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# The Implementation Concept and Frequency of Safety Audit Programs: A Systemic Integrative Literature Review

**Dwi Lestary[1*], Megi H. Hemliadi[2], Nunuk Praptiningsih[3], Ichyu Machmiyana[4], Rahmawati Sukra[5]**
Politeknik Penerbangan Indonesia Curug

***Correspondence:**
dwi.lestary@ppicurug.ac.id

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**ABSTRACT**

The institutionalization of Safety Management Systems (SMS), following the adoption of Annex 19 by the International Civil Aviation Organization (ICAO), has become a fundamental component of contemporary aviation safety governance. Within this framework, safety audits are positioned as a core element of safety assurance, intended to evaluate system effectiveness, assess the adequacy of risk control measures, and support informed organizational decision-making. Despite the global standardization of SMS principles, considerable variation persists in the design of safety audit programs, particularly in determining appropriate audit frequency. This challenge is especially evident in Approved Training Organizations (ATOs), whose operational environments integrate academic instruction, practical training, and safety-critical activities. Although national aviation regulations, including those implemented in Indonesia, act as regulatory drivers for SMS adoption, aligning audit frequency with operational risk dynamics represents a global and systemic challenge shared by ATOs across jurisdictions. This study examines the conceptual and empirical development of safety audit implementation and audit frequency over the past fourteen years through a qualitative narrative literature review conducted using a structured review protocol. The review process was informed by PRISMA principles and employed predefined search strings related to safety audits, audit frequency, Safety Management Systems, Safety Performance Indicators (SPIs), and aviation training organizations across major academic databases. Inclusion criteria focused on peer-reviewed publications published between 2011 and 2025 that addressed safety assurance practices within aviation and other safety-critical domains. The synthesis of the literature identifies a clear transition from periodic, compliance-oriented audits toward adaptive and performance-based audit models increasingly informed by SPIs and prior safety performance outcomes. Building on this synthesis, the study proposes a contextualized safety audit model for ATOs that operationalizes the shift from periodic to performance-based auditing. The model integrates system-based auditing, organizational safety culture evaluation, and SPI-based performance monitoring within the Plan–Do–Check–Act (PDCA) continuous improvement cycle. In this framework, SPIs function as dynamic inputs for determining audit frequency and scope: stable or improving SPI trends may justify extended audit intervals, whereas deteriorating or volatile performance patterns trigger more frequent, targeted, and in-depth audits. By replacing fixed, calendar-driven schedules with a risk-responsive approach, the proposed model aligns audit intensity with actual operational exposure, supports proportional allocation of audit resources, and strengthens early detection of emerging safety risks. Through this adaptive structure, safety audits are positioned as active safety assurance mechanisms that support continuous improvement, organizational resilience, and sustained safety performance within the global aviation training environment.

## INTRODUCTION

The mandatory adoption of Safety Management Systems (SMS) by states and aviation service providers has profoundly transformed how aviation organizations conceptualize, operationalize, and assure safety performance. Globally, the International Civil Aviation Organization (ICAO) has formalized SMS as an integrated, data-driven, and performance-based approach to managing operational risk and ensuring continuous safety improvement (ICAO Annex 19 "Safety Management," n.d.). In Indonesia, Law No. 1 of 2009 on Aviation and its derivative regulations, together with Annex 19 to the Chicago Convention, stipulate that every aviation service provider must establish, implement, evaluate, and continuously improve its SMS in alignment with the national aviation safety policy (Undang-Undang Penerbangan, 2009). This obligation represents a paradigm shift from reactive, compliance-oriented oversight toward proactive and predictive safety governance.

Despite the clarity of this regulatory mandate, significant challenges persist in practice, particularly among *Approved Training Organizations* (ATOs). These institutions, while not directly engaged in flight operations, are nevertheless integral to the aviation safety ecosystem as they are responsible for producing competent human resources capable of maintaining safety-critical functions in airlines, airports, and air navigation services (Permenhub No. 100 Tahun 2021, n.d.).

Recent decades have witnessed an evolution in how aviation organizations conceptualize safety assurance. Traditional audits; primarily scheduled, checklist-based, and compliance-driven, have gradually evolved into more dynamic, data-informed systems that utilize *Safety Performance Indicators* (SPIs) and predictive analytics to trigger targeted assessments (Kaspers et al., 2017, 2019; Mitchell et al., 2012). These models emphasize adaptability: audit frequency and focus areas are adjusted based on operational risk trends, previous findings, and safety performance outcomes.

Empirical studies have highlighted that the effectiveness of audits depends on several factors, including organizational safety culture, management commitment, and the analytical capability of safety teams (Mendonca & Carney, 2017; Reza et al., 2011). The integration of *organizational culture assessment* into the audit process enables a more holistic understanding of human and sociotechnical contributors to safety performance (Adjekum & Tous, 2020). Furthermore, the increasing availability of data and digital monitoring systems has led to the emergence of *SPI dashboards* that provide real-time visualizations of performance metrics, facilitating evidence-based decision-making (Lestary, Surtiningtyas, et al., 2023a).

In the Indonesian context, safety oversight and training development have undergone significant transformation since 2019, driven by national policy emphasizing vocational education reform and industry partnership. As ATOs become integral to this transformation, their internal management systems must demonstrate both educational excellence and operational safety. Consequently, the implementation of SMS; including the safety audit mechanism, has become not merely an administrative requirement but a strategic institutional priority that ensures both compliance and credibility in global aviation education networks.

Despite a growing body of literature on SMS and safety auditing, several analytical gaps remain unaddressed; particularly concerning the ATO context. First, most prior studies focus on airlines, air navigation service providers (ANSPs), or airport operators, leaving a paucity of empirical work exploring how training organizations manage safety risks within their unique operational environments (Lestary, Surtiningtyas, et al., 2023b; Mitchell et al., 2011, 2012). The nature of ATO operations; combining academic, practical, and technical domains creates distinctive risk profiles that are not adequately represented in mainstream SMS models.

Second, although *performance-based* and *risk-based* approaches to safety assurance are increasingly advocated, few studies have operationalized how SPI thresholds should function as audit triggers within training institutions. The absence of a standardized framework results in variability in how audit frequency,

scope, and methodology are defined. This inconsistency undermines comparability across institutions and complicates oversight by regulatory authorities.

Third, while the concept of *just culture* is widely recognized as central to safety improvement, empirical integration of this concept into structured audit mechanisms remains limited. Many organizations continue to treat audit findings as punitive rather than developmental, discouraging open reporting and learning. The literature also suggests that while SMS frameworks emphasize continuous improvement through the *Plan–Do–Check–Act (PDCA)* cycle, few studies demonstrate how audit outcomes are systematically reintegrated into organizational planning and decision-making within educational aviation environments (Nandan & Krishnakanth, 2015).

Finally, there is limited research that explicitly connects safety audit design with institutional capacity-building, such as auditor competency development, digitalization of safety data, and feedback integration into strategic planning. These dimensions are critical for ensuring that SMS implementation transcends documentation and becomes a living system that fosters resilience and learning. This study is theoretically anchored in the four pillars of ICAO's Safety Management System: Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion (*Doc 9859 Safety Management Manual*, 2018).

Additionally, the concept of *just culture* (Lestary, 2020; Lestary, Widadi, et al., 2023; Marx, 2019b) provides the normative framework for interpreting human behavior in safety audits. Rather than focusing solely on error detection, a just culture framework promotes understanding of why errors occur, distinguishing between acceptable human error, at-risk behavior, and reckless behavior. Within the context of an ATO, this theoretical lens aligns safety auditing with educational objectives; transforming audits into learning opportunities rather than punitive exercises.

From a systems theory perspective, SMS implementation is viewed as an *open adaptive system* that responds to internal and external stimuli (Reason, J. 1997; Reason & Hobbs, 2017). Within this perspective, overall safety performance emerges from the dynamic interaction between technical, human, and organizational subsystems rather than from isolated components. Consequently, this study adopts an integrative theoretical framework that combines systems thinking, the Plan–Do–Check–Act (PDCA) continuous improvement logic, and just culture principles to evaluate and enhance safety audit mechanisms within the institutional context of ATO.

Building upon the analytical gaps identified in existing literature, particularly those related to the design of safety audit programs and the determination of audit frequency within Safety Management Systems, this study seeks to deepen the understanding of how safety assurance practices have evolved over time. While regulatory drivers at the national level have influenced the implementation of Safety Management Systems in various jurisdictions, the challenge of aligning audit frequency with operational risk dynamics remains a shared concern across aviation training environments. In this context, the present study formulates the following research question: *How have safety audit programs and their frequencies evolved in global and national literature over the past fourteen years, and how can a context-sensitive safety audit model be developed for Approved Training Organizations (ATOs) that integrates system-based, culture-based, and Safety Performance Indicator (SPI)-based domains within the Plan–Do–Check–Act (PDCA) continuous improvement cycle?*

To address the overarching research question, this study pursues four specific objectives:

1. To synthesize theoretical and empirical developments in safety audit design and audit frequency reported in the literature from 2011 to 2025;
2. To identify key determinants influencing audit effectiveness and audit frequency within aviation training organizations;
3. To develop a context-sensitive safety audit model for Approved Training Organizations (ATOs) that integrates system-based, culture-based, and Safety Performance Indicator (SPI)-based components; and
4. To formulate practical implementation recommendations, including an SPI dashboard framework, auditor competency reinforcement, and mechanisms for integrating audit outcomes into institutional decision-making processes.

To ensure conceptual clarity and readability, the theoretical foundation of this study is structured around three complementary pillars, as summarized in Table 1.

Table 1. Theoretical Trinity Underpinning the Study

| Theoretical Pillar | Core Function | Relevance to This Study |
|---|---|---|
| ICAO SMS Four Pillars (Safety Policy, Safety Risk Management, Safety Assurance, Safety Promotion) | Regulatory and structural framework | Provides the institutional and regulatory architecture within which safety audits operate |
| PDCA Cycle (Deming) | Continuous improvement logic | Structures the iterative process through which audit planning, execution, evaluation, and corrective actions are systematically linked |
| Just Culture (Reason; Marx) | Human-centered safety perspective | Frames audits as learning-oriented, non-punitive mechanisms that encourage transparency, accountability, and organizational trust |

Together, these three pillars form an integrated analytical lens through which safety audit mechanisms and audit frequency can be evaluated and enhanced within the context of aviation training organizations.

The novelty of this study resides in its explicit examination of safety audit governance within Approved Training Organizations (ATOs), an area that remains insufficiently explored in the Safety Management System (SMS) literature, which has largely focused on airlines, airports, and air navigation service providers. Unlike previous studies that adapt audit frameworks developed for commercial flight operations, this research proposes a safety audit model specifically designed to address the operational characteristics and risk profile of ATOs. The model advances existing knowledge by integrating Safety Performance Indicator (SPI)-triggered audit frequency into the Plan–Do–Check–Act (PDCA) cycle, enabling audit timing and intensity to be adjusted dynamically according to observed safety performance rather than predetermined schedules. Furthermore, the incorporation of Just Culture principles transforms safety audits from compliance-oriented inspections into learning-centered assurance processes that strengthen organizational accountability, transparency, and continuous improvement. Collectively, these contributions establish a context-sensitive framework that enhances safety governance in aviation training organizations while extending the application of performance-based safety assurance within the broader SMS paradigm.

Through these contributions, the study positions the ATO context as a representative and transferable model for strengthening safety governance in aviation training environments, thereby supporting the broader objective of enhancing global aviation safety performance.

## METHOD

### a. Research Design

This study employed a Systematic Integrative Literature Review (SILR) to synthesize conceptual and empirical evidence on safety audits, audit frequency, and their integration within the Safety Management System (SMS) framework in Approved Training Organizations (ATOs). The SILR approach was selected because it enables a transparent and reproducible identification of relevant peer-reviewed studies while integrating diverse theoretical and empirical perspectives into a coherent analytical framework for model development. Compared with traditional narrative reviews, SILR combines structured search strategies and explicit inclusion criteria with the flexibility required for conceptual synthesis, making it well suited to multidisciplinary research on aviation safety, human factors, organizational studies, and risk management.

The study is grounded in the SMS framework, which provides the foundation for safety policy, risk management, safety assurance, and data-driven continuous improvement (Kaspers et al., 2019). Consistent with the evolution of SMS from a compliance-oriented system to a proactive, performance-based approach encompassing organizational, sociotechnical, and cultural dimensions, this study conceptualizes safety audits as adaptive safety assurance mechanisms that support continuous organizational improvement rather than merely verifying regulatory compliance.

### b. Research Subjects and Sources

The units of analysis comprised peer-reviewed journal articles, selected policy documents, and institutional reports addressing safety audits, audit frequency, and Safety Management System (SMS) implementation in aviation and other safety-critical sectors, with particular emphasis on safety assurance, performance-based oversight, and organizational safety culture relevant to Approved Training Organizations (ATOs). The literature search covered major international databases, including Scopus- and Web of Science-indexed journals accessed through ScienceDirect and EBSCOhost, complemented by DOAJ and Google

Scholar. ResearchGate was used only during the initial screening to trace citations and author-shared manuscripts, whereas only peer-reviewed journal articles and reputable conference proceedings were included in the final analysis. The review encompassed publications from 2011 to 2025, corresponding to the post-ICAO Annex 19 era. Eligible studies explicitly addressed SMS, safety audits, audit frequency, or performance-based safety assurance, reported transparent methodologies, and provided conceptual or empirical contributions relevant to aviation or comparable safety-critical domains. Studies lacking methodological rigor, focusing on unrelated industrial contexts, or offering purely descriptive discussions were excluded following duplicate removal and eligibility screening.

**c. Data Collection Procedures**

The literature search and selection followed a structured procedure to ensure transparency and replicability. Relevant English and Indonesian keywords, including *Safety Management System*, *safety audit*, *audit frequency*, *Safety Performance Indicators (SPIs)*, *aviation training organization*, and *just culture*, were combined using Boolean operators (AND, OR, NOT) and applied across the selected databases. Retrieved records were screened based on titles, abstracts, publication years, and duplicate removal, followed by full-text eligibility assessment considering methodological quality, thematic relevance, and accessibility. Eligible studies were subsequently classified into three analytical domains: system-based audits, safety culture and just culture, and SPI-based performance monitoring. The entire process adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, with all search procedures, inclusion decisions, and exclusion criteria documented to ensure methodological transparency and reproducibility.

**d. Quality Evaluation of Literature**

To enhance analytical validity, all selected studies underwent a critical appraisal based on source credibility, methodological rigor, quality of evidence and argumentation, thematic relevance, and publication recency. Only peer-reviewed or indexed publications with transparent methodologies, coherent data analysis, and direct relevance to Safety Management Systems (SMS), safety audits, audit frequency, or safety culture were retained. To ensure contemporary relevance, the review was limited to studies published between 2011 and 2025. This appraisal process ensured that the final dataset comprised academically rigorous, high-quality, and contextually relevant literature.

**e. Data Analysis Techniques**

Data were analyzed using thematic content analysis and comparative synthesis to identify recurring patterns and conceptual relationships across the selected literature. Relevant concepts, theoretical frameworks, and methodological trends were coded, organized into three analytical domains (system-based audits, culture-based audits, and SPI-driven performance evaluation), and synthesized to develop a contextualized safety audit model for Approved Training Organizations (ATOs). Constant comparative analysis was applied to identify similarities, differences, and emerging trends among the reviewed studies. To enhance analytical rigor, coding and thematic interpretation were independently reviewed by three researchers through a triangulated consensus process, while preliminary findings were cross-checked against institutional audit records and ICAO documentation to ensure theoretical consistency and practical relevance.

**f. Audit Frequency Determination**

Consistent with contemporary performance-based safety assurance, this study determines audit frequency using a risk-responsive framework rather than fixed calendar intervals (Hollnagel, 2014). The framework integrates three complementary determinants: operational risk dynamics, historical audit outcomes, and Safety Performance Indicators (SPIs). Operational risk reflects variations in workload, staffing, and training activities; historical audit outcomes consider corrective-action status and recurring findings; while SPIs provide data-driven signals for detecting deviations in safety performance and triggering targeted audit interventions. This framework is operationalized through an Audit Frequency Matrix that links safety performance conditions with corresponding audit responses. The matrix, presented in the Results section, illustrates how these determinants guide adjustments to audit frequency and scope.

Table 2. Audit Frequency Determination Matrix (Conceptual)

| Safety Performance Condition | SPI Trend | Audit History | Recommended Audit Response |
|---|---|---|---|
| Stable operations, low risk exposure | Stable or improving | Findings closed, positive trends | Extended audit interval |

| Safety Performance Condition | SPI Trend | Audit History | Recommended Audit Response |
|---|---|---|---|
| Moderate risk exposure | Minor fluctuations | Isolated findings, corrective actions in progress | Standard audit interval |
| Elevated or changing risk conditions | Deteriorating or volatile | Recurrent findings or delayed closure | Increased audit frequency |
| Emerging or critical risk indicators | Significant deviation | Unresolved critical findings | Immediate targeted audit |

The matrix operationalizes a risk-responsive approach by linking audit frequency to observable safety performance conditions. Consequently, audit intensity is adjusted according to operational risk, supporting efficient resource allocation and timely intervention in line with performance-based SMS principles.

## RESULT AND DISCUSSION

### a. Evolution of Safety Audit Programs and Frequency (2011–2025)

The literature published between 2011 and 2025 demonstrates a clear transition in safety audit programs from compliance-oriented inspection toward systemic, risk-based, and performance-driven safety assurance across aviation and other safety-critical sectors.

*Conceptualization and Purpose of Safety Audits*

Earlier studies primarily viewed safety audits as mechanisms for verifying regulatory compliance and procedural conformity (Mitchell et al., 2011, 2012; Reza et al., 2011). More recent research, however, positions audits as integral components of the Safety Management System (SMS), supporting organizational learning, risk mitigation, and continuous performance improvement through structured feedback (Kaspers et al., 2016, 2019; Lestary, Surtiningtyas, et al., 2023a).

*Evolving Models and Approaches*

Audit methodologies have evolved from checklist-based inspections toward performance-based, behavioral, and risk-responsive approaches that incorporate human factors, organizational culture, and system dynamics. Since 2015, hybrid models integrating qualitative assessments with quantitative measures, particularly Safety Performance Indicators (SPIs), have enabled organizations to evaluate safety culture, resilience, and operational performance more comprehensively (Bartulović, 2021; Mendonca & Carney, 2017; Woo, 2015)

*Audit Frequency and System Effectiveness*

A similar evolution is evident in audit frequency. Earlier studies recommended fixed audit intervals, whereas contemporary research advocates adaptive scheduling based on operational risk, organizational maturity, and safety performance. Evidence indicates that both excessive and infrequent audits reduce assurance effectiveness, supporting the adoption of SPI-driven, risk-responsive audit planning to balance oversight with resource efficiency (Calderón Ramírez et al., 2023).

*Integration of Audits within SMS Frameworks*

Recent literature consistently positions safety audits as core elements of the SMS assurance process, contributing not only to regulatory compliance but also to the evaluation of risk controls, management effectiveness, and organizational learning. This integration reinforces the interdependence of the four SMS components: Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion, as the foundation of continuous safety improvement.

*Comparative Synthesis: From Compliance-Based to Performance-Based Auditing*

To enhance clarity and accessibility, the evolution of safety auditing identified in the literature is summarized in Table 3.

Table 3. Evolution of Safety Audit Paradigms (2011–2025)

| Dimension | Compliance-Based Auditing (Earlier Literature) | Performance-Based Auditing (Recent Literature) |
|---|---|---|
| Primary Objective | Regulatory compliance verification | Risk-informed performance assurance |
| Audit Orientation | Checklist and procedure focused | Systemic, behavioral, and outcome oriented |
| Audit Frequency | Fixed, calendar-driven intervals | Adaptive, risk- and SPI-triggered intervals |

| Dimension | Compliance-Based Auditing (Earlier Literature) | Performance-Based Auditing (Recent Literature) |
|---|---|---|
| Role of Data | Retrospective reporting | Predictive and real-time safety intelligence |
| Organizational Impact | Control and oversight | Learning, adaptation, and resilience building |
| Cultural Perspective | Compliance enforcement | Just culture and shared accountability |

*Implementation Challenges and Strategic Implications*

The reviewed literature identifies several persistent barriers to effective safety auditing, including limited auditor competency, resistance to transparency, resource constraints, and symbolic compliance (Krisna et al., 2021; Marx, 2019b). These findings highlight the need for stronger auditor capability, the integration of Just Culture principles, and institutional mechanisms that translate audit findings into continuous organizational learning and improvement. Collectively, the evidence indicates that safety audits have evolved into adaptive, risk-responsive assurance mechanisms that support integrated safety governance within aviation training organizations.

**b. Methodological and Empirical Gaps in the Literature**

A review of the literature published over the past 14 years reveals substantial methodological diversity and thematic fragmentation in safety audit research. Existing studies encompass conceptual frameworks, case-based investigations, quantitative analyses, and systematic reviews. Conceptual studies provide regulatory and theoretical foundations but offer limited empirical validation (Mendonca & Carney, 2017; Stolzer, 2008), whereas case studies generate practical insights into safety audit implementation yet remain context-specific and lack generalizability (Sharma n.d.; Woo, 2015). Quantitative approaches employing techniques such as Data Envelopment Analysis (DEA) and ARIMA demonstrate the potential of predictive audit planning but depend on data infrastructures often unavailable in smaller aviation organizations (Bartulović, 2021; Reza et al., 2011). Systematic reviews synthesize best practices across regulatory frameworks; however, they provide limited evidence specific to ATOs (Al-Sadoon & Almohammad-Albakkar, 2024; Calderón Ramírez et al., 2023).

*Thematic Gaps Identified*

The literature synthesis reveals three major analytical and empirical gaps. First, safety auditing has shifted from compliance-oriented approaches toward predictive, data-driven methodologies, including SPI-based and risk-responsive audit planning; however, practical implementation remains inconsistent across organizations (Bartulović, 2021, Mitchell et al., 2012). Second, existing studies tend to emphasize either procedural compliance or organizational safety culture, with limited integration of systemic, cultural, and performance-based dimensions within a single audit framework (Al-Sadoon & Almohammad-Albakkar, 2024; Calderón Ramírez et al., 2023; Mendonca & Carney, 2017). These findings highlight the need for an integrated, context-sensitive audit framework that combine-Third, although predictive techniques such as ARIMA and other analytical models show considerable potential, their application remains limited in resource-constrained environments, particularly Approved Training Organizations (ATOs), and few studies evaluate audit effectiveness using measurable safety performance outcomess system-based, culture-based, and SPI-driven approaches within a PDCA-oriented Safety Management System. The present study addresses this gap by proposing a performance-based safety audit model specifically designed for ATOs.

**c. Conceptual Implementation of Safety Audit Programs and Frequency in ATOs (PPI Curug)**

Drawing on the synthesized literature (Annex 19 Safety Management, 2016; Permenhub No. 100 Tahun 2021, n.d.), and the operational characteristics of aviation training organizations, this study proposes an integrated Safety Audit Program Model for Approved Training Organizations (ATOs). As illustrated in Figure 1, the model conceptualizes safety audits as an adaptive safety assurance architecture that integrates three complementary domains—system-based, culture-based, and Safety Performance Indicator (SPI)-based audits, within the Plan–Do–Check–Act (PDCA) cycle. Through this integration, audit activities function as interconnected mechanisms that support compliance, organizational learning, risk-responsive decision-making, and continuous safety improvement.

*Integration of Audit Domains within the PDCA Cycle*

The proposed model integrates three complementary audit domains within the Plan–Do–Check–Act (PDCA) cycle. System-based audits primarily support the **Plan** and **Check** phases by evaluating SMS structures, procedures, and regulatory compliance. Culture-based audits are embedded in

the **Do** and **Check** phases to assess leadership, communication, behavioral practices, and the implementation of Just Culture principles. SPI-based audits reinforce the **Check** and **Act** phases by using Safety Performance Indicators to monitor performance, determine audit frequency and scope, and trigger corrective actions when predefined thresholds are exceeded. Together, these domains establish a closed-loop safety assurance process in which audit findings continuously inform management review, organizational learning, and system improvement.


Figure 1. Integrated Safety Audit Program Model for Approved Training Organizations

Figure 1 presents the proposed Safety Audit Program Model, integrating system-based, culture-based, and Safety Performance Indicator (SPI)-based audits within the Plan–Do–Check–Act (PDCA) cycle. The model establishes a continuous feedback mechanism linking regulatory compliance, organizational culture, and safety performance to support risk-responsive decision-making and continuous improvement. Through this integrated structure, audit findings inform management review, corrective actions, and dynamic adjustments of audit frequency according to operational risk and safety performance.

*Audit Frequency Design*

The literature indicates that audit frequency should be determined by organizational risk conditions rather than fixed schedules. In the proposed framework, audit intervals are adjusted according to five complementary determinants: operational risk, SMS maturity, historical audit outcomes, auditor competence, and Safety Performance Indicators (SPIs). Organizations with stable performance and mature safety systems may adopt longer audit intervals, whereas elevated operational risk, unresolved findings, or deteriorating SPI trends require more frequent or targeted audits. This performance-based approach aligns audit intensity with actual operational exposure, enabling proportional resource allocation while strengthening continuous safety assurance.

Table 4. Determinants Influencing Safety Audit Frequency

| No. | Determinant Category | Specific Factors | Data Source / Trigger | Observed Impact on Audit Frequency |
|---|---|---|---|---|
| 1 | Operational Risk | Flight volume, fleet type, instructor workload | Operational reports, hazard logs, training schedules | Higher operational risk correlates with increased audit frequency |
| 2 | Organizational Complexity | SMS maturity level, safety culture strength | SMS maturity assessment, safety culture survey results | More mature systems allow extended audit cycles |
| 3 | Prior Audit Outcomes | Corrective action closure rate, recurrence of findings | Audit reports, corrective action tracking system | Poor closure or repeated findings require intensified oversight |
| 4 | Auditor Competence | Risk-based auditing skills, analytical literacy | Auditor qualification records, recurrent training evaluations | Higher competence enhances audit accuracy and reduces oversight bias |
| 5 | SPI Utilization | Performance trends, threshold exceedance | SPI dashboards, safety performance monitoring systems | Enables predictive, targeted, and performance-based audit scheduling |

Table 4 summarizes the principal determinants influencing audit frequency. By linking operational risk, organizational maturity, prior audit outcomes, auditor competence, and Safety Performance Indicators (SPIs) to identifiable data sources, the framework supports transparent, evidence-based, and risk-responsive audit planning.

*Audit Implementation*

The proposed audit process follows the Plan–Do–Check–Act (PDCA) cycle: **Plan**, define objectives and risk priorities; **Do**, conduct system and behavioral audits; **Check**, evaluate findings against SPI trends and risk criteria; and **Act**, implement corrective actions and adjust future audit frequency based on updated safety performance.

*Practical Implications*

Effective implementation requires continuous SPI monitoring, risk-based auditor competency development, integration of audit results into management review, and cross-functional organizational learning. Collectively, these elements position safety audits as proactive safety assurance mechanisms that support continuous improvement within Approved Training Organizations (ATOs).

**d. Discussion and Implications**

The findings demonstrate that contemporary safety auditing has evolved from a compliance-oriented activity into an integrated, adaptive, and performance-based safety assurance mechanism. By combining system-based, culture-based, and Safety Performance Indicator (SPI)-based audits within the Safety Management System (SMS), the proposed framework strengthens organizational learning, supports proactive risk management, and aligns with ICAO's emphasis on continuous improvement and organizational resilience.

Embedding the audit process within the Plan–Do–Check–Act (PDCA) cycle transforms audits from periodic inspections into continuous feedback mechanisms that inform management review, corrective actions, and policy refinement. For Approved Training Organizations (ATOs), this integrated approach extends safety assurance beyond regulatory compliance to encompass instructional processes, organizational culture, and performance monitoring.

The integration of Just Culture principles reinforces the human dimension of safety by encouraging transparent reporting, accountability, and organizational learning rather than punitive responses to operational errors (Kaspers et al., 2019; Marx, 2019a). At the same time, the combined use of qualitative cultural assessment and quantitative SPI monitoring provides a comprehensive basis for evidence-based decision-making, enabling organizations to detect emerging safety risks and implement timely interventions.

From a practical perspective, the proposed model supports risk-responsive audit planning by adjusting audit frequency and scope according to operational risk, SMS maturity, audit history, and SPI performance. This adaptive approach improves resource allocation, reduces audit fatigue, and enhances institutional resilience while maintaining effective safety oversight.

Overall, the proposed framework offers a transferable model for aviation training organizations seeking to strengthen safety governance through integrated, data-informed, and continuously improving audit practices.

## CONCLUSION

This study set out to examine the conceptual and empirical development of safety audit programs and their associated frequencies over the past fourteen years, with the objective of formulating a contextual audit model applicable to Approved Training Organizations (ATOs). Through a systematic synthesis of regulatory frameworks, theoretical perspectives, and peer-reviewed empirical literature, the research demonstrates how safety auditing has progressively evolved from periodic, compliance-oriented activities toward integrated, risk-based, and performance-driven safety assurance mechanisms.

The analysis identified five dominant themes underlying this evolution:

1. a conceptual shift from compliance verification toward continuous improvement;
2. the emergence of adaptive and data-informed audit methodologies;
3. Increasing recognition of the relationship between audit frequency and system effectiveness;
4. the integration of audits within the broader Safety Management System (SMS) cycle; and
5. persistent implementation challenges, including limitations in auditor competence, organizational resistance, and constrained resources.

Together, these themes illustrate both the maturation of safety auditing concepts and the practical constraints that continue to shape their application in aviation training environments.

At the same time, the findings highlight important limitations inherent in the existing body of knowledge. As this study is grounded in secondary data derived from published literature, the proposed audit framework has not yet been empirically validated through direct application or longitudinal field studies. Rather than representing a weakness, this limitation underscores a critical opportunity for further inquiry. The absence of consensus on optimal audit frequency, the limited availability of integrative models that combine system-based, culture-based, and performance-based audits, and the underutilization of predictive analytics in smaller or educational aviation organizations collectively signal a clear agenda for future research.

Accordingly, this study is intended to serve as a call to action for the aviation safety research community. It invites empirical testing, contextual adaptation, and longitudinal validation of performance-based and SPI-triggered audit models across diverse ATO settings. By positioning the proposed framework as a theoretically grounded yet practically testable construct, the study contributes a foundational reference point for advancing evidence-based safety governance and supports the continued evolution of safety auditing as a learning-oriented and adaptive organizational capability within global aviation training systems.

To address these gaps, the study developed a context-sensitive audit model for Approved Training Organizations (ATOs) that integrates system-based, culture-based, and Safety Performance Indicator (SPI)-based audits within a Plan–Do–Check–Act (PDCA) continuous improvement framework. This model reconceptualizes safety audits as feedback-driven assurance mechanisms rather than isolated control activities, thereby positioning safety assurance as a living and adaptive organizational process. The incorporation of SPIs provides a quantitative and performance-based foundation for triggering audit frequency and scope, while culture-based evaluations enable the early identification of behavioral and attitudinal risks that may undermine safety performance. Together, these dimensions form an integrative mechanism that addresses the long-standing lack of consensus on audit frequency while responding to the absence of holistic audit models in existing literature.

From a theoretical perspective, this research advances the discourse on safety management and performance-based oversight by proposing a unified framework that systematically links operational data, human factors, and governance principles within the context of aviation vocational education. Practically, the model offers aviation training institutions a structured yet flexible approach to designing risk-responsive audit programs that are sensitive to instructional environments and learning-oriented operational settings. By embedding audit activities within the SMS assurance cycle, organizations are better equipped to translate risk assessments into measurable improvements and to ensure that continuous feedback loops refine both policy formulation and operational practice. In this way, the proposed model contributes not only to regulatory compliance but also to the sustained development of resilient and learning-centered safety systems within aviation training institutions.

Nevertheless, this study acknowledges several limitations. First, the analysis relied primarily on secondary data derived from existing literature; empirical validation through field implementation in Approved Training Organizations (ATOs) remains an important area for future investigation. Second, although the model incorporates SPI-based monitoring, its predictive effectiveness is contingent upon data quality, analytical capability, and institutional readiness, which may vary across organizations. Third, while cultural factors are conceptually integrated, their practical operationalization requires further development through standardized assessment instruments and longitudinal observation to capture behavioral change over time.

Despite these limitations, the study makes a substantive contribution to the advancement of aviation safety governance by offering an integrative perspective on safety auditing. It demonstrates that effective safety assurance cannot be achieved through compliance mechanisms alone, but must emerge from the interaction of organizational structure, human behavior, and performance intelligence. In this respect, the proposed model is intentionally constructed around a tripartite synergy: the **system-based audit** provides the structural foundation that ensures regulatory alignment and procedural integrity; the **culture-based audit** represents the human and ethical dimension that sustains just culture, learning, and accountability; and the **SPI-based audit** functions as the analytical core that translates safety data into timely, performance-driven oversight.

Together, these three dimensions form a coherent and adaptive safety assurance architecture in which audits operate not as isolated evaluative events, but as interconnected components of a living system. This integration enables aviation training organizations to balance compliance with learning, stability with

adaptability, and control with trust. By harmonizing the "skeleton" of regulatory structure, the "soul" of organizational culture, and the "brain" of data-informed performance monitoring, the model provides a replicable foundation for advancing safety auditing from a procedural obligation into a strategic organizational capability.

In conclusion, this research bridges theory and practice by reframing safety audits as adaptive learning systems; evidence-based, culturally aligned, and performance-responsive, capable of sustaining safety performance and institutional excellence within the increasingly complex landscape of modern aviation.

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