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Towards Airlines IT Audit Challenges & Success Factors: A Systematic Review.

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Abstract- Examining the field of Information Technology (IT) audit in the airline industry, the methodical investigation seeks to uncover elements contributing to success as well as obstacles. The importance of this study stems from the crucial role of IT systems in ensuring efficiency, safety, and customer satisfaction in the rapidly expanding aviation industry. The study begins with a brief overview of IT auditing in the aviation business, revealing details about audit methods and kinds. Given the critical role that IT systems play in aiding airline operations, a thorough examination of their audit processes becomes necessary. The systematic review encompasses a comprehensive examination of 61 prior articles, offering an in-depth look at the current state of knowledge on this topic. The following sections describe the research methods employed in conducting the systematic review, including the methodology and criteria used for selecting and interpreting the literature. This sets the stage for the findings to be presented and thoroughly discussed. Throughout this process, a special emphasis is placed on explaining the obstacles encountered during IT audits in the aviation industry and identifying the key elements that contribute to their effectiveness. In addition to providing a comprehensive review of the current literature, the study offers valuable insights into the challenges that IT audits face in the aviation industry, as well as the key success factors required to overcome these issues. The results synthesis aims to inspire future research topics and provide practical applications for IT audit experts working in the ever-changing and technologically complex aviation sector. This systematic evaluation, therefore, provides a comprehensive reference for knowledge, addressing and improving IT audit processes in airline operations.

Keywords: Information technology, IT systems, IT infrastructure, IT Audit, Airline IT Audit, Success factors, Airline industry.

1 - Introduction

The growth of the airline sector has grown as well as dramatically changed over the years, thanks to technological innovations that have reshaped how airlines operate. However, all aspects of airline operations seamlessly integrate IT systems. Whereas the airline industry relies increasingly on sophisticated IT infrastructures to promote efficiency and

competitiveness, the demand for rigorous IT audit processes is vital to ensure the integrity, security, and compliance of these systems grows. Furthermore, the evaluation method of this systematic review delves into the sensitive relationship within an airline's IT system infrastructure and the auditing systems that ensure its operations. The aim of this systematic study is to provide a comprehensive understanding of the current environment of IT audit within the airline industry, emphasizing key concerns and opportunities that impact IT audit within the airline sector. Nowadays, in a dynamic aviation business, IT is critical to allowing flawless operations, ensuring passenger happiness, and preserving regulatory compliance. The complexity and interconnection of airline IT systems need a comprehensive and methodical examination to assure their effectiveness, security, and compliance with industry standards. This is a situation where IT audits come into action. The auditing process plays a crucial role in identifying human errors and system weaknesses through monitoring and verification, as well as employing the audit process. Where audit tasks include identifying the target or existing problem and proposing solutions to mitigate its escalation. Nevertheless, as the market economic climate evolves, legal systems progress, and the audit atmosphere grows more complicated, audit risks have grown in significance [1].

1.1- IT Audit

Recently, the IT audits have played a vital role in the aviation industry to ensure and examine the effectiveness of IT systems security and legality. Therefore, the key areas focus on how to assess the protection of sensitive data and ensure data integrity and availability, as well as confirm and meet compliance with industry standards established by the International Air Transport Association (IATA). Thus, IT audits can include disaster recovery and continuity of operations plans, where IT risk management, technical infrastructure examinations, and security and performance assessments of independent IT service providers are performed. Within this context, IT audits contribute to the resilience and adaptability of airline IT systems, leading to boosted security services and dependability in air transport operations. Also, IT audits evaluate the performance of IT procedures and processes

to ensure integrity, security, and regulatory compliance of data. Furthermore, it is conducted in various nations throughout the globe to evaluate the IT infrastructure and operations of organizations such as government agencies, enterprises, and healthcare facilities. The goal is to identify possible risks, vulnerabilities, and opportunities for enhancement of IT systems to improve security as a whole and efficiency during operation. [2] IT audits [3] are used in civil aviation to review and evaluate the efficacy, security, and dependability of IT systems and infrastructure. Moreover, the study contributes to the security, compliance, and optimum operation of aviation's IT systems, which include air-ground communication, navigation aids, aeronautical surveillance, and system-wide information management. An IT audit may also help uncover possible vulnerabilities, analyze cybersecurity risks, and apply suitable risk mitigation measures. Figure 1 illustrates an audit process in general that is used in various sectors.

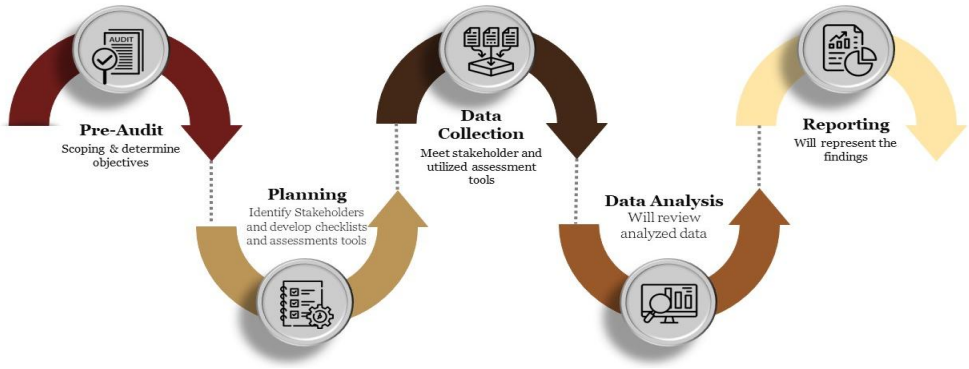

***Figure 1**: Generic IT Audit Process.*

For most instances, Figure 1 describes the generic IT audit process involved in conducting an IT audit:

i. **Pre-audit:** As part of the pre-audit process, audit planning is usually conducted. This involves determining the audit strategy and assigning resources to carry it out. Before moving on to data collection, analysis, and reporting, this step establishes the framework for the audit.

ii. **Planning:** An audit entails settling on an audit plan and distributing resources to carry it out.

iii. **Collecting Data:** Interviews, observations, and pertinent document gathering are examples of manual sampling methods used to get the necessary data.

iv. **Data Analysis:** To evaluate the process's efficiency and compliance, the obtained data samples are examined.

v. **Reporting:** The results of the analytics audit are shared with the public.

1.2- Types of Audits

There are two types of IT audits: internal and external. Internal IT auditing in the airline business entails analyzing and guaranteeing efficacy and effectiveness while including security within the airline's information technology systems and infrastructure. This audit is conducted internally via an airline's own IT auditing group or department to ensure regulatory compliance, identify possible risks, and enhance IT governance. It focuses on data security, network infrastructure, system stability, and adherence to industry standards. The internal IT audit is intended to improve the airline's IT processes. reduce possible risks and protect critical passengers. and operational data. [2] The paper discusses the use of internal and external audits. Internal audits are conducted through the Internal Audit Service (IAS). The Internal Audit and Assurance division coordinates external audits. The work detailed in the publication focuses on adapting FOMS to operate in the presence of partial information. [4]. Table 1 illustrates the key difference between internal audit and external audit. Also, Figure 2 provides an overall description of the overall review process subsection.

Figure 2: *Overview of Review Process.*

Table 1: Audit Types Comparison.

Aspect	Internal Audit	External Audit
Scope of Work	Organizational operations	Fiscal Functional Records
Focus	Enhancement to protect organization value	Faire representation for finical statement
Risk Range	Board	Narrow
Primary Audience	Board and Executive Management	Inventors and public interests
Employment	Depends on internal employees	Depending on third party
Qualification	Not Mandatory	Mandatory
Licensing	No	Yes

Figure 3 outlines the organized systematic review study flow. Therefore, the current systematic review study is for airlines IT audit concerns to explore the challenges and success factors. Moreover, the study inspiration and contribution are organized as follows: the study begins with introducing the IT audit process and kinds (internal and external) within Section 1, followed by a literature study and analysis of 61 previous studies involving IT audits in the aviation industry during Section 2, whereas previous studies are in chronological order and summarized. Following that, the study methods for this systematic review are identified via Section 3. The findings and analysis section addresses the research question within Section 4. Finally, the conclusion and future work are provided in Section 5. Therefore, a list of the abbreviation table that displays keyword abbreviations is mentioned in Appendix A.

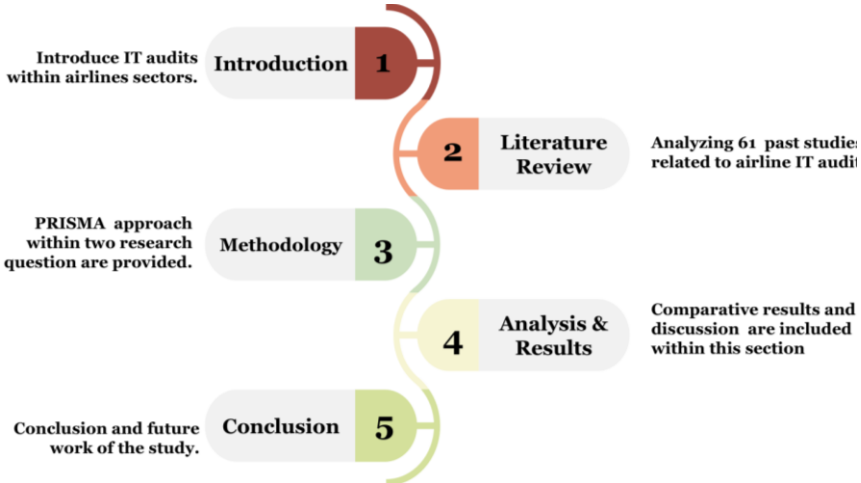

Figure 3: Overview of Proposed Research.

2- Literature Review

To begin with the literature review section, the study examines 61 previous studies of research published between 2015 and 2025, ordered in chronological order. However,

Table 2 provides an overall summary of the contributions and limitations of various past studies. Therefore, this section is categorized as follows:

2.1 Audit, Risk Management, and Cybersecurity Frameworks in the Aviation Sector

The global growth of technology impacts the increase of cyberattacks and cyber risks that surface. However, relevant research examined the airline IT audit to understand what frameworks, contributions, and limitations were employed, where the authors of the study [3] described Fly Africa's effective implementation of Information Technology Risk Management (ITRM) utilizing the RITM 23 method. This strategy, which encompassed standards such as COSO ERM, ISO 31000, and COBIT 5, provided a complete and simple approach to ITRM. The deployment procedure comprised both ITRM protocols and IT risk governance mechanisms. Although the report in [5] shows the preliminary planning work completed through the Nebraska Auditor of Public Accounts in response to the concerns raised regarding the American Rescue Plan Act funds provided to Airlines Next LLC, a virtual airline based at Lincoln's municipal airport. While the article [6] provides an overview of APA’s concerns as well as potential remedies. The study objective is to educate stakeholders and the broader public about the APA's findings and to advocate for corrective action to address the problems raised. Thus, the research [7] examines the implications of the COVID-19 pandemic on representations in passenger airline financial accounts using International Financial Reporting Standards (IFRS) and US Generally Accepted Accounting Principles (GAAP). Furthermore, it contrasts the transparency practices and standards of these two accounting systems. Moreover, private ownership, low-cost airlines, increasing trade ties, and technical improvements have all contributed to the aviation industry's exponential rise [8]. Therefore, Qatar Airways has employed techniques that include purchasing interests with different airlines, expanding into new areas, and supporting activities to accelerate its worldwide growth. Due to [9], the authors give a threat categorization study based on the STRIDE model, emphasizing the need for suitable systems and infrastructure for maintaining

airworthiness. Likewise, the purpose of using IT audits inside [10] is critical in the context of controlling safety risks in aviation maintenance outsourcing since cyber risk presents a severe danger to safety. Furthermore, IT audits assist in the security of information technology resources, examination records, and qualification papers, all of which are utilized to assess if MROs follow requirements.

2.2 Practical Limitations of Existing Approaches

Recently, various practical methods have become popular, especially those based on the multi-level framework from [11] created by Frambach and Schillewaert in 2022, which look at various issues related to airline partnerships and airport-led transfer programs in the industry. Furthermore, Etihad Airways' [12] requirement for internal audit capabilities is motivated by the significance of delivering guarantee services in a wide variety of business sectors, which has grown increasingly crucial. Internal audit functions are critical in establishing trust and credibility, improving the validity of information, procedures, and reports, and giving assurance to a broad variety of stakeholders. Moreover, the internal audit operations may contribute value by conducting business process improvement audits, risk management evaluations, and fraud detection. Additionally, the research [13] considers the use of internal audits, especially internal algorithmic audits, in order to guarantee that AI systems fulfill ethical norms and standards. This research paper proposes an internal audit framework for AI systems, especially the SMACTR framework. Thus, by evaluating a huge dataset of passenger evaluations [14], the research helps to better understand consumer satisfaction and feedback in the aviation sector. It employs the use of semantic network analysis as well as regression analysis to determine the elements that influence customer happiness and recommendation. The results provide insights into building long-term plans in the airline sector and emphasize the relevance of consumer input to corporate success. The report also underlines the importance of understanding internet reviews and their ramifications for the airline business. Therefore, the study [15] emphasizes the evolution of airline ownership and control

compliance with US legislation rather than IT systems or infrastructure. According to the study [16], they examine the implementation of a modernizing IT risk universe framework to satisfy the new needs in the IT audit plan for the aviation sector. This approach is suggested to address the risks that come with digital transformation. The research helps to identify the needs and prospects for upgrading the IT risk universe in IT audit methods, especially in the framework of digital transformation. It offers a framework for dealing with the rising complexity of IT risk categories. Also, within [17], the research was done to analyze the degree of compliance with an airworthiness criterion in Myanmar's aviation industry. Furthermore, the report illustrated the airlines' existing airworthiness preparation and recommended modifications to training programs. In addition, the research [18] helps to clarify the function of internal auditors in ensuring regulatory compliance and safety in aviation maintenance, as well as the use of the Becker Model to analyze the benefit, cost, and likelihood of illegal activity in this context.

2.3 Research Gaps & Limitations

This subsection examines the limitations and research gaps based on analyzing the previous studies. However, the approach for performing airport security audits, which is shown in [19], underlines the need to hire external auditors who are experienced in assessing airport management and organization. Therefore, the research in [20] focuses on airlines' susceptibility to being appropriately qualified and having specialist knowledge of the sector being audited. The research also examines the method of auditing civil airport security and protection, and it advises using external auditors to ensure impartiality and objectivity in cyberattacks and the possible implications. It outlines examples of system failures at United Airlines and Alaska Airlines, resulting in flight interruptions and revenue losses. Numerous cyber risks, including DDoS assaults, viruses, and data breaches discussed in [21], emphasize the need for robust cybersecurity procedures, frameworks, and guidelines. It also discusses the misuse of passenger information and the associated liability for airlines. While it does not

explicitly state contributions, the research emphasizes the importance of cybersecurity within the airline sector and briefly touches on limits, such as persistent cyber threats and the impact of social networking sites on airline operations.

Table 2: *Analysis of Past Studies.*

Ref.	Year	Type	Frameworks	Contribution	Limitation
[3]	2023	Case Study	ISO 31000 & COSO ERM.	The RITM 23 methodologies approach is utilized in this study to look at the implementation of a proposed ITRM system throughout an African airline.	Lack of a complete End-to-End technique for ITRM. This problem is significant because it suggests that the research does not effectively integrate or account for the interconnectedness of numerous risk management systems as well as the resulting cumulative effect on the firm.
[6]	2023	Audit Report	Audit Process	They attempted to improve the authority's processes and practices, notably those related to finance and contract regulations.	Report on the constraints of IT audit techniques, as they may not reveal all potential shortcomings in policies or procedures.
[7]	2021	Financial Research Study	IFRS & US GAAP, & GOST R ISO 19011.	Examines implications of COVID-19 on passenger airline financial reports and gives info on the openness and quality of business reporting and the auditors' replies in their reports. Also, it revealed the existence of tax breaks and continued issues.	Reported that the research sample of 24 statements of income is limited and should not be used to extrapolate larger groups. Also, they acknowledge the significant difference in the complexity of disclosures linked to the effect of the epidemic to the chosen sample of statements.
[9]	2021	Review Paper	NIST Framework. ISO 27001	It examines the significance of cybersecurity in aviation, prospective dangers, including DDOS attacks, and how cybercrime affects air transportation.	Lack of awareness Complexity of systems Insider threats Limited resources
[10]	2020	Review Paper	SWOT Framework.	Provide info on worldwide aviation maintenance outsourcing, its risk factors, and safety concerns. It also gives insights into outsourcing, global trends of aviation outsourcing, and the regulatory procedures taken by FAA agencies.	The constraints and limits of IT auditing in the context of maintenance for aviation outsourcing might encompass the requirement for real-time data access, capabilities for data analysis and interpretation, and data-driven decision-making.
[12]	2020	Review Study	Framework based on service quality; they suggest.	Proposing a framework for evaluating the perceived value added by internal audit functions based on insights from literature on internal auditing and service quality disciplines. It also conducts a thematic analysis of published profiles of various organizations' internal audit functions to identify recurring value-adding attributes.	The research contributes by presenting a methodology for assessing the perceived value contributed by internal audit functions, according to findings from the literature on internal auditing and quality of service professions. It further performs a topical evaluation of published profiles of different firms' internal audit functions to identify recurrent value-added characteristics.
[13]	2020	Research Study	SMACTR framework	Underlines the significance of conducting internal audits on AI systems to guarantee ethical and responsible	While the paper does not go into depth on the contributions and limits of IT audits, it does emphasize the need for internal algorithmic audits

				growth. The suggested SMACTR framework intends to guide realistic deployments of internal audits for AI systems by identifying failure mechanisms, prioritizing risks, and generating problem-solving strategies.	within the overall picture of artificial intelligence development.
[15]	2019	Report	U.S. Government Accountability Office (GAO)	This report adds to our knowledge of the difficulties and issues regarding foreign ownership throughout the US aviation sector.	As a result, it provides essential stakeholder viewpoints, but it may fall short of delivering a thorough and complete study of the possible effects of changing foreign ownership regulations on the US aviation sector.
[17]	2018	Thesis	ICAO & EASA	The contribution may be deduced from the evaluation of compliance with the airworthiness criteria in Myanmar's aviation sector.	Constraints can involve data collecting limits, number of samples, or other issues influencing the study's breadth and generalizability.
[19]	2016	Research Study	PDCA	Use external auditors who have sufficient expertise to ensure impartiality and objectivity while assessing airport security, show a methodology to perform airport security audits: administrative, technological, & physical factors, recommend using checklists to cover all processes, operations, duties, and functions throughout the audit & emphasizes the need to plan corrective measures for recognized faults.	The report does not dive into case studies or illustrations of how the proposed approach is used in practical problems with airport security audits. It fails to tackle any possible issues or barriers that may occur throughout the suggested framework's implementation process. The report fails to provide a full analysis of the costs or resource requirements for performing airport security audits utilizing the specified methodology.
[20]	2015	Research Study	ISO 27001, CIS Controls, & NIST	Airline technology and systems were found to have weaknesses. The need to safeguard passenger information was again stressed.	There is a dearth of data pertaining to individual cyberattacks. Moreover, details regarding the veracity of certain assertions are lacking.
[21]	2022	Systematic Review	Audit Process	Provides info on security vulnerabilities, risks, and possible surfaces in the civil aviation business. The findings depend on an assessment of reported occurrences and recommended security solutions.	The study emphasizes the difficulties in obtaining accurate and complete information on aviation events owing to the industry's sensitive nature as well as the overwhelming majority being owned by government entities.

3- Methodology

The methodology section provides a detailed overview of the review approach utilized in the study.

1.1 Review Planning

The review planning method for this systematic review is detailed in this section. This review's planning phase included the creation of the study questions, the development

of an approach to searching, and the design of study selection criteria. The goal of describing the review strategy is to assure openness, replicability, and thoroughness.

1.1.1 Research Question

The following study questions were developed with the goal of performing a quantitative examination of the research literature in science, investigating the possible application of process mining in conventional auditing, and investigating the problems associated with process mining-based audits:

RQ1: What are the key challenges associated with utilizing the audit process within airline companies?

RQ2: What are the success factors of IT audits within airline companies?

1.1.2 Review Procedure

The review methodology was created by constructing search strings, choosing appropriate databases to perform the search, and defining the criteria for both inclusion and exclusion. Each of these subsections is discussed in further depth below.

1.1.2.1 Search String

Numerous trial investigations into literature were undertaken prior to developing the best search phrase. Nevertheless, the query that followed was chosen for its capacity to provide the most pertinent search results. (Audit OR auditing) AND (IT Audit OR “information technology audit”) AND (Airlines IT Audit OR Aviation IT Audit) The localized rendition of the preceding query for searching was used for each of the specified literature indexing databases.

1.1.2.2 Databases to Search

The literature search for this review was conducted using various online resources that index scholarly literature, including:

- ScienceDirect
- IEEE Explore
- ACM Digital Library
- Springer Link

- Google scholar
- ProQuest
- ResearchGate
- Elsevier
- Other various Journals.

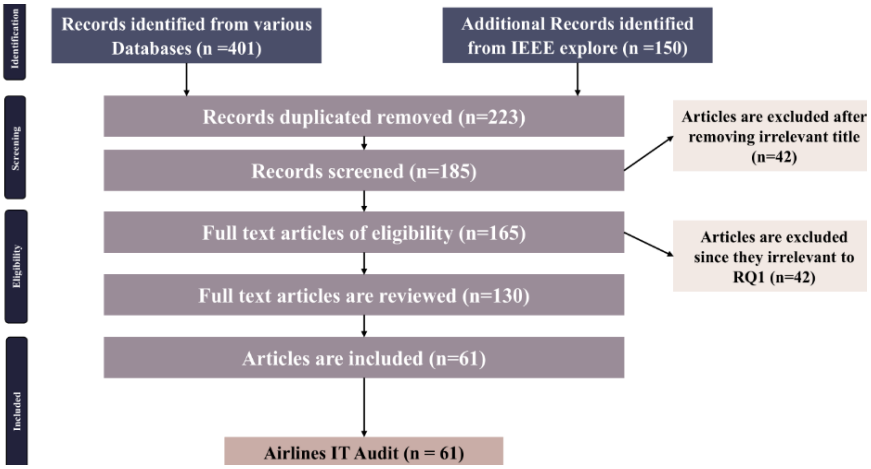

Figure 4: *PRISMA Diagram for Systematic Review.*

1.2 Report Conducting

Regarding this phase, the review plan created in the previous stage is executed. Where the search for databases and the results obtained are done. Therefore, a title-based duplication approach is utilized to remove identical papers from several databases. The publications were screened according to inclusion and exclusion criteria, comprising titles and abstracts. After passing the previous screening phases, the articles underwent full-text screening. Answers from chosen articles were recorded on an Excel sheet.

1.2.1 Data Collection and Analysis

The data regarding the overall study question was gathered using a Microsoft Excel form, which also aided in the quantitative analysis for the information that was collected. The last phase in the review process was to report on the results, which will be discussed in the next section.

1.3 Reporting and Findings

In this phase, the review results are reported. Our methodology for this systematic review is based on the PRISMA declaration. Figure 4 is a high-level overview of the

piece of literature selection process, showing the steps taken and the articles included or excluded depending on the approach employed. Listed below is a breakdown of the following steps that make up the procedure: To fulfill the study's concerns, sixty research papers were considered appropriate. Figure 5 depicts the distribution of research by year, whereas Figure 6 shows the distribution by publication type. Figure 5 shows that the frequency of publications has been on the rise throughout the years, but it has been on the downturn as of late. Figure 6 shows that there was no significant difference in the distribution of the studies included across journal articles and those published at conferences. The number of articles presented at conferences was somewhat lower than that in journals. The results section that follows will discuss the findings that are pertinent to each study topic.

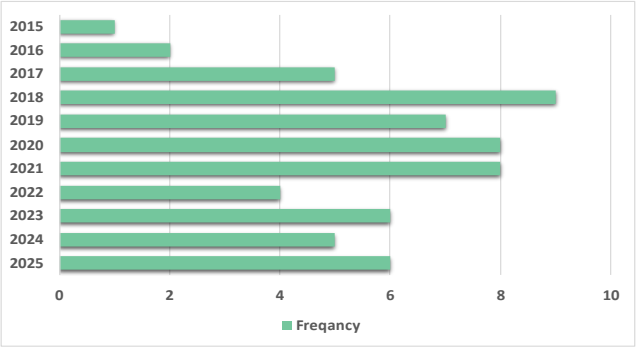

Figure 5: *Yearly Publication Distribution.*

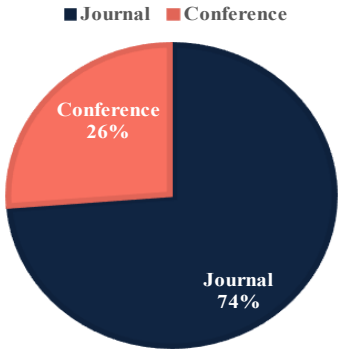

Figure 6: *Distribution of Publication Types.*

4- Analysis and Results

The results of the review are detailed here. The research questions established during the review planning phase served as a guide for the analysis and structuring of the findings. At

the outset, the section provides a detailed presentation of the results pertaining to each study topic, backed up by appropriate data, tables, and figures. Investigators and those working in the area may greatly benefit from the insights provided by this section, which offers a comprehensive look at the pros and cons of employing process mining for business process audits. Focusing on the efficacy of organizational procedures and applied business principles, the internal audit process seeks to guarantee the fulfillment of both internal and external requirements. It is widespread practice for an organization's internal auditors to conduct audits inside the company [22, 23]. Conversely, external audits are conducted by independent auditors who verify compliance with external regulations. In cases where the airline may also choose to hire an outside firm to conduct an IT audit in order to ensure that its systems are secure, up to code, and operating according to industry standards, The efficacy of the airline's information technology controls may be evaluated, and opportunities for improvement can be identified with the help of external auditors who provide specialized knowledge and an outside viewpoint. [24]. Their recommendation that airlines employ internal and external audits to protect themselves against cyberattacks is due [25]. Although external audits deliver an unbiased assessment of security measures, internal audits aid in evaluating risks inside the business. The thorough evaluation of security measures and the identification and correction of any vulnerabilities are both aided by this two-pronged strategy. Furthermore, [26], they utilize audits from both within and outside the company. When it comes to customs hazards, internal audits are used to analyze and target all the data that can manifest, while organizations such as the ICAO and the IATA do external audits for assessing security precautions and monitoring. To find patterns in the use of process mining techniques in distinct kinds of audits, studies were classified according to the audit type. Research dispersion according to Figure 6. Categories of publications distributed. Figure 7 displays the audit type. The items that relate to each kind of audit are listed in Table 3. These findings suggest that academics have paid greater consideration to internal audits than external audits, or both. A more positive outcome with process mining-based audits seems to be internal audits, according to the research that is currently accessible. Additionally, Table 1 provides a concise comparison using both internal and external audits.

Table 3: Articles Using Internal and External IT Audits.

Internal IT audit	[2],[5],[11],[12],[13],[16],[18],[27],[28],[36],[39],[40],[41],[44], [49], [50],[52],[53],[56],[57],[58]
External IT audit	[6],[7],[15],[19][23],[25],[38],[48],[51],[60].
Both	[1],[3],[4],[8],[9], [24],[29],[30],[31],[35],[43],[54],[55],[59],[61].

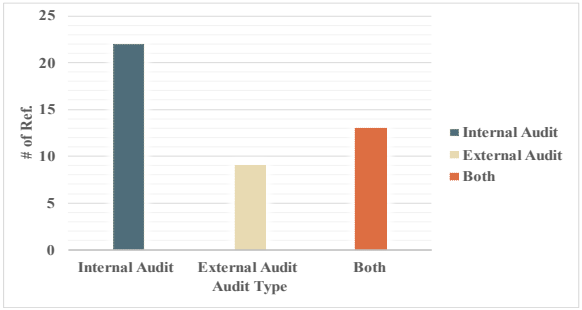

Figure 7: Distribution of Publications by Type of Audit.

Figure 8 represents an overall airline distribution within a worldwide range where the past studies related to these airlines are case studies, review studies, reports, and surveys.

4.1 **RQ1:** What are the key challenges associated with utilizing the audit process within airline companies?

Regarding the research question, this subsection begins to answer the research question; therefore, the key challenges are associated with utilizing IT audits in airline companies. Further, the successful factors for IT audits within airline companies. To guarantee that firms' IT implementations are secure, auditors conduct.

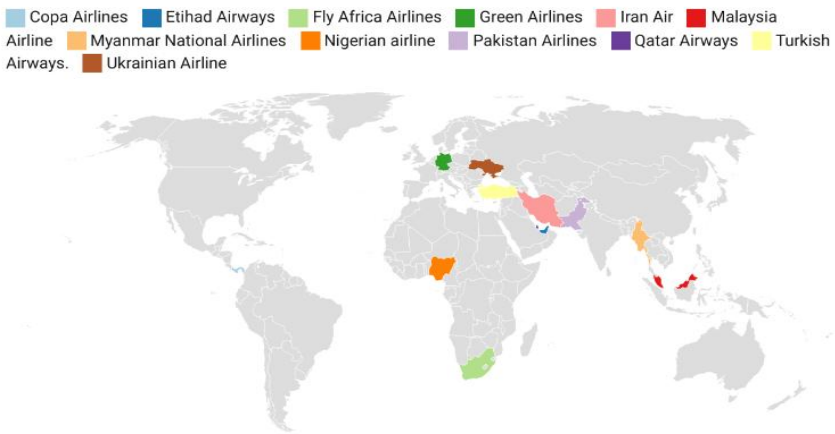

Figure 8: Airlines Distribution Over Worldwide.

IT audits. They also noted that there are several advantages to doing an IT audit inside airlines, including reduced expenses, safer data storage, and a better overall experience for customers in [32]. They are conducted to guarantee the efficacy, efficiency, and security of IT systems and procedures. The growing importance of IT and the consequences of fast technological development highlight the need for regular IT audits in today's organizations. [33] In addition, vulnerability assessment and innovative security technology are necessities in the aviation business due to the importance of security [34]. An evaluation and proposal for a vulnerability assessment methodology targeting aviation cyber-physical systems (ACPS) have been made. Nevertheless, [35], authors underline the necessity of the internal auditor's role in providing objective assurance, as well as advising in analyzing and monitoring the firm's ERM implementation. The study additionally highlights the need for a robust internal audit role in ensuring that risk management and governance systems are in place. There are numerous key challenges for IT audits within the airline industry. Where Table 4 provides a general key challenge for an IT audit within an airline company with a description and frequency, frequency refers to the number of repeated challenges within past studies. To begin with [36], there is an imbalance in the coordination of policies and objectives between different management systems, which may reduce efficiency. Although, due to the study [37], the key challenges for airlines in IT audits include ensuring cybersecurity in aviation, addressing cybersecurity threats and risks, and managing the security of air traffic control systems. In [23, 38], difficulties in identifying and reporting key audit matters include determining the most important concept and emphasizing specific aspects of the audited entity. The review of audit reports from transportation companies shows that the most mentioned critical issues are how revenue is recognized, the loss of value in receivables, and planning for major repairs of leased aircraft, which is important and critical. This report may have been stolen or leaked to reveal the airline's plans, which attackers could exploit to cause financial harm or damage the airline's reputation. This

instance simplifies the scenario of exploiting and stealing information to cause damage to the airline company. More about key challenges, while [39] examines the problems of IT audits, highlighting the need for frequent audits to check the security of data and communication networks. It emphasizes the significance of international standards and guidelines in the design and implementation of information security systems. The paper also discusses the difficulty and time of acquiring audit material, in addition to the need for a precise audit methodology and schedule. It also underlines the importance of this audit report for discovering current flaws and strengthening the security systems. Within [40], they mentioned mobile device security for managing the security of mobile devices used by airline staff for operational and administrative purposes. Also, cloud security addresses security concerns related to the use of cloud-based infrastructure for airline operations and data storage. Figure 9 illustrates key challenges over frequency, where the top three highest frequency challenges are complex IT systems, data security, and privacy concerns, and ensuring regulatory compliance.

***Table 4**: General Airlines IT Audit Key Challenges.*

Key Challenge	Description	Frequency
Complexity of IT Systems	Airlines operate complex IT systems that handle reservations, flight operations, maintenance, and customer service, posing challenges in auditing these systems effectively.	18
Insider threats	Insider knowledge within the aviation industry can lead to potential security breaches.	1
Data Security and Privacy concern	Ensuring the security and privacy of passenger and operational data is crucial, and auditing IT systems for compliance with data protection regulations is a significant challenge.	17
Ensuring Regulatory Compliance	Airlines must comply with various industry regulations and standards, making it challenging to ensure that IT systems align with these requirements. Ensuring compliance with industry regulations and standards such as ICAO, FAA, and EASA.	19
Integration of Legacy Systems	Various airlines still use legacy IT systems, and auditing the integration of these systems with modern technologies presents a challenge.	5
Training and Expertise	Continually training and development of staff to counter the latest threats to cybersecurity is a challenge.	2
Resource Constraints	Lack of resources can hinder the implementation of effective IT audits.	1
Cybersecurity Risks	Airlines face challenges in safeguarding their IT systems from cyberattacks, making it crucial to address cybersecurity risks in IT audits. Also, it is sensitive to passenger data and flight operations.	12
Budget Limitations	Limited funds allocated to IT audit budgets can be a significant challenge.	2
Integration of New Technologies	Incorporating modern technologies such as AI, IoT, and blockchain into existing systems while ensuring security and compliance is a challenge.	7
Disaster Recovery and Business Continuity	Planning for and mitigating the impact of IT system failures or disruptions on airline operations.	3

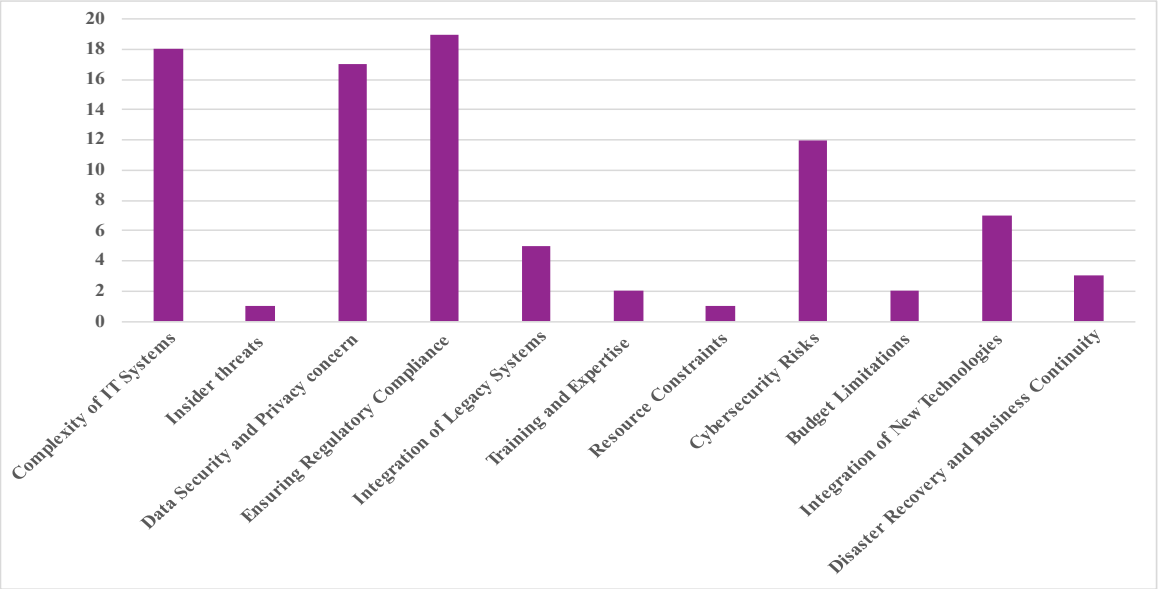

Figure 9: *Key Challenges Distribution.*

4.2 RQ2: What are the success factors of IT audits within airline companies?

This subsection represents and briefly discusses the success factors for airline IT audits. However, Table 5 provides a detailed overview of success factors for IT audits within airline companies. Where is the list of success factors, descriptions, and frequency of repeated studies due to various past studies. Furthermore, these success factors aim to mitigate risks and enhance the quality of airline IT audit work. Within [41], they focus on FOSA, which is an internal safety audit system. It is designed to collect, store, and analyze data related to human behavior during normal flight operations to proactively identify and address safety risks. Therefore, the audit system discussed in the document is an internal audit.

Table 5*: Overall Airlines IT Audit Success Factors.*

Success Factors	Description	Frequency
Compliance with Data Protection Laws	Ensuring adherence to data protection and privacy regulations.	3
Cybersecurity Measures	Implementing robust cybersecurity protocols to protect against cyber threats.	11
Continuous Monitoring	Implementing continuous monitoring tools and processes enables proactive identification and response to IT risks	8
Collaboration with IT and Business Units	Effective collaboration between IT, audit, and business units to ensure alignment with strategic objectives and risk management.	9
Risk-Based Approach	Focusing on high-impact IT risks and vulnerabilities allows for more effective audits and risk management within the airline industry.	12
Talent and Expertise	Having skilled IT auditors with expertise in aviation technology and regulations is essential for successful audits in airline companies.	9

Alignment with Industry Standards & Best practices	Alignment with Industry Standards: Successful IT audits align with industry-specific standards and best practices, such as those outlined by aviation regulatory bodies and IT governance frameworks.	11
Adaptability to Change	Given the dynamic nature of the airline industry, successful IT audits are adaptable to changes in technology, regulations, and operational processes.	6
Regular Training and Awareness	Ensuring that airline staff are well-trained in IT security and compliance.	5
Data Encryption and Privacy Measures	Implementing encryption and privacy measures to protect sensitive data and ensure compliance with data protection regulations.	2

Moreover, as mentioned in work [37], success factors involve implementing adaptive security solutions, conducting real-world penetration testing, and developing advanced security approaches for tactical and strategic operations. Additionally, incorporating consumption-focused indicators for resource efficiency and reliability in the aviation industry is crucial. Furthermore, via the study [42], the authors define success indicators for an airline IT audit as evaluating the effectiveness of IT systems in improving operational effectiveness, guaranteeing data security and privacy compliance, determining the integration of IT systems via business processes, and discovering ways to build innovations in technology to enhance consumer satisfaction and streamline operations. Moreover, the audit should assess the IT infrastructure's capacity to help achieve the airline's development and expansion objectives, as well as its resistance to cyberattacks and interruptions. While in [38], the authors discuss the adoption of industry best practices and standards for IT governance and compliance, such as COBIT and ITIL frameworks. Also, they mentioned a robust collaboration between IT, operations, and compliance teams to align IT strategies with business objectives. Moreover, within [43, 44], they suggest regular training and awareness programs for employees on IT security and compliance.

In addition, the utilization of advanced IT audit tools and technologies for comprehensive monitoring and analysis, as well as keeping updated with technological advancements to address emerging threats. The authors [2] focus on the LOSA methodology, which is a proactive safety management tool used in high-risk industries such as aviation. LOSA is an internal audit methodology that involves the collection of de-identified, non-punitive quantitative and qualitative work performance data by trained LOSA observers. Table 6 provides a summary related to IT audits of airlines. key challenges and success factors. Furthermore, Figure 10 provides a key success factor distribution over frequency. Thus,

the top three success factors are a risk-based approach, cybersecurity measurements, and alignment with industry standards and best practices.

In the case of an airline, continuous monitoring means monitoring not only the usual IT systems but also, and more critically, the safety systems, flight operations, and the environments. This is unlike the usual IT environments, where continuous monitoring primarily means the monitoring of avionics systems, maintenance information systems, and the operations. Human-related issues also make the situation quite tricky, especially because the auditing and maintaining of the systems make way for human errors during the periods of maintenance and inspections.

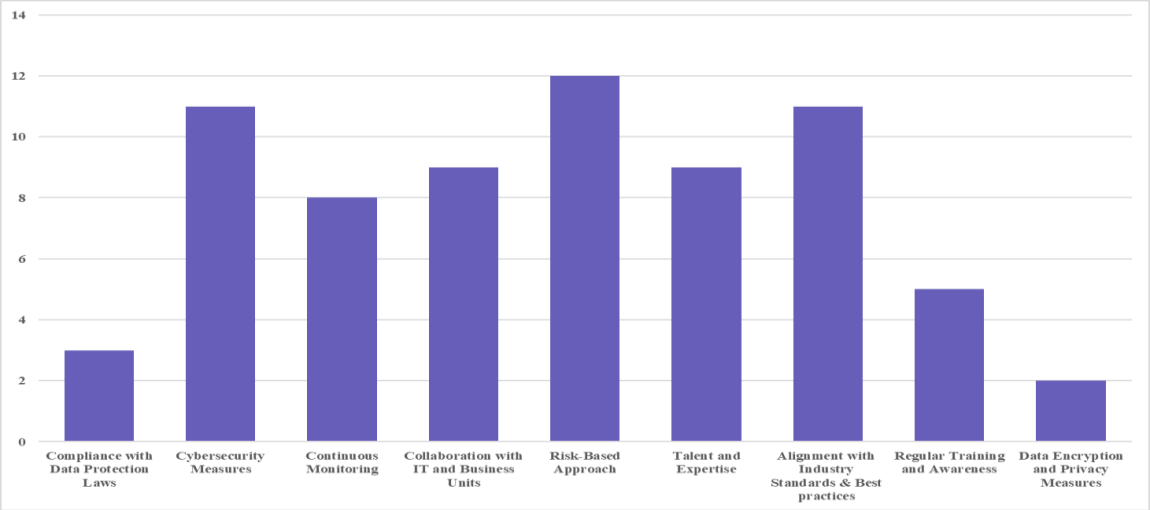

Figure 10: *Success Factor Distribution.*

In the case of the risk-based auditing system, the continuous monitoring and auditing of the systems in the context of an airline means the system focuses less on the application of universal audit controls and rather focuses on high-impact domains and sectors. Where security audit systems, operated through the context of flight operators, also face the issues of highlighting the importance of prioritization, especially through the context of risks, safety performance indicators, and regulatory findings. In the context of the strategic airline environment, where there are both micro and macro factors and issues, there is the need to have risks assessed through the application of an adaptive system.

Table 6: Overall Airlines Key Challenges & Success Factors IT Audit Comparison.

Ref.	Year	Key challenges	Success Factors
[45]	2023	The challenge includes resolving regulatory concerns, guaranteeing data security, and being current with technical developments.	It consists of employing innovative audit technologies and procedures, having auditors that are both informed and talented, and communicating effectively with stakeholders.
[36]	2023	The research found that aviation management systems lack consistency and uniformity, notably in policies, goals, and risk assessment. The lack of policy and objective coordination and various danger verification and risk assessment methodologies hinder efficiency and safety.	Success aspects include centralizing methods for reporting for disparate systems and identifying threats from several sources. To overcome these issues, the paper recommends extra global standards and aviation IMS research.
[46]	2022	• Regulatory Compliance: Adhering to federal aviation rules and industry norms. • Risk Management: Managing aviation's elevated level of hazards. • Technology Transfer Limitations: Exclusive information requirements for corporate operations restrict technology transfer. • Requires specific talents, abilities, and understanding for aviation industry space product manufacture.	• The process method is used to identify, monitor, and regulate the primary and supplementary activities within the company's operations. • Perform internal audits to assess quality management system aspects and assure compliance. • Strategic Planning: Strategic objectives and long-term planning guide resource use. • Continuous improvement: Adheres to full quality control to enhance goods, services, and production/rendering processes.
[47]	2021	• Cybersecurity risks such as securing communication systems which include ADS-B, RFID, as well as internet connection to prevent unwanted access and control. • Addressing vulnerabilities in GPS navigation and location validation mechanisms to avoid spoofing and hacking. • Encrypting data with AES and RSA for safe transfer and sensitive information protection. • Integrating Blockchain Technology for flight data encryption and tracking to maintain data integrity and security. • Public approval: Addressing the public's doubts and creating confidence in flying vehicle safety and security to win national airspace acceptability.	• Robust Cybersecurity Measures: Implementing fully autonomous flight with secure communication and navigation systems. • Compliance with Security Standards: Adhering to industry standards and regulations to ensure the safety and security of flying cars. • Government and Private Sector Collaboration: Collaboration between government and private companies to prioritize user safety and cybersecurity. • Long-Term Vision: Developing a holistic infrastructure to support secure cybersecurity operations for future flying cars. • Technological Innovation: Embracing advanced encryption methods and emerging technologies to address cybersecurity challenges effectively.
[48]	2020	Remaining with quickly expanding technology, guaranteeing data security, and managing regulatory compliance.	Success criteria may include a professional and experienced IT audit team, outstanding interaction among stakeholders, and an ability to react to technological developments.
[49]	2018	The primary problems of IT auditing include keeping up with quickly expanding technology, ensuring regulatory and standard conformity, and managing cybersecurity concerns.	Success variables include experienced and knowledgeable IT auditors, good stakeholder communication, and alignment with business goals. Additionally, using technology and data insights may improve the efficacy of IT audits.
[33]	2018	• Risks associated with IT audit, which have a multi-dimensional and subjective concept, making it difficult to evaluate the impact of IT audit.	• Adequacy and operation of the IT function within the organization. • Components such as the audit team, audit process and methodology, client control, technical competence of IT audit personnel, social people skills of IT audit personnel,

		• Lack of academic research on IT audits, leading to limited theoretical support for IT audit practices. • Complexity of modern organizational environments, which makes IT audit more complex and challenging.		client organizational environment, and IT audit targets.
[18]	2017	IT audits face significant problems such as keeping up with quickly changing technology, assuring regulatory and standard compliance, and managing cybersecurity concerns.		Success variables include knowledgeable and skilled IT auditors, good stakeholder engagement, and consistency with business goals.
[50]	2016	Certain obstacles may develop in meeting and maintaining Green Airlines' sustainable development objectives.		• Environmental Management System (EMS) Implementation • Sustainable Environmental Assessment • Corporate Environmental Management Practices • Greening Initiatives such as flight planning, greening on board, and ground operations. • Third-party Consultancy Evaluation based on environmental standards and practices.
[51]	2025	• Lack of uniform global standards for aviation monitoring and revision. • Data fragmentation in international regulatory bodies. • Difficulty monitoring real -time monitoring across different sectors. • Integration challenges between different technology systems and inheritance infrastructure.		• Implementing of integrated technical framework for monitoring and auditing. • Use of automated matching tools and data reconciliation techniques. • Adoption AI-driven analysis for adjusting cross-border regulations. • Stronger cooperation between international aviation authorities.
[52]	2025	• Limited awareness and understanding of insider threats in the aviation sector. • Override security while ignoring internal vulnerabilities. • Inadequate training, reporting mechanisms, and sharing of threat telecommunications. • Lack of organizational complacency and continuous risk assessment.		• Promoting a culture of security awareness across all aviation personnel. • Integrating behavioral analytics and insider risk detection systems. • Continuous training and education on insider threat indicators. • Collaboration between industry stakeholders and security agencies for better threat mitigation.

The aim of the research was to investigate the literature on concern for cybersecurity [54], focusing on risk, compliance, and regulatory adjustment. The study showed that digital integration, legacy systems, and outdated software made aviation systems more susceptible. Whereas control frameworks, real-time threat detection, and cross-industry collaboration improve cyber resistance and regulatory compliance. In addition, a blockchain-driven aviation cybersecurity architecture in [55] aims to secure airlines and airport information systems. According to studies, Blockchain reduces the risk of computers through decentralized trust, unchanging records, and smart contract-based authentication. This technology-driven strategy improves openness, traceability, and operational confidence in the aviation ecosystem. However, a hybrid Aczel–Alsina and

Grey DEMATEL-ISM model is used to establish a causal link between industrial aviation transitional barriers [56]. Their results show that a lack of digital infrastructure, lack of competence, and significant adaptation costs prevent industrial aviation standardization. According to the report, strategy and innovation are the keys to seamless transformation. In [57], strategic security management in airlines is investigated using CPI-driven observation for continuous improvement. According to research, quantitative security indicators improve performance dashboards' security management system visibility, accountability, and decision-making. This shows that data-driven internal audits are crucial for security experience. Aviation Cybersecurity Organizational Preparedness was investigated using a technology assessment methodology. Within [58], a Secure E-payment system found deficiencies in risk management, personnel expertise, and technology adoption. The research found that training, leadership engagement, and political texture improve maturity and compliance preparedness. Even [59] used DEMATEL-QSFS to prioritize aviation cybersecurity measures by assessing mutual addiction in criteria for cyber preparedness. Risk beliefs, infrastructure Resilience, and enforcement of policy affect the cybersecurity performance according to their model. Evidence-based cybersecurity resource allocation is supported by outcomes. A classification of aircraft hackers and types of attacks is presented in [60]. The report categorizes attackers by motivation, from online criminals and hacktivists to state-sponsored groups, and describes their techniques, including phishing, injection of malware, and system penetration. It advocates better external threat monitoring and information exchange to defend cyberspace aviation. The research concludes with a comprehensive framework for combining IT audit approaches with automation technologies [61].

5- Conclusion and Future Work

Several airlines have regulatory issues, as well as concerns about privacy and risk management. Ensuring compliance, the complicated nature of IT systems, and other challenges. Success elements include incorporating novel audit technologies and

methodologies, attracting qualified and knowledgeable auditors, and successfully connecting stakeholders. A comprehensive review of IT audits carried out in the aviation sector reveals the primary obstacles and success factors involved with this vital activity. The study highlights the importance of IT audits within the airline sector, emphasizing the challenges and success factors faced by airlines. Furthermore, it emphasizes the need for regulatory compliance, data security, and risk management for airlines. In contrast, success variables include the utilization of innovative audit technology and the presence of qualified auditors, along with successful stakeholder involvement. This in-depth analysis offers significant insights that may help educate and drive the creation of efforts to improve IT audit procedures in the aviation sector. However, developing a comprehensive framework in the future for airline IT auditing that incorporates best practices, regulatory requirements, and emerging technologies, aimed at enhancing the overall effectiveness and efficiency of IT audits in the aviation sector.

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***Appendix A**: Table 7 List of Abbreviations.*

Abbreviation	Description
IFRS	International Financial Reporting Standards.
GAAP	Generally Accepted Accounting Principles.
ITRM	Information Technology Risk Management.
ISO	International Organization for Standardization.
NIST	National Institute of Standards and Technology.
COBET	Control Objectives for Information and Related Technology.
SWOT	Strengths, Weaknesses, Opportunities, and Threats.
DDoS	Distributed Denial of Service.
LOSA	Line Operations Safety Audit.
FOMS	Flight Operations Management Systems.
UIA	Ukraine International Airlines.
EASA	European Aviation Safety Agency.
ICAO	International Civil Aviation Organization.
ACPS	Aviation Cyber-Physical Systems.
IT audit	Information Technology Audit.
FOMS	Flying Operations Management Systems.
IATA	International Air Transport Association.
ERM	Enterprise Risk Management.