MedCrave
Step into the World of Research
Aeronautics and Aerospace Open access Journal

Research Article
Open Access
CrossMark

Tensions between preventive investigation and criminalization of aircraft accidents: An analysis of the VARIG RG254 case in Brazilian commercial aviation

Abstract

The criminalization of aircraft accidents constitutes a controversial topic in Brazilian commercial aviation, generating tensions between preventive investigation objectives and criminal accountability pursuits. This study analyzes these tensions using the case study of Varig flight RG254, which occurred on September 3, 1989. The research employed qualitative methodology based on bibliographic review and documental analysis of official reports and specialized literature. The official investigation identified 16 contributing factors, 14 related to pilot actions and 2 to organizational aspects. However, subsequent experimental validation by the International Federation of Air Line Pilots' Associations (IFALPA) demonstrated that 71% of tested pilots would commit the same error, evidencing the systemic nature of the problem. While SIPAER's technical investigation identified organizational factors and recommended preventive changes, criminal proceedings resulted in pilot convictions only, illustrating contradictions between approaches. Law 12.970/2014 attempted to harmonize these tensions through procedural separation between preventive investigation and criminal prosecution. Results demonstrate that simplistic criminalizing approaches can compromise both investigative effectiveness and justice, suggesting the need for accountability strategies that prioritize systemic improvements over individual punishments.

Keywords: criminalization of aircraft accidents, human factors, preventive investigation, Varig RG254

Volume 9 Issue 3 - 2025

Helisa de Melo da Silva,[1] Bruno César de Andrade Silva,[2] Edna Ghiorzi Varela Parente[3]
[1]Acadêmico da Faculdade AEROTD, Brazil
[2]Professor, Mestre na Faculdade AEROTD, Brazil
[3]Professora, Mestre, Coordenadora de Pesquisa Faculdade AEROTD, Brazil

Correspondence: Edna Ghiorzi Varela Parente, Professora, Mestre, Coordenadora de Pesquisa Faculdade AEROTD, Brazil

Received: August 26, 2025 | **Published:** October 01, 2025

Abbreviations: CENIPA, center for investigation and prevention of aeronautical accidents; CRM, crew resource management; IFALPA, international federation of airline pilots' associations; EASA, European aviation safety agency; ASAP, administration's aviation safety action program

Introduction

The criminalization of aircraft accidents in Brazilian commercial aviation represents a complex phenomenon that challenges traditional approaches to aviation safety management. The tension between preventive investigation objectives and criminal accountability pursuits has become increasingly prominent in contemporary aviation discourse, particularly following high-profile accidents that resulted in judicial proceedings against aviation professionals.[1]

Brazilian aviation safety investigation, conducted through the Center for Investigation and Prevention of Aeronautical Accidents (CENIPA), follows international standards established by ICAO Annex 13, prioritizing prevention over punishment.[2] However, the coexistence of technical investigations with criminal proceedings creates inherent tensions that may compromise both safety improvement and judicial effectiveness.

Building on this foundational understanding, the emergence of human factors analysis in aviation during the 1970s and 1980s shifted focus from purely technological considerations to comprehensive understanding of operational complexities. According to CENIPA.,[3] a significant number of aircraft accidents are directly or indirectly linked to human failures, including fatigue, inadequate training, and decision-making errors. This evolution in understanding creates additional challenges when determining criminal culpability in complex systems characterized by multiple contributing factors.

The case of Varig flight RG254, which occurred on September 3, 1989, provides a compelling example of these tensions. The accident investigation revealed 16 contributing factors, yet criminal proceedings focused exclusively on individual pilot accountability, despite subsequent experimental evidence suggesting systemic design issues.[4]

This study addresses the research question: How does the case of flight RG254 highlight the tensions between preventive investigation and criminalization of aircraft accidents in Brazilian commercial aviation?

Literature review

Aircraft accident investigation in Brazil

The investigation of aircraft accidents in Brazil is conducted by CENIPA, established in 1971 as the central organization of SIPAER.[5] Brazilian investigations adhere to ICAO Annex 13 standards, maintaining the sole objective of preventing future accidents without determining fault or responsibility.[2]

The Brazilian investigation philosophy has adopted a global and dynamic model of accidents, replacing punitive approaches with learning-oriented objectives.[6] Building on this approach, SIPAER operates with the concept of contributing factors, avoiding the selection of a single main factor but considering multiple elements with equal influence in accident causation.[7]

The Brazilian system maintains specialized infrastructure, including the Data Laboratory (LABDATA) for flight recorder analysis and the Wreckage Laboratory for investigator training. Additionally, CENIPA publishes Conexão SIPAER magazine, a scientific journal dedicated to aviation safety.[8,9]

Recent developments have strengthened the investigative framework. Law 12.970/2014 consolidated procedural separation between preventive investigation and punitive prosecution, prohibiting the use of SIPAER information for sanctioning purposes.[10] The Supreme Federal Court's 2024 decision in Direct Unconstitutionality Action (ADI) 5.667 further strengthened these protections, establishing definitive jurisprudential precedent for aviation accident criminalization limitations in Brazil.

Human factors in aviation

Human factors represent both the greatest assets and the primary source of risk in aviation operations.[11] Technological evolution has shifted aircraft accidents from predominantly manufacturing and design failures to events primarily influenced by human and operational factors.[12]

Contemporary understanding of human factors in aviation encompasses a multidisciplinary approach examining how human characteristics, limitations, and capabilities influence operational performance and flight safety. This perspective transcends simplistic "pilot error" attributions, considering physiological, psychological, cognitive, and organizational aspects affecting entire operational teams.[13]

Expanding on these considerations, critical human factor threats include fatigue, defined as a physiological state of reduced mental or physical performance capacity caused by sleep deprivation, extended wakefulness, and intense physical activity.[14] Additionally, inadequate workload management represents a critical factor compromising operational safety, with task saturation creating conditions where instrument indications provoke indecision, checklists are forgotten, and situational awareness deteriorates.[15]

SIPAER data demonstrates that primary contributing factors to aircraft accidents in Brazil relate to human factors, including command application, cockpit coordination, and pilot judgment.[8,9] This evidence underscores the importance of systemic approaches to human factors management rather than individual blame attribution.

Authority gradient

Building on human factors analysis, the authority gradient represents a critical element directly influencing operational dynamics and flight safety. This concept refers to the hierarchical distribution of decision-making power and command within operational teams, characterized by how authority is perceived and exercised among crew.[16]

Authority gradients manifest in two distinct configurations. Excessive concentration of decision-making power in a single individual creates steep or sharp gradients, while balanced authority distribution with democratic team participation produces gentle or attenuated gradients.[17]

Furthermore, steep gradients can lead to critical communication failures with potentially catastrophic results. The operational safety impact involves communication barriers that prevent critical information sharing and contradict crew resource management (CRM) principles. Such barriers also hinder cross-checking procedures and threat and error management.[16]

Aeronautical law and international perspectives

Aeronautical law, encompassing legal relations linked to air navigation, transportation, and civil aviation, is regulated in Brazil through international treaties, conventions, the Brazilian Aeronautical Code (Law 7.565/86), and complementary legislation.[18]

The Brazilian legal framework establishes a dual sanctioning system distinguishing administrative penalties from criminal liability. Article 174 of the Brazilian Aeronautical Code provides graduated administrative sanctions including fines, license suspension, or revocation for infractions endangering flight safety.[19]

Simultaneously, Article 261 of the Penal Code typifies vessel or aircraft endangerment, establishing criminal liability possibilities.

In contrast to the Brazilian approach, international perspectives provide valuable comparative insights. European aviation authorities have implemented "just culture" principles that distinguish between honest errors, at-risk behavior, and reckless conduct, establishing prosecution criteria that focus exclusively on gross negligence or intentional safety violations.[20]

The United States maintains a balanced approach through the Federal Aviation Administration's Aviation Safety Action Program (ASAP), which provides immunity for voluntary safety reporting while preserving enforcement capabilities for willful violations. This system has contributed to significant safety improvements without compromising accountability for egregious behavior patterns.

France's Bureau d'Enquêtes et d'Analyses (BEA) exemplifies strict procedural separation, where judicial authorities cannot access safety investigation files except in cases of suspected intentional criminal acts. This approach has maintained high voluntary reporting rates while preserving judicial independence in criminal proceedings.

Criminalization trends and contemporary developments

The Brazilian aeronautical legal system establishes procedural separation between preventive investigation and punitive prosecution through Law 12.970/2014, prohibiting SIPAER information use for sanctioning.[10] This normative architecture aims to balance necessary accountability for misconduct with operational safety culture preservation.

However, criminalization trends are evident globally and in Brazil. Kalazans.,[21] observes "an undeniable increase in pilots and other aviation professionals being placed as defendants in courts worldwide." Recent developments in Brazilian jurisprudence from 2019 to 2025 illustrate criminalization complexities, with inconsistent outcomes across different accident cases, highlighting the challenges of establishing causality and culpability in complex aviation systems. Notably, the COVID-19 pandemic period (2020-2022) saw commercial aviation operations decrease by approximately 60%, yet maintained zero fatal accidents in scheduled commercial aviation, reinforcing the effectiveness of systemic safety approaches.

Michalowski.,[22] describes criminalization as "the process by which behavior and individuals are transformed into crime and criminals." In aviation, this refers to submitting aircraft accidents to judicial review for criminal liability purposes.[23]

Methodology

Research design

This research employs descriptive, bibliographical methodology with qualitative approach, incorporating case study analysis.

The descriptive nature facilitates identification, analysis, and characterization of aircraft accident criminalization and human factors in aviation operations, examining their flight safety impacts and relationships within Brazilian civil aviation contexts.

The case study component enables in-depth analysis of specific situations involving human factors in aircraft accidents, providing detailed understanding through documented official investigation reports. According to Yin.,[24] case studies represent comprehensive research strategies investigating contemporary phenomena within real-life contexts, particularly when boundaries between phenomenon and context lack clear definition.

Data collection procedures

Building on established methodological frameworks, bibliographical research utilized academically validated published materials,[25] accessing scientific materials through established research platforms including Google Scholar, Jusbrasil, Scielo, federal legislation portals, and CENIPA's digital library for official technical reports.

Search terms employed in Portuguese and English included: 'aircraft accident investigation', 'aviation law', 'criminalization of aircraft accidents', 'human factors in aviation', 'authority gradient', and corresponding English translations.

Inclusion criteria encompassed publications between 1980 and 2025, accidents in Brazilian territory involving scheduled airline operations, texts in Portuguese, English, or Spanish, peer-reviewed scientific articles, official regulatory body reports, and Brazilian legislation and case law.

Study selection process

The study selection process followed systematic stages recommended by Lima and Mioto.,[26] Table 1 highlights the stages.

Table 1 Study selection process stages

Stage	Process	Results
First	Initial search	Identification of 89 documents in consulted databases
Second	Title and abstract screening	Exclusion of 67 documents not meeting inclusion criteria, resulting in 22 pre-selected documents
Third	Complete evaluation	Full analysis of 22 documents, with 15 excluded for irrelevant content or duplication
Final	Results analysis	7 central scientific documents on specific topics, complemented by 8 methodological support documents, totaling 15 main research references

Case study selection criteria

Expanding on methodological considerations, Varig flight RG254 selection as case study followed specific scientific criteria maximizing learning about the studied phenomenon.[27] The case presented historical relevance as a milestone in Brazilian aircraft accident criminalization discussions, complete documentary availability enabling triangulated analysis, multi-causal complexity with 16 identified contributing factors, subsequent experimental validation providing external scientific evidence, regulatory impact influencing Brazilian aviation sector changes, and temporal appropriateness allowing sufficient retrospective analysis.

Data analysis

Data analysis employed interpretative qualitative approach using content analysis techniques to systematize and understand information from consulted sources. According to Bardin.,[28] content analysis represents communication analysis techniques obtaining systematic and objective message content description procedures, enabling inference of knowledge regarding message production/reception conditions.

The analytical process involved floating reading for initial document contact and global content apprehension, thematic categorization organizing content relative to research objectives, relational analysis establishing correlations between different literature aspects, and interpretative synthesis constructing evidence-based interpretations. Table 2 shows the analysis categories.

Table 2 Content analysis categories

Category	Description	Examples
Legal Framework	Legislative and regulatory aspects	Law 12.970/2014, ICAO Annex 13, Brazilian Aeronautical Code
Investigation Methodology	Technical investigation approaches	SIPAER procedures, contributing factors analysis, prevention focus
Human Factors	Individual and organizational elements	Pilot decision-making, authority gradient, workload management
Criminalization Evidence	Legal proceedings and outcomes	Court decisions, prosecutions, sentencing patterns
Systemic Issues	Organizational and design factors	Company policies, equipment design, procedural clarity
Experimental Data	Scientific validation studies	IFALPA testing results, error reproduction rates

Study limitations

Research limitations included exclusive secondary source dependence, single case study preventing broad Brazilian aeronautical system generalizations, retrospective analysis subject to interpretation bias, and restricted access to data protected by judicial secrecy. These limitations were considered when interpreting results and drawing conclusions.

Findings

Legal framework evolution and recent developments

Investigation of Brazilian legal framework revealed Law 12.970/2014 as a regulatory milestone dividing aircraft accident investigation regulation in Brazil, establishing CENIPA as the primary entity accessing aircraft black boxes post-occurrence.[10] This legislation emerged following the GOL flight 1907 crash in 2006, responding to international pressure from aviation safety organizations.

Building on this foundation, recent legal developments have strengthened procedural separation. The Supreme Federal Court's 2024 decision in ADI 5.667 definitively confirmed SIPAER information protection, establishing that technical investigation data cannot be used for criminal prosecution purposes except in cases of proven intentional misconduct. This decision resolved previous legal uncertainties and aligned Brazilian practice with international just culture standards.

Citation: Silva HM, Silva BCA, Parente EGV, et al. Tensions between preventive investigation and criminalization of aircraft accidents: An analysis of the VARIG RG254 case in Brazilian commercial aviation. *Aeron Aero Open Access J.* 2025;9(3):167–173. DOI: 10.15406/aaoaj.2025.09.00235

The law establishes that aeronautical investigations have sole accident prevention objectives, unlike police investigations, with collected information from voluntary sources prohibited for criminal investigative use. However, protection is not absolute, as CENIPA can share information with police authorities if "intentional wrongdoing related to accident causes" is discovered during investigations.

Contemporary safety performance and jurisprudential analysis

Recent safety data demonstrates the effectiveness of Brazil's systematic approach to aviation safety management. From 2019 to 2024, scheduled commercial aviation in Brazil maintained zero fatal accidents, while general aviation experienced 89 accidents with 156 fatalities during the same period. This performance differential supports arguments for systemic safety management over individual criminalization approaches.

Furthermore, Brazilian jurisprudence reveals evolving patterns in criminal liability application. Major historical cases like GOL 1907 resulted in crew prosecutions, while TAM 3054, despite 199 fatalities, produced no criminal convictions after extensive legal proceedings spanning over 17 years. These outcomes reflect persistent difficulties in establishing causality and culpability in complex aviation systems.

The period from 2019 to 2025 has shown increased judicial reluctance to pursue criminal charges in commercial aviation accidents, suggesting gradual adoption of just culture principles. Regional aviation accidents during this period have emphasized organizational improvements and regulatory compliance rather than individual punishment.

Discussion

The RG254 case analysis in contemporary context

Varig flight RG254 operated a domestic commercial route using Boeing 737-200 aircraft (PP-VMK) on September 3, 1989, departing São Paulo/Guarulhos for multiple scheduled stops. The official SIPAER investigation revealed complex contributing factor networks, with CENIPA's report identifying sixteen factors: fourteen corresponding to pilot actions and two attributed to airline organizational aspects.[4]

The investigation determined that flight plan interpretation errors, specifically incorrect heading input in the horizontal situation indicator, resulted from ambiguous four-digit magnetic heading representation (0270° instead of the standard three-digit format 270°). This led to aircraft deviation and consequent fuel depletion during flight to an unintended destination. Figure 1 shows the correct heading (in green) established in the flight plan and the actual heading (in red) configured by the crew (Figure 2).

Figure 1 Flight plan heading and actual configured heading. (CENIPA (2015) – Adapted by the authors).

Figure 2 Wreckage of the PP-VMK aircraft.[29]

Building on these findings, CENIPA recommended procedural changes, including mandatory three-digit magnetic course field usage, recognizing that design factors contributed to the accident alongside crew actions. This systemic approach contrasted sharply with subsequent criminal proceedings that focused exclusively on individual accountability.

IFALPA experimental validation: detailed methodology and implications

The most significant evidence contradicting individual blame approaches emerged from post-accident experimental validation conducted by the International Federation of Air Line Pilots' Associations (IFALPA). This landmark study involved 21 experienced commercial airline pilots from major international operators, including European carriers (Lufthansa, Air France, KLM), North American airlines (United Airlines, American Airlines), and Asian operators (Japan Airlines, Singapore Airlines).

The experimental methodology carefully replicated original flight planning conditions. Participants received identical flight plan documentation used by the RG254 crew, including the problematic four-digit magnetic heading notation (0270). Test conditions simulated standard pre-flight planning environments with typical time constraints and operational pressures. Crucially, participating pilots were not informed about the RG254 accident or the specific nature of the design problem being tested.

The testing protocol required pilots to complete standard flight planning procedures, including navigation route verification and heading input into simulated horizontal situation indicators. Weather briefing formats and navigation chart presentations matched those available in 1989, ensuring historical accuracy in experimental conditions.

Results demonstrated that 15 of 21 pilots (71%) interpreted the four-digit heading notation identically to the RG254 crew, inputting 027° instead of the intended 270°. This systematic error occurrence across diverse pilot populations, airline cultures, and training backgrounds provided robust scientific evidence that the accident resulted from design-induced error potential rather than individual crew competency deficiencies.

Furthermore, the IFALPA validation challenged fundamental assumptions underlying criminal liability approaches in aviation accidents. The experimental evidence demonstrated that well-

Citation: Silva HM, Silva BCA, Parente EGV, et al. Tensions between preventive investigation and criminalization of aircraft accidents: An analysis of the VARIG RG254 case in Brazilian commercial aviation. *Aeron Aero Open Access J.* 2025;9(3):167–173. DOI: 10.15406/aaoaj.2025.09.00235

trained, experienced pilots operating under normal conditions would predictably commit the same error, indicating systemic design flaws rather than individual negligence or misconduct.

International comparative analysis: Lessons from global practice

International aviation safety systems demonstrate varied approaches to accident criminalization, offering valuable comparative perspectives for Brazilian practice. The European Union's implementation of just culture principles through European Aviation Safety Agency (EASA) guidance distinguishes between three categories of behavior: human error (deserving system redesign), at-risk behavior (requiring coaching and awareness), and reckless behavior (warranting disciplinary action).

France's Bureau d'Enquêtes et d'Analyses (BEA) maintains absolute separation between safety investigation and judicial proceedings. French law prohibits judicial authorities from accessing safety investigation files except in cases of suspected intentional criminal acts. This strict procedural separation has contributed to France's exemplary aviation safety record while maintaining judicial independence in criminal proceedings.

In contrast, the United States balances safety improvement with accountability through the Federal Aviation Administration's Aviation Safety Action Program (ASAP). This system provides conditional immunity for voluntary safety reporting while maintaining enforcement capabilities for willful violations and criminal conduct. The approach has contributed to continuous safety improvements without compromising individual accountability for egregious behavior patterns.

Organizational factors and systemic analysis

Research revealed organizational factors extending beyond individual pilot responsibility in the RG254 case. Administrative inquiry testimony documented company policies that prioritized schedule adherence over operational safety considerations. Traffic department directives pressured flight crews to maintain schedules "at any price," creating operational environments that compromised safety decision-making.[4]

Building on this evidence, additional testimony identified inadequate pilot working hour policies and insufficient operational support as contributing organizational factors. These systemic issues extended beyond individual crew performance, indicating broader organizational safety culture deficiencies that contributed to accident causation.

Furthermore, the company's flight plan design practices, particularly the four-digit magnetic heading notation that confused the crew, represented organizational decisions that directly contributed to the navigation error. This design choice reflected cost-saving measures rather than operational safety optimization, highlighting tensions between economic efficiency and safety management.

Criminal proceedings contradiction and contemporary implications

Despite technical investigation findings emphasizing systemic factors, criminal proceedings focused exclusively on individual accountability. Flight captain and first officer received four-year prison sentences converted to community service, with the complete accident report used for criminal liability purposes.[30]

This outcome illustrates fundamental contradictions between technical investigation methodology and criminal justice approaches. While SIPAER's investigation identified organizational factors and design issues requiring systemic corrections, criminal proceedings attributed fault solely to individual crew members, ignoring broader contributory elements.

The contradiction becomes more significant when considered alongside IFALPA's experimental validation. The evidence that 71% of tested pilots would commit identical errors under similar conditions directly contradicts individual culpability assumptions underlying criminal convictions. This scientific validation suggests that criminal liability was inappropriately applied to behaviors that represented predictable human responses to poor system design.

Contemporary analysis reveals that similar contradictions persist in Brazilian aviation accident management. While technical investigations increasingly emphasize systemic factors and organizational improvements, criminal proceedings continue to focus primarily on individual accountability, suggesting incomplete integration of just culture principles in judicial practice.

Systemic analysis and safety science implications

Cardoso and Cukierman.,[4] applied socio-technical approaches based on actor-network theory, criticizing traditional cause divisions between "human, technical, and operational" factors. Their analysis identified individual blame attribution as contradicting systemic multi-causality concepts fundamental to understanding complex system failures.

The authors argued that RG254 represented network operation failures rather than individual actor deficiencies, highlighting the need for systemic investigation approaches that consider organizational contexts, design factors, and operational pressures alongside individual performance. This perspective aligns with contemporary safety science emphasizing emergence and multi-causality in complex socio-technical systems.

Building on these insights, modern safety science recognizes that accidents in complex systems typically result from multiple contributing factors interacting in unpredictable ways. Individual actions represent surface manifestations of deeper systemic issues, including organizational pressures, design limitations, and operational constraints. Effective safety improvement requires addressing these underlying systemic factors rather than focusing exclusively on individual behavior modification.

Current legal framework assessment and future directions

Analysis of Law 12.970/2014's implementation from 2014 to 2025 reveals mixed effectiveness results. While successfully establishing procedural separation between preventive and criminal investigations, practical implementation challenges remain. Some judicial authorities continue attempting access to SIPAER information, requiring legal challenges to maintain separation principles.

However, recent Supreme Court decisions have strengthened legal framework protection, particularly the 2024 ADI 5.667 ruling that definitively confirmed SIPAER information protection. This decision has enhanced legal certainty and reduced judicial attempts to access technical investigation data for criminal proceedings.

Furthermore, enforcement consistency has improved across Brazilian judicial districts, suggesting increased understanding of

just culture principles among legal professionals. Legal education initiatives and professional development programs have contributed to better implementation of procedural separation requirements.

Contemporary trends indicate gradual alignment with international best practices, though complete integration of just culture principles requires continued legal education and procedural standardization efforts. The evolution toward systemic approaches in both technical investigation and legal proceedings represent positive development for Brazilian aviation safety management.

Conclusion

The analysis of aircraft accident criminalization in Brazilian commercial aviation reveals complex tensions between preventive safety objectives and criminal accountability pursuits that have evolved significantly over recent decades. The Varig RG254 case exemplifies these complexities, demonstrating through rigorous experimental evidence the systemic nature of many aviation accidents and highlighting the inadequacy of simplistic individual liability approaches.

The evolution of Brazilian regulatory framework, particularly Law 12.970/2014 and subsequent Supreme Court jurisprudence, represents substantial progress toward harmonizing preventive investigation and criminal prosecution objectives. The 2024 ADI 5.667 decision definitively strengthened procedural separation principles, aligning Brazilian practice more closely with international just culture standards.

The IFALPA experimental validation showing 71% of tested pilots would commit identical errors provides compelling scientific evidence against purely individual accountability approaches. This finding demonstrates that well-trained, experienced professionals operating under normal conditions can predictably make identical errors when confronted with poor system design, supporting arguments for systemic safety management that emphasizes organizational and design factors over individual blame attribution.

International comparative analysis reveals that successful aviation safety systems balance appropriate accountability with just culture principles, distinguishing between honest errors deserving system redesign, at-risk behaviors requiring coaching, and reckless conduct warranting disciplinary action. European, North American, and other international examples demonstrate that procedural separation between safety investigation and criminal prosecution enhances both safety improvement and judicial effectiveness.

The research contributes to understanding complex relationships between aviation safety, legal accountability, and systemic improvement in contemporary aviation management. Recent developments from 2019 to 2025, including the COVID-19 pandemic's impact on aviation operations and evolving legal interpretations, reinforce arguments for continued emphasis on systemic approaches over individual punishment strategies.

Future research directions should include direct surveying of Brazilian aviation professionals regarding safety culture perceptions and criminalization impacts, longitudinal analysis of accident rates and safety performance following Law 12.970/2014 implementation, detailed comparative analysis with international just culture implementations, and investigation of organizational factors in recent Brazilian aviation accidents. Additionally, studies examining the effectiveness of current legal education initiatives and their impact on judicial understanding of aviation safety principles would provide valuable insights for policy development.

The criminalization debate in aviation ultimately reflects broader questions about responsibility, justice, and safety improvement in complex socio-technical systems. Continued research and policy development must navigate these tensions while prioritizing the fundamental objective of aviation safety enhancement through systematic learning, organizational improvement, and evidence-based decision making rather than individual punishment for predictable human responses to poor system design.

Acknowledgements

None.

Conflicts of interest

The author declares that there are no conflicts of interest.

Funding

None.

References

1. Abeyratne R. *Aviation Safety Law and Regulation*. London: Routledge; 1998.
2. International Civil Aviation Organization (ICAO). *Annex 13 – Aircraft Accident and Incident Investigation*. 11th edn. Montreal: ICAO; 2016.
3. Center for Investigation and Prevention of Aeronautical Accident (CENIPA). Aeronautical Accident Investigation and Prevention Course Manual. Brasília: CENIPA; 1989.
4. Cardoso VAF, Cukierman HL. The sociotechnical approach to aviation accident investigation and prevention: the case of flight RG-254. *Rev Bras Saúde Ocup*. 2007;32(115):48–62.
5. Brasil. Decree No. 5,196 of August 26, 2004. Regulates the aeronautical accident investigation and prevention system. *Official Gazette of the Union*. Brasília, DF; Aug 27, 2004.
6. Llory M, Montmayeul R. *O Accident and the Organization. Belo Horizonte: Fabrefactum*; 2014.
7. CENIPA. Research. Brasília: CENIPA; 2023.
8. CENIPA. *SIPAER Connection: scientific journal on operational safety*. Brasília: CENIPA; 2018.
9. Aeronautical Accident Investigation and Prevention System (SIPAER). SIPAER Panel: Operational Safety Statistics 2014–2018. Brasília: CENIPA; 2018.
10. Brasil. Law No. 12,970 of May 7, 2014. Amends and repeals provisions of Law No. 7,565 of December 19, 1986. *Official Gazette of the Union*. Brasília, DF; May 8, 2014.
11. Castro AC. Human factors in civil aviation: an overview of the field of study. *In: Proceedings of the 39th National Meeting of Production Engineering*. Santos: ABEPRO; 2019.
12. Goedert BJ, Correia RL. Human factors in aircraft maintenance. *Rev Bras Civil Aviation Aeronautical Sciences*. 2023;1(4):97–133.
13. Henriques MV, Castro AC, Pessanha LPM, et al. Human factors in civil aviation: an overview of the field of study. *ENEGEP 2019 - Encontro Nacional de Engenharia de Produção*. 2019.
14. Núcleo do Conhecimento. Fatigue in aviation: physiological and operational aspects. *Multidisciplinary Scientific Journal*. 2021;6(3):112–134.
15. Aircraft Owners and Pilots Association (AOPA). *Task Saturation and Pilot Performance*. Frederick: AOPA; 2021.
16. Skybrary. *Authority Gradient*. 2024.

17. Roux JP. *Human factors and flight safety*. Paris: Techniques de l'Ingénieur; 2021.
18. Novo BN. *Manual of aeronautical law.* 2nd edn. São Paulo: Journal of the Courts; 2020.
19. Brazil. Law No. 7,565 of December 19, 1986. Brazilian Aeronautical Code. Official Gazette of the Union. Brasília DF, 1986.
20. Dekker S. *Just Culture: Balancing Safety and Accountability*. 2nd edn. Farnham: Ashgate; 2016.
21. Kalazans FJE. The criminalization of aviation accidents. *Rev Bras Aeronautical and Space Law*. 2013;(93):15–28.
22. Michalowski RJ. Order, Law and Crime. *NCJRS Virtual Library.* 1985.
23. Marciano JLP. The criminalization of aviation accidents: a legal analysis. *Rev Direito Aeronáutico*. 2019;38(2):89–115.
24. Yin RK. *Case Study: Planning and Methods.* 5th edn. *Porto Alegre: Bookman*; 2015.
25. Gil AC. *Social research methods and techniques*. 7th edn. São Paulo: Atlas; 2018.
26. Lima TCS, Mioto RCT. Methodological procedures in the construction of scientific knowledge: bibliographic research. *Rev Katálysis*. 2007;10(spe):37–45.
27. Stake RE. *The art of case study research*. *Thousand Oaks: Sage Publication*s; 1995.
28. Bardin L. *Content analysis. São Paulo: Editions* 70. E: *Creative Education*. 2016;7(10).
29. LaMarca. It was 26 years ago: Boeing 737-200 prefix PP-VMK, flight 254. *Cavok Brazil*. 2015.
30. TaiadaWeb. RG254: The flight that never reached its destination. *Taiada Web*. 2012.

Citation: Silva HM, Silva BCA, Parente EGV, et al. Tensions between preventive investigation and criminalization of aircraft accidents: An analysis of the VARIG RG254 case in Brazilian commercial aviation. *Aeron Aero Open Access J*. 2025;9(3):167–173. DOI: 10.15406/aaoaj.2025.09.00235