorithmic decision-support tools, and AI-mediated operational environments introduce new forms of performance variability, including automation complacency, mode confusion, and system-induced violations (Parasuraman & Riley, 1997; Dekker & Woods, 2002). In such contexts, human actions may reflect attempts to compensate for system limitations rather than deliberate disregard for safety. Without robust human factors methodologies, Just Culture investigations risk misattributing system-driven behaviour to individual failure.

THEORETICAL FOUNDATIONS OF HUMAN ERROR AND JUST CULTURE

Human error has been a central construct in safety research for several decades, yet its theoretical interpretation has undergone significant evolution. Early safety models conceptualised error primarily as a deviation from prescribed procedures or standards, implicitly locating failure within individual performance. While such approaches facilitated accountability, they provided limited explanatory power for understanding why competent and well-trained professionals continue to make errors in highly regulated environments (Reason, 1997). Contemporary human factors theory has since reframed human error as an emergent property of complex socio-technical systems, shaped by the interaction between human cognition, organisational context, task design, and technological constraints (Rasmussen, 1997; Hollnagel, 2014). Container terminal investigations confirm that training deficiencies, communication breakdowns, and supervisory gaps are primary error contributors, not individual negligence (Ellepola & Sridarran, 2025).

From this perspective, human error is neither random nor inherently negligent. Instead, it reflects the adaptive strategies individuals employ to manage uncertainty, competing goals, and resource limitations. Operators continuously balance efficiency and thoroughness, adjusting behaviour in response to situational demands—a process that can enhance system performance under normal conditions but also introduce vulnerability when margins are exceeded (Hollnagel, 2009). This systemic view challenges simplistic causal attributions and underscores the necessity of examining context, rather than outcome, when investigating safety events.

Reason's organisational accident model formalised this shift by distinguishing between active failures and latent conditions. Active failures occur at the operational level and are immediately observable, whereas latent conditions originate from decisions made at higher organisational levels, often remaining dormant until they align with local circumstances (Reason, 1997). This model highlights that frontline actions are rarely the sole or primary cause of accidents, but rather the final manifestation of deeper systemic issues embedded in design, training, supervision, and policy.

Mistakes and Violations as Distinct Behavioural Phenomena

Within human error theory, a critical distinction is drawn between *mistakes* and *violations*. This distinction is foundational for both accurate investigation and fair accountability. Mistakes are unintentional errors arising from deficiencies in planning, judgement, or interpretation. They occur when an individual's mental model of the situation is incomplete or inaccurate, leading to inappropriate decisions despite the intention to act correctly (Reason, 1997). Mistakes are often associated with novel situations, ambiguous cues, high cognitive workload, or inadequate system feedback, and are therefore strongly influenced by training quality and system design.

Violations, by contrast, involve intentional deviations from rules, procedures, or standards. Importantly, human factors research demonstrates that most violations are not reckless or malicious, but rather adaptive responses to operational realities such as time pressure, workload,

impractical procedures, or conflicting organisational goals (Dekker, 2014; Hollnagel, 2012). Over time, such deviations may become normalised within organisations, leading to procedural drift and erosion of safety margins—a phenomenon extensively documented across transportation domains.

Theoretical clarity between mistakes and violations is essential because each reflects different causal mechanisms and requires different organisational responses. Treating all unsafe acts as equivalent obscures their origins and leads to ineffective or unjust interventions. While mistakes signal opportunities for learning, redesign, and training enhancement, violations often indicate misalignment between work-as-imagined and work-as-done, necessitating procedural review and organisational change rather than individual sanction (Rasmussen, 1997).

Systemic Models of Human Error and Investigation

To operationalise these distinctions, safety science has developed systemic models capable of capturing the multi-level nature of human error. The Human Factors Analysis and Classification System (HFACS) extends Reason's framework by categorising contributing factors across organisational influences, unsafe supervision, preconditions for unsafe acts, and frontline behaviour (Wiegmann & Shappell, 2003). HFACS has been widely adopted in aviation and other transportation domains due to its structured approach to identifying latent and active failures.

More recent developments, such as the Functional Resonance Analysis Method (FRAM), further emphasise performance variability rather than failure classification. FRAM conceptualises safety and failure as outcomes of everyday performance, recognising that the same adaptive behaviours that enable success can, under certain conditions, contribute to adverse events (Hollnagel, 2012). This approach aligns closely with Just Culture principles by reframing deviations not as aberrations, but as signals of system dynamics.

Just Culture as an Ethical and Operational Framework

Just Culture emerged as a response to the limitations of both punitive and blame-free safety cultures. While punitive approaches suppress reporting and learning, entirely blame-free systems risk eroding accountability and normative boundaries (Dekker, 2016). Just Culture seeks to balance these extremes by establishing clear behavioural expectations while acknowledging human fallibility and systemic influence.

At its core, Just Culture emphasises *behavioural choice* rather than *event outcome* as the basis for accountability. Investigative focus shifts toward understanding why actions made sense to individuals at the time, given the information, constraints, and incentives present (Reason, 1997; Dekker, 2014). This perspective aligns with ethical principles of fairness and proportionality, ensuring that individuals are not punished for system-induced error while preserving organisational responsibility to address reckless conduct. Regulatory authorities have increasingly incorporated Just Culture principles into safety governance frameworks, particularly within SMS and occurrence reporting systems (ICAO, 2018; EASA, 2022). However, the effectiveness of these frameworks depends on the availability

of structured investigative methodologies capable of supporting consistent, transparent, and evidence-based decisions.

Integrating Human Error Theory and Just Culture

Integrating human error theory with Just Culture provides a coherent foundation for investigating mistakes and violations in transportation operations. Human factors theory offers the analytical tools required to understand behaviour within context, while Just Culture provides the ethical framework for responding to that behaviour. Together, they enable organisations to transform human error from a trigger for blame into a resource for learning and resilience (Table 1).

Table 1: Theoretical foundations of human error and just culture in transportation operations.

Construct	Condensed Core Idea	Key Sources	Just Culture Implication
Systemic Nature of Error	Errors arise from system interactions and organisational conditions	Reason (1997); Rasmussen (1997); Hollnagel (2014)	Shifts focus from blame to system context
Performance Variability	Human adaptation can enable success or failure	Hollnagel (2009, 2012)	Reframes deviations as adaptive behaviour
Error Types & Intent	Mistakes and violations shaped by cognition and context	Reason (1997); Dekker (2014)	Supports intent-based accountability
Drift, Investigation & Governance	Organisational drift addressed through structured, ethical SMS	Rasmussen (1997); ICAO (2018); EASA (2022); FAA (2020); Wiegmann & Shappell (2003)	Enables fair, non-punitive safety management

METHODOLOGY

This study employs a qualitative, theory-driven, integrative methodology grounded in human factors, safety science, and Just Culture principles. Given the socio-technical nature of human error in transportation operations, an interpretive analytical approach was selected rather than an experimental or quantitative design. This approach is consistent with established accident investigation practice, where unsafe acts are examined in relation to system design, organisational context, and operational constraints rather than isolated individual performance (Reason, 1997; Hollnagel, Woods, & Leveson, 2014). The methodological objective is to support consistent, evidence-based differentiation between mistakes and violations, in line with regulatory expectations for fair accountability. The theoretical foundation integrates contemporary human error models with Just Culture as an ethical and operational framework. Human behaviour is analysed as an emergent outcome of interactions between cognition, task demands, procedures, and

organisational pressures (Rasmussen, 1997; Hollnagel, 2014). Just Culture principles are applied to ensure that investigative judgments are based on intent, risk awareness, and system contribution rather than outcome severity, reflecting the proportionality and non-punitive intent articulated in EASA and ICAO guidance (Dekker, 2016; EASA, 2022).

Data sources consist of a structured synthesis of peer-reviewed literature across human factors, accident investigation, and organisational safety, complemented by regulatory material from ICAO, EASA, and the FAA. Particular emphasis was placed on systemic accident models and investigative methodologies commonly referenced in regulatory practice, including HFACS and FRAM (Wiegmann & Shappell, 2003; Hollnagel, 2012). These sources were selected to ensure alignment with Safety Management System (SMS) requirements and occurrence investigation expectations applicable across transportation domains. Analytically, mistakes and violations were examined against contextual performance-shaping factors, including workload, fatigue, procedural usability, and organisational norms. Human factors methods were evaluated for their capacity to support transparent, reproducible investigative outcomes.

FINDINGS

The analysis reveals that the effective differentiation between mistakes and violations within Just Culture transportation operations depends on the consistent application of human factors theory, systemic investigative models, and clearly articulated accountability principles. Across transportation modes, failures in Just Culture implementation are not primarily attributable to policy absence, but to variability in investigative depth, methodological rigour, and behavioural interpretation.

Systemic Nature of Human Error in Just Culture Investigations

A central finding is that human error is most reliably understood and managed when treated as a system property rather than an individual deficiency. Consistent with established safety theory, frontline actions identified during investigations frequently represent the final manifestation of upstream organisational, technical, and procedural influences (Reason, 1997; Rasmussen, 1997). When investigations focus narrowly on procedural deviation, latent conditions such as workload saturation, inadequate interface design, or supervisory pressures remain unaddressed.

Differentiation Between Mistakes and Violations

The findings confirm that mistakes and violations represent distinct behavioural phenomena with fundamentally different causal mechanisms. Mistakes emerge predominantly from cognitive limitations, ambiguity, or flawed mental models and are strongly influenced by training adequacy and system design.

Violations, by contrast, are intentional deviations but are most often situational or routine rather than reckless. As indicated in Table 2 (Distinguishing Mistakes and Violations in Just Culture Investigations),

the majority of violations observed in operational contexts are adaptive responses to misaligned procedures, time pressure, or conflicting performance goals (Dekker, 2014; Hollnagel, 2012). Fault tree analysis combined with systemic error classification frameworks successfully differentiates cognitive limitations from intentional deviations by examining performance-shaping factors rather than outcomes alone (Isbăşoiu, 2025). Where violations are widespread, they reliably signal organisational drift rather than individual misconduct.

Table 2: Distinguishing mistakes & violations in just culture investigations.

Dimension	Mistakes	Violations
Intent & Cognition	Unintentional; flawed mental models	Intentional; context-driven choice
Contributing Factors	Workload, ambiguity, design, training gaps	Time pressure, procedural mismatch, drift
Moral Standing	Non-culpable	Context-dependent
Just Culture Response	Learning and system redesign	Contextual analysis; sanction only if reckless

Role of Human Factors Methods in Supporting Just Culture

Maritime and process industries demonstrate that human error's impact on safety and financial outcomes cannot be addressed through individual accountability alone; socio-technical complexity requires system-level interventions (Nazir, 2024). Another significant finding is the critical role of human factors investigative tools in sustaining Just Culture principles. Investigations that rely solely on compliance checks or rule-based classification are prone to hindsight bias and inconsistent enforcement. In contrast, the application of structured methodologies—such as cognitive task analysis, workload assessment, HFACS, and FRAM—provides objective mechanisms for evaluating behaviour within context.

Emerging Error Pathways in Automated and AI-Supported Operations

The findings further indicate that advanced automation and AI-enabled decision support introduce novel error pathways that challenge traditional Just Culture interpretations. Automation complacency, mode confusion, and algorithmic opacity increasingly shape human decision-making, sometimes resulting in system-induced violations where procedural compliance conflicts with operational effectiveness (Parasuraman & Riley, 1997; Dekker & Woods, 2002).

DISCUSSION

The findings reinforce the central premise that effective Just Culture implementation depends less on the formal adoption of policy and more on the consistency and methodological rigour with which human behaviour is investigated. As demonstrated in the Findings section, the distinction

between mistakes and violations cannot be sustained through outcome-based or compliance-driven approaches. Instead, it requires structured analysis of intent, context, and system contribution, consistent with contemporary human error theory and regulatory guidance (Reason, 1997; Hollnagel, 2014; EASA, 2022). Where such analytical discipline is absent, organisations risk misclassification of behaviour, leading either to unjust accountability or to tolerance of unsafe practices, both of which undermine safety management system effectiveness. From an organisational and regulatory perspective, the integration of human factors investigative methods—such as those summarised in Tables 1 and 2—emerges as a critical enabler of Just Culture. Road transport data showing driver error contributes to 75% of crashes underscores that error management programs, not blame assignment, yield safety improvements (Salmon et al., 2005). These methods provide the evidentiary basis required to demonstrate proportionality, fairness, and transparency in accountability decisions, which are core expectations within EASA and ICAO oversight frameworks. The findings indicate that when investigative processes explicitly examine performance-shaping factors, including workload, fatigue, procedural usability, and organisational norms, accountability decisions become more consistent and defensible. This alignment strengthens trust in reporting systems and supports the identification of latent conditions, thereby enhancing organisational learning and resilience. The discussion also highlights the increasing relevance of Just Culture in technologically advanced and AI-supported operational environments. As automation and decision-support systems reshape human roles, traditional interpretations of compliance and deviation become insufficient.

CONCLUSION

This paper demonstrates that effective management of human error in transportation operations depends on the rigorous, evidence-based application of Just Culture principles rather than their nominal adoption. Distinguishing between mistakes and violations requires structured human factors investigation that accounts for intent, context, and system contribution, ensuring proportional accountability while sustaining trust and reporting integrity. The findings confirm that most errors reflect system vulnerabilities and adaptive human performance rather than individual misconduct, and that inconsistent or outcome-driven interpretations undermine both safety and organisational learning. As transportation systems become increasingly complex through automation and AI-supported operations, Just Culture must function as an operational capability—embedded within investigative practice, regulatory compliance, and system design—to maintain safety, resilience, and fairness across safety-critical domains.

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