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A Hybrid Framework for Airport Safety Oversight: Integrating FAA Part 139 and ICAO SMS

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Abstract

Airport safety oversight in the United States has traditionally relied on the prescriptive compliance structure of FAA Part 139, while the ICAO Safety Management System (SMS) emphasizes proactive, performance-based safety management. Although these approaches are often discussed separately, they address complementary dimensions of airport safety. This study develops a conceptual crosswalk that aligns selected FAA Part 139 requirements with the four ICAO SMS pillars: safety policy, safety risk management, safety assurance, and safety promotion. Using publicly available regulatory documents, guidance materials, and oversight reports, the paper compares the strengths and limitations of each framework and identifies areas where prescriptive compliance and SMS-based practices can reinforce one another. The analysis shows that Part 139 provides strong baseline control for high-consequence operational areas, including Aircraft Rescue and Firefighting, pavement condition, lighting, and wildlife hazard management, while SMS adds value through structured hazard identification, continuous monitoring, organizational learning, and safety culture. Based on this comparison, the paper proposes a hybrid oversight framework that preserves mandatory inspection requirements while incorporating SMS-driven processes for adaptive risk management. The framework is intended to support regulatory alignment, reduce gaps between checklist-based and performance-based oversight, and provide a practical basis for future empirical evaluation.

Keywords

Airport Safety Oversight, FAA Part 139, ICAO Safety Management System, Prescriptive Oversight, Performance-Based Oversight, International Regulatory Harmonization, Hazard Identification and Risk Management, Aircraft Rescue and Firefighting (ARFF), Hybrid Oversight Framework

1. Introduction

Airport safety oversight is fundamental to the reliability and resilience of the aviation system [1]. In the United States, the Federal Aviation Administration (FAA) regulates certificated airports under Part 139, which establishes standardized requirements for airfield conditions, lighting, signage, Aircraft Rescue and Firefighting (ARFF) readiness, and wildlife hazard management [2]. Historically, Part 139 oversight has relied primarily on prescriptive compliance through inspections and regulatory standards. More recently, however, the FAA has expanded its oversight framework by requiring Safety Management Systems (SMS) for certain Part 139-certificated airports, reflecting a broader shift toward integrating performance-based safety management with traditional compliance activities [3]. ICAO's Safety Management System (SMS) similarly emphasizes proactive hazard identification, structured risk management, safety assurance, and the promotion of safety culture, providing a complementary perspective on airport safety oversight [4] [5]. Although both approaches are increasingly recognized as complementary components of modern airport safety oversight, relatively few studies have systematically compared their regulatory structures or examined how prescriptive compliance and performance-based safety management can be integrated within a unified oversight framework [6] [7].

Research Objective

This study addresses this gap by i) developing a structured crosswalk that maps FAA Part 139 requirements to the four pillars of the ICAO Safety Management System (SMS), ii) comparing the regulatory scope, strengths, and limitations of the two oversight approaches to identify areas of overlap and divergence, and iii) proposing a hybrid airport safety oversight framework that integrates prescriptive compliance with performance-based safety management. The overall objective is to provide a conceptual foundation for aligning U.S. airport safety oversight with internationally recognized safety management principles while identifying opportunities for future implementation and evaluation.

2. Literature Review

Airport safety oversight has consistently been regarded as a central pillar of aviation safety, and its development has been shaped by evolving regulatory philosophies across jurisdictions. Within the United States, the Federal Aviation Administration (FAA) administers airport certification under Part 139 through standardized operational requirements and inspections covering critical safety elements [2]. While this framework has traditionally emphasized prescriptive compliance, recent regulatory developments have expanded its scope to incorporate Safety Management System (SMS) requirements for certain certificated airports [3]. Together, these approaches establish a strong safety baseline while supporting more proactive management of operational risks. Previous studies nevertheless suggest that prescriptive oversight alone may be less effective in addressing emerging risks

that are not explicitly reflected in regulatory requirements [8].

ICAO's Safety Management System (SMS), introduced under Annex 19, provides a complementary performance-driven approach centered on hazard anticipation, structured risk assessment, continuous assurance, and safety culture development [4] [5]. By embedding safety management into everyday operations, SMS enhances adaptability and facilitates early identification of systemic risks. Comparative analyses have shown that SMS frameworks promote organizational learning and more effective risk mitigation than compliance-only models [6] [9].

Empirical studies have shown that effective implementation of Safety Management Systems (SMS) strengthens hazard identification, safety assurance, organizational learning, and continuous safety improvement across aviation organizations [10]. Additional research conducted in Europe and Asia has further demonstrated that higher levels of SMS maturity are associated with stronger safety culture and improved safety performance [11]. Nonetheless, most of these investigations examine SMS implementation independently or focus on specific regulatory systems without systematically comparing how FAA Part 139 and ICAO SMS complement one another within an integrated airport safety oversight framework. **Figure 1** illustrates the trend in FAA enforcement and compliance actions, highlighting the evolution of FAA oversight practices over time.

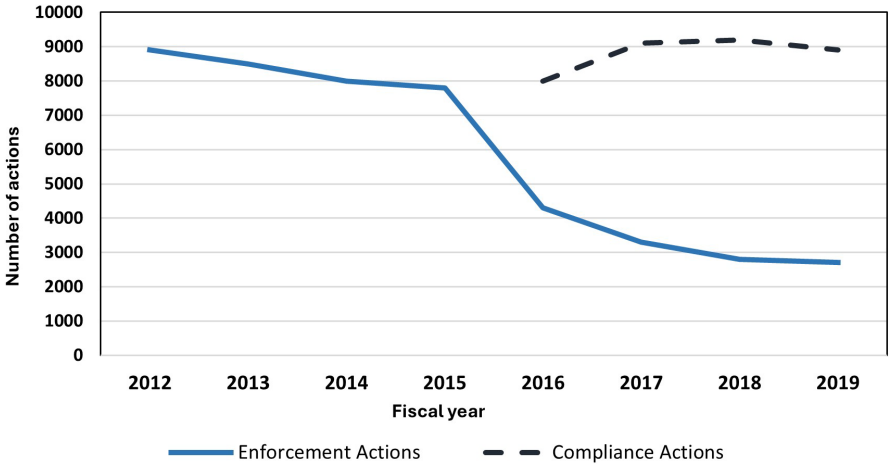

Figure 1. Enforcement and compliance actions closed by selected FAA program offices (FY 2012-2019), illustrating the evolution of FAA oversight practices. Adapted from GAO-20-642 [12].

Policy evaluations have also emphasized the growing role of Safety Management Systems (SMS) within national airport oversight. Recent FAA initiatives requiring SMS implementation for certain Part 139-certificated airports demonstrate an ongoing effort to integrate prescriptive compliance with performance-based safety management [3] [13]. At the same time, government reports from the U.S. Government Accountability Office (GAO) and the Department of Transportation Office of Inspector General (DOT OIG) continue to identify challenges

related to oversight consistency, performance measurement, and implementation practices [7] [12] [14]. These observations underscore the need for a structured comparison of the two approaches and provide the foundation for the conceptual framework developed in this study. Table 1 presents a comparison of the FAA Part 139 oversight framework and the ICAO Safety Management System (SMS), highlighting their key similarities and differences.

Table 1. Key regulatory, guidance, audit, and policy sources related to FAA Part 139 and ICAO Safety Management System (SMS), highlighting their scope, primary focus, and contribution to the development of a hybrid airport safety oversight framework.

Source	Year	Scope	Measures	Relationship to Part 139 and SMS	Key Observation	Reference
FAA Final Rule: Airport SMS (14 CFR Part 139)	2023	U.S. Airports (Subset)	Mandates SMS, phased implementation	Not Yet	Pre-2023 evidence mostly voluntary, no integrated outcomes dataset	[3]
FAA SMS Site & AC150/5200-37A	2023-2025	Guidance for Airports	Implementation guidance, FAQs, desk reference	No	Guidance focus, not outcomes evaluation	[3] [13]
GAO-12-898	2012	FAA Enterprise	Recommends tracking SMS implementation and outcomes	No	FAA lacked systems to evaluate SMS effectiveness across units	[7]
GAO-14-516	2014	FAA Oversight Planning	Calls for a plan to oversee industry SMS	No	Uneven, non-generalizable data, need for guidance and training	[15]
GAO-20-642	2020	FAA Programs	Notes need for better SMS performance metrics	No	Shift to risk-based oversight complicates outcome measurement	[12]
DOT OIG ARFF Oversight Report	2016	Part 139 ARFF	Finds inconsistency in inspections and training oversight	No	Prescriptive stream had data quality issues, blocking linkage to SMS	[14]
ICAO Annex 19 and USOAP	2013	States Worldwide	SSP and SMS requirements, state EI indicators	No (Different Level)	State-level indicators do not match FAA airport-level findings	[4]

Recent studies have increasingly recognized the value of integrating prescriptive and performance-based oversight rather than treating them as competing approaches. Combining regulatory compliance with proactive safety management has the potential to improve organizational learning, strengthen oversight effectiveness, and support more consistent airport safety oversight activities [16] [17]. Hybrid approaches retain the structured compliance requirements necessary for

high-consequence operational areas while incorporating risk-based processes that support continuous improvement and adaptive decision-making [15] [17].

In summary, FAA Part 139 and ICAO SMS each contribute important but distinct strengths to airport safety oversight. While previous research has examined these frameworks independently, fewer studies have systematically compared their regulatory roles or explored how they can be integrated within a unified oversight framework. Addressing this gap provides the foundation for the conceptual crosswalk and hybrid framework proposed in this study.

3. Materials and Methods

This study adopts a comparative qualitative research design to examine the relationship between the prescriptive oversight framework established under FAA Part 139 and the performance-based approach promoted through the ICAO Safety Management System (SMS). Rather than evaluating airport-level performance statistically, the study develops a structured regulatory comparison based on publicly available regulatory documents, guidance materials, oversight reports, and operational references. The methodological framework consists of three stages: source selection, crosswalk development, and comparative analysis.

3.1. Dataset Selection

The comparative analysis draws upon publicly available regulatory documents, guidance materials, government oversight reports, and operational references to examine the relationship between the FAA Part 139 airport certification framework and the ICAO Safety Management System (SMS). Rather than constructing an airport-level statistical dataset, these sources were used to compare the regulatory scope, oversight philosophy, and practical application of the two frameworks. The primary sources include:

1) FAA Part 139 regulations and associated guidance, which establish airport certification requirements, inspection procedures, operational standards, and Safety Management System (SMS) implementation guidance for certificated airports [2] [3] [13].

2) ICAO Annex 19, the Safety Management Manual (Doc 9859), and the Universal Safety Oversight Audit Programme (USOAP), which define internationally recognized principles for safety management, safety oversight, and continuous improvement [4] [5].

3) Government oversight reports, including publications issued by the U.S. Government Accountability Office (GAO) and the Department of Transportation Office of Inspector General (DOT OIG), which provide independent evaluations of airport safety oversight practices, implementation challenges, and regulatory performance [14].

To provide additional operational and regulatory context, publicly available FAA Safety Management System (SMS) regulations and guidance, Bureau of Transportation Statistics (BTS) operational information, NOAA weather datasets, and

ICAO oversight guidance were also reviewed [18]-[23]. These sources were used to illustrate the operational environment in which airport safety oversight is implemented and to support the comparative discussion throughout the paper. They were not used to develop or validate airport-level statistical models, nor were they intended to establish causal relationships between regulatory approaches and safety performance.

3.2. Crosswalk Development

A structured crosswalk was developed to compare the prescriptive requirements of FAA Part 139 with the four pillars of the ICAO Safety Management System (SMS): Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion. The crosswalk was constructed by reviewing regulatory requirements, guidance documents, and oversight practices to identify areas of regulatory alignment, complementary functions, and differences in oversight philosophy.

Key operational domains addressed under Part 139, including Aircraft Rescue and Firefighting (ARFF), pavement condition, airfield lighting, emergency planning, training, and wildlife hazard management, were systematically mapped to the corresponding SMS pillars based on their primary safety objectives and operational functions [2] [5]. The mapping focused on identifying where the two frameworks address similar safety goals through different regulatory approaches and where one framework provides broader coverage than the other.

The conceptual consistency of the crosswalk was verified using the ICAO Safety Management Manual (Doc 9859) and the FAA Airport Safety Management System guidance to ensure that the comparisons reflected the intent of both regulatory frameworks rather than direct regulatory equivalence [5] [13]. The resulting crosswalk provides the foundation for comparative analysis and the proposed hybrid airport safety oversight framework presented in this study.

3.3. Analytical Procedures

The comparative analysis was conducted to identify areas of convergence and divergence between the FAA Part 139 oversight framework and the ICAO Safety Management System (SMS). The analysis focused on comparing the scope, objectives, and implementation characteristics of each framework rather than evaluating their effectiveness through statistical testing.

The comparison consisted of four complementary components:

1) Regulatory comparison: FAA Part 139 operational requirements were compared with the corresponding ICAO SMS pillars to identify similarities, complementary functions, and differences in regulatory emphasis.

2) Crosswalk assessment: The crosswalk developed in **Table 2** was used to evaluate the extent to which individual Part 139 operational domains align with the four SMS pillars and to identify areas where one framework provides broader coverage than the other.

3) Comparative evaluation: The strengths and limitations of both oversight ap-

proaches were examined using published regulatory guidance, government oversight reports, and existing literature. Particular attention was given to compliance assurance, hazard identification, organizational safety culture, continuous improvement, and risk management practices.

4) Framework development: Findings from the comparative analysis were synthesized to develop a hybrid airport safety oversight framework that combines the structured compliance requirements of FAA Part 139 with the proactive safety management principles of ICAO SMS.

Table 2. Conceptual crosswalk between FAA Part 139 operational domains and the four pillars of the ICAO Safety Management System (SMS), illustrating areas of regulatory alignment, complementary functions, and opportunities for integration within a hybrid airport safety oversight framework.

Part 139 Checklist Element	ICAO SMS Pillar Alignment	Overlap/Strengths	Unique to Part 139	Unique to ICAO SMS	Identified Gaps
ARFF readiness (staffing, training, equipment)	Safety Policy/Safety Assurance	Strong compliance oversight ensures readiness	Mandatory staffing and equipment levels	Promotion of safety culture and continuous competency training	Limited focus on safety promotion beyond compliance
Wildlife hazard management	Risk Management/ Safety Assurance	Structured inspection and corrective action	Detailed programmatic requirements	Hazard identification and predictive assessment	Limited predictive analytics and reliance on observed deficiencies
Training requirements (operations, maintenance, ARFF)	Safety Promotion	Ensures baseline training compliance	Prescribed minimum training	Emphasis on safety culture and proactive promotion	Absence of focus on safety culture or behavioral change
Emergency planning (drills, coordination)	Safety Policy/Risk Management	Coordination and readiness checks	Mandatory full-scale drills	Integration into SMS hazard-identification cycles	Reactive orientation, not predictive hazard assessment

3.4. Ethical Considerations

This study is based exclusively on publicly available regulatory documents, guidance materials, government reports, and operational references. No proprietary, confidential, or personally identifiable information was collected or analyzed. Because the study presents a conceptual comparison of existing regulatory frameworks, it did not involve human participants, human subjects research, or the use of restricted datasets. The research was conducted in accordance with accepted academic standards for the use and citation of publicly available information. Figure 2 presents the overall research methodology adopted in this study, including source selection, crosswalk development, comparative analysis, and framework development.

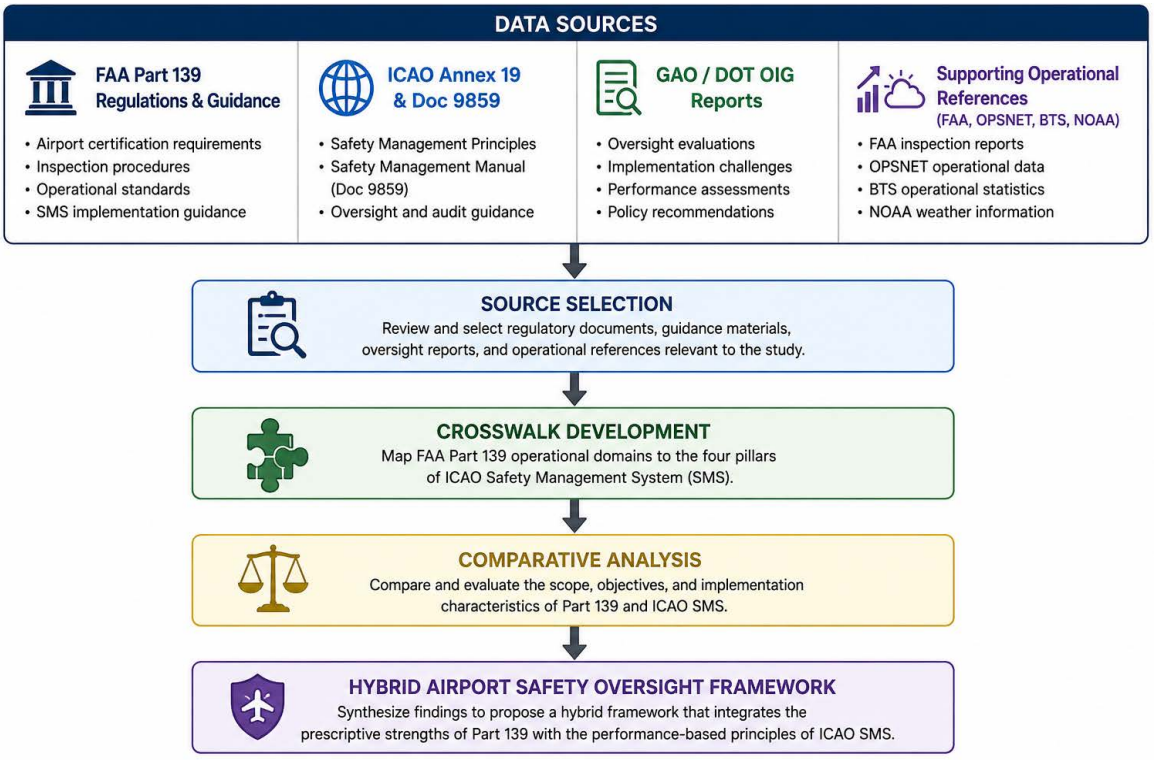

Figure 2. Overview of the study methodology showing the sequential process of source selection, crosswalk development, comparative analysis, and development of the proposed hybrid airport safety oversight framework.

4. Results

4.1. Comparative Findings

The comparative review of FAA Part 139 and the ICAO Safety Management System (SMS) indicates that the two frameworks address airport safety through complementary regulatory approaches. FAA Part 139 establishes prescriptive operational requirements supported by standardized inspections, providing a consistent baseline for compliance in critical safety areas such as Aircraft Rescue and Firefighting (ARFF), pavement condition, airfield lighting, emergency planning, and wildlife hazard management [2]. These requirements promote uniform implementation and regulatory consistency across certificated airports.

In contrast, the ICAO SMS framework emphasizes continuous safety management through proactive hazard identification, safety risk management, safety assurance, and safety promotion [4] [5]. Rather than replacing prescriptive oversight, SMS expands the scope of safety management by encouraging continuous monitoring, organizational learning, and the integration of safety into everyday operational decision-making.

The comparison suggests that the strengths of one framework complement the limitations of the other. While FAA Part 139 provides clear regulatory requirements and standardized compliance mechanisms, ICAO SMS offers greater flexibility for managing emerging operational risks and strengthening organizational safety culture. These observations provide the foundation for the conceptual cross-

walk and the hybrid airport safety oversight framework presented in the following sections.

4.2. Crosswalk Analysis: FAA Part 139 and ICAO SMS

The crosswalk presented in Table 2 compares the principal operational domains of FAA Part 139 with the four pillars of the ICAO Safety Management System (SMS). The comparison demonstrates that both frameworks share the common objective of improving airport safety, although they achieve this objective through different regulatory approaches.

Strong alignment is observed in areas related to Safety Assurance and Safety Policy, where FAA Part 139 establishes detailed operational requirements for inspections, documentation, emergency preparedness, and Aircraft Rescue and Firefighting (ARFF) readiness. These requirements provide a structured compliance framework that promotes consistency across certificated airports.

The comparison also identifies complementary areas where ICAO SMS extends beyond prescriptive compliance. In particular, Safety Risk Management and Safety Promotion emphasize proactive hazard identification, continuous monitoring, organizational learning, and the development of a positive safety culture. These elements strengthen an organization's ability to identify emerging risks before they result in operational deficiencies.

FAA Part 139 Operational Domains	ICAO Safety Management System (SMS) Pillars			
	Safety Policy	Safety Risk Management	Safety Assurance	Safety Promotion
ARFF readiness	STRONG	PARTIAL	STRONG	LIMITED ALIGNMENT
Wildlife hazard management	PARTIAL	STRONG	STRONG	LIMITED ALIGNMENT
Training requirements	PARTIAL	PARTIAL	PARTIAL	STRONG
Emergency planning	STRONG	STRONG	PARTIAL	LIMITED ALIGNMENT

Figure 3. Conceptual crosswalk illustrating the relationship between major FAA Part 139 operational domains and the four pillars of the ICAO Safety Management System (SMS). Green indicates strong alignment, yellow indicates partial alignment, and red indicates areas where additional integration opportunities exist within the proposed hybrid airport safety oversight framework.

Overall, the crosswalk demonstrates that the two frameworks are complementary rather than competing. FAA Part 139 provides the regulatory foundation for operational compliance, while ICAO SMS introduces management processes that enhance adaptability, continuous improvement, and long-term safety performance.

These findings support the development of the hybrid airport safety oversight framework proposed in this study. **Figure 3** presents the conceptual crosswalk between FAA Part 139 operational domains and the four pillars of the ICAO Safety Management System (SMS).

4.3. Comparative Evaluation of the Oversight Frameworks

The comparative evaluation of FAA Part 139 and the ICAO Safety Management System (SMS) highlights the complementary strengths of the two oversight approaches. FAA Part 139 provides a structured regulatory framework built on standardized operational requirements and inspections, ensuring consistent compliance in critical safety areas such as runway pavement condition, airfield lighting, wildlife hazard management, emergency planning, and Aircraft Rescue and Firefighting (ARFF) readiness [2]. This prescriptive approach establishes a uniform baseline for airport safety oversight.

In contrast, ICAO SMS focuses on the organizational processes that support long-term safety performance. Through safety risk management, safety assurance, safety promotion, and continuous monitoring, SMS encourages airport operators to identify hazards proactively, strengthen organizational learning, and continuously improve safety performance [4] [5].

The crosswalk demonstrates that these approaches are not mutually exclusive. Instead, they address different aspects of airport safety oversight. While Part 139 establishes clear regulatory expectations and compliance mechanisms, SMS provides a structured management framework for addressing evolving operational risks and strengthening safety culture. Together, these complementary characteristics support the development of a hybrid airport safety oversight framework that combines regulatory consistency with proactive safety management.

4.4. Implications of the Comparative Analysis

The comparative analysis indicates that neither FAA Part 139 nor the ICAO Safety Management System (SMS) fully addresses all aspects of airport safety oversight. The proposed hybrid framework is intended to provide a more comprehensive approach to airport safety oversight by integrating the complementary strengths of both approaches. FAA Part 139 provides a well-defined regulatory structure that supports consistent implementation, standardized inspections, and accountability across certificated airports. In contrast, ICAO SMS emphasizes organizational learning, proactive hazard identification, continuous safety assurance, and the development of a positive safety culture.

These observations support the need for an oversight approach that integrates the regulatory consistency of Part 139 with the adaptive management principles of SMS. Such an approach can strengthen the ability of airport operators and regulators to address both established operational requirements and emerging safety challenges while maintaining alignment with national and international safety objectives.

The findings presented in this study are based on a comparative review of regulatory frameworks and published guidance rather than statistical validation. Consequently, the proposed hybrid framework should be viewed as a conceptual model that provides a foundation for future empirical evaluation and practical implementation within airport safety oversight programs.

4.5. Summary of Comparative Findings

The comparative analysis demonstrates that FAA Part 139 and the ICAO Safety Management System (SMS) provide complementary approaches to airport safety oversight. FAA Part 139 establishes a consistent regulatory foundation through standardized operational requirements and compliance-based inspections, particularly in high-consequence areas such as Aircraft Rescue and Firefighting (ARFF), pavement condition, airfield lighting, and emergency preparedness [2]. In contrast, ICAO SMS broadens the scope of safety oversight by emphasizing proactive hazard identification, continuous safety assurance, organizational learning, and the promotion of a positive safety culture [4] [5].

The crosswalk analysis indicates that integrating these complementary strengths can support a more balanced and adaptive oversight approach. Based on these findings, this study proposes a hybrid airport safety oversight framework that combines the structured compliance mechanisms of FAA Part 139 with the proactive management principles of ICAO SMS. The proposed framework provides a practical foundation for strengthening airport safety oversight while supporting future implementation and evaluation.

5. Discussion

This study examined the relationship between the prescriptive oversight framework established under FAA Part 139 and the performance-based approach promoted through the ICAO Safety Management System (SMS). The comparative findings reveal that the two frameworks serve complementary roles in airport safety oversight rather than representing competing regulatory philosophies. FAA Part 139 provides a consistent regulatory foundation through standardized operational requirements and inspections, particularly in high-consequence operational areas. These observations are consistent with previous studies showing that prescriptive oversight effectively establishes baseline safety standards across certificated airports, particularly among airports with varying operational characteristics and resources [8].

At the same time, the crosswalk analysis highlights that Part 139 provides more limited coverage of proactive safety management processes and safety promotion. In contrast, ICAO SMS explicitly emphasizes hazard identification, structured safety risk management, continuous safety assurance, and organizational learning, all of which strengthen an organization's ability to anticipate emerging risks and continuously improve safety performance [5] [6]. These differences illustrate how performance-based safety management complements, rather than replaces, tradi-

tional compliance-based oversight.

Comparative findings suggest that integrating the strengths of both approaches can provide a more balanced airport safety oversight framework. Prescriptive inspections establish clear regulatory expectations and accountability, while performance-based safety management introduces adaptive processes that strengthen organizational resilience and continuous improvement. Building on these findings, the proposed hybrid framework illustrates how these complementary approaches can operate together to enhance airport safety oversight while maintaining consistency with existing regulatory requirements.

The policy implications of these findings are significant. Continued integration of Safety Management System principles within the FAA Part 139 oversight framework provides an opportunity to strengthen alignment between U.S. airport regulations and internationally recognized safety management practices. Embedding proactive risk management, organizational learning, and continuous safety improvement within existing oversight activities would further support the evolution of airport safety governance while preserving the regulatory consistency established through Part 139 inspections.

From a broader policy perspective, harmonizing prescriptive and performance-based oversight supports both operational and strategic objectives. It promotes more comprehensive airport safety oversight, strengthens alignment with international safety management practices, and provides a practical framework for integrating regulatory compliance with continuous safety improvement [16]. Beyond aviation, this approach contributes to infrastructure resilience, operational reliability, and public confidence in the safety of the air transportation system.

This study has several limitations. The proposed hybrid oversight framework is based on a comparative review of publicly available regulatory documents, guidance materials, government oversight reports, and supporting literature rather than airport-level implementation data. Accordingly, the framework should be viewed as a conceptual model intended to support future empirical research and practical application. Future studies may evaluate the proposed framework using airport case studies, implementation assessments, or longitudinal operational data to examine its effectiveness across different airport operating environments.

6. Proposed Framework

The comparative analysis indicates that neither the prescriptive oversight framework established under FAA Part 139 nor the performance-based approach promoted through the ICAO Safety Management System (SMS) independently addresses the full range of safety challenges encountered in modern airport operations. Instead, each framework contributes distinct strengths that can enhance airport safety when applied in a complementary manner. Based on the regulatory comparison and crosswalk analysis presented in this study, a hybrid airport safety oversight framework is proposed that integrates the structured compliance requirements of Part 139 with the proactive safety management principles of ICAO SMS.

6.1. Core Principles of the Hybrid Framework

1) Prescriptive Baseline Controls

High-consequence operational areas, including Aircraft Rescue and Firefighting (ARFF) readiness, pavement condition, airfield lighting, emergency planning, and wildlife hazard management, should continue to be governed by the prescriptive requirements established under FAA Part 139 [2]. These requirements provide a consistent regulatory foundation and ensure that minimum safety standards are maintained across certificated airports.

2) Performance-Based Safety Management

Complementing these regulatory requirements, ICAO SMS principles should be incorporated to strengthen hazard identification, safety risk management, continuous safety assurance, and safety promotion [5]. These processes enable airport operators to address emerging operational risks proactively while supporting continuous organizational learning and improvement.

3) Integrated Safety Oversight: Some Operational Domains Require Both Approaches

A hybrid oversight approach combines prescriptive compliance activities with performance-based safety management to support a more comprehensive oversight system. Regulatory inspections verify compliance with established requirements, while SMS processes provide continuous monitoring, internal evaluation, and proactive management of safety risks.

4) Continuous Safety Improvement

The integration of compliance-based oversight and performance-based management encourages continuous evaluation of airport safety performance. Safety reporting, organizational learning, leadership engagement, and periodic review of safety practices contribute to the ongoing improvement of airport safety oversight while maintaining regulatory consistency.

6.2. Framework Structure

The proposed hybrid airport safety oversight framework is organized as a two-layer structure that combines regulatory compliance with continuous safety management. Each layer performs a distinct function while supporting the overall objective of strengthening airport safety oversight.

The first layer consists of the prescriptive oversight activities established under FAA Part 139, including airport inspections, operational requirements, documentation, and compliance verification. These activities provide a consistent regulatory baseline for certificated airports and ensure adherence to established safety standards.

The second layer incorporates the principles of the ICAO Safety Management System (SMS), including safety risk management, safety assurance, safety promotion, and continuous monitoring. These processes complement regulatory oversight by encouraging proactive hazard identification, organizational learning, and continuous improvement.

Together, the two layers create an integrated oversight approach in which compliance verification and performance-based safety management reinforce one another. The resulting framework supports regulatory consistency while providing the flexibility needed to address evolving operational risks and strengthen long-term airport safety performance. Figure 4 illustrates the proposed hybrid airport safety oversight framework developed from the comparative analysis.

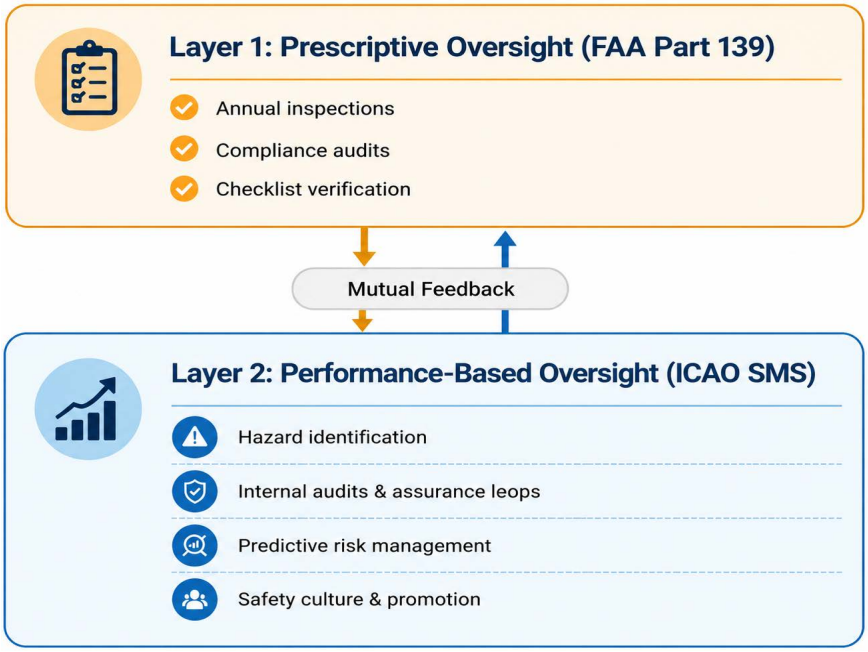

Figure 4. Proposed hybrid airport safety oversight framework integrating prescriptive FAA Part 139 oversight with performance-based ICAO Safety Management System (SMS) processes.

6.3. Decision Matrix for Application

The decision matrix presented in Table 3 illustrates how different airport safety domains may benefit from different oversight approaches based on their operational characteristics. Rather than relying exclusively on either prescriptive compliance or performance-based safety management, the matrix demonstrates where each approach provides the greatest value and where a hybrid strategy offers the most balanced solution.

High-consequence operational areas that require standardized procedures and regulatory consistency are best managed through prescriptive oversight. In contrast, organizational and human-factor-related issues benefit from performance-based safety management, which emphasizes continuous monitoring, hazard identification, and organizational learning. Certain operational domains benefit from integrating both approaches, where regulatory compliance establishes minimum safety standards while SMS processes enhance proactive risk management and continuous improvement.

The decision matrix serves as a practical reference for regulators and airport

operators when selecting the most appropriate oversight strategy for different airport safety functions. It also demonstrates how the proposed hybrid framework can be applied across a range of operational environments while maintaining consistency with both FAA Part 139 requirements and ICAO SMS principles.

Table 3. Decision matrix for selecting the appropriate oversight approach for major airport safety domains within the proposed hybrid airport safety oversight framework.

Airport Safety Domain	Recommended Oversight Approach	Rationale
Runway pavement condition	Prescriptive	Requires compliance with established engineering and operational standards through routine inspections.
Aircraft rescue and firefighting (ARFF)	Prescriptive	High-consequence operational function requiring mandatory staffing, equipment, training, and regulatory compliance.
Airfield lighting and signage	Prescriptive	Standardized technical requirements support consistent operational safety.
Wildlife hazard management	Hybrid	Combines regulatory inspection requirements with proactive monitoring, hazard assessment, and continuous risk management.
Emergency planning and response	Hybrid	Regulatory compliance is strengthened through continuous evaluation, training, and safety management processes.
Safety reporting systems	Performance-based	Relies on proactive reporting, organizational learning, and continuous improvement rather than inspection alone.
Safety culture and promotion	Performance-based	Focuses on leadership commitment, communication, employee engagement, continuous safety awareness, and proactive management of human factors [21].
Fatigue risk management	Performance-based	Requires continuous monitoring, organizational policies, and proactive risk management rather than prescriptive inspection.

6.4. Policy Implications

The proposed hybrid airport safety oversight framework offers practical implications for both regulators and airport operators. By integrating the structured compliance requirements of FAA Part 139 with the proactive management principles of the ICAO Safety Management System (SMS), the framework supports a more comprehensive approach to airport safety oversight while maintaining consistency with existing regulatory requirements [24].

For regulators, the framework provides a structured basis for incorporating performance-based safety management into established oversight activities without replacing the prescriptive controls that remain essential for high-consequence operational areas. For airport operators, it encourages greater integration of hazard identification, safety assurance, organizational learning, and continuous improvement within daily operations [9].

More broadly, the proposed framework supports continued alignment between U.S. airport safety oversight and internationally recognized safety management practices. By promoting both regulatory consistency and proactive safety manage-

ment, the framework contributes to stronger organizational resilience, improved safety governance, and a more adaptive approach to managing evolving operational risks. It also provides a practical foundation for future implementation, evaluation, and refinement as airport safety oversight continues to evolve.

7. Conclusions

This study presented a comparative assessment of the FAA Part 139 airport certification framework and the ICAO Safety Management System (SMS) to examine how prescriptive and performance-based approaches can complement one another in airport safety oversight. Comparative analysis demonstrates that Part 139 provides a consistent regulatory foundation through standardized operational requirements and compliance-based inspections, while ICAO SMS strengthens safety oversight through proactive hazard identification, continuous safety assurance, organizational learning, and safety promotion.

Based on the regulatory comparison and crosswalk analysis, this study proposed a hybrid airport safety oversight framework that integrates the structured compliance requirements of FAA Part 139 with the adaptive management principles of ICAO SMS. The framework recognizes that effective airport safety oversight benefits from both regulatory consistency and proactive safety management, providing a practical approach for addressing both established operational requirements and emerging safety challenges.

The proposed framework also supports greater alignment between U.S. airport safety oversight and internationally recognized safety management practices. By integrating prescriptive oversight with performance-based safety management, the framework offers a conceptual foundation for strengthening airport safety governance while supporting continuous improvement and organizational resilience.

Although the proposed framework is conceptual in nature, it provides a structured basis for future implementation and evaluation. Future research should examine its application through airport case studies, implementation assessments, and comparative analyses involving the FAA, the European Union Aviation Safety Agency (EASA), and other international aviation authorities. Such studies would help evaluate the framework's practical effectiveness and identify opportunities for further harmonization of airport safety oversight practices.

Future research should explore the integration of digital monitoring technologies and intelligent decision-support systems to support proactive airport safety oversight through continuous situational awareness and more timely risk-informed operational decision-making [25].

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Stolzer, A.J., Halford, C.D. and Goglia, J.J. (2023) Safety Management Systems in Aviation. 3rd Edition, CRC Press. https://www.taylorfrancis.com/books/mono/10.1201/9781003286127/safety-management-systems-aviation-alan-stolzer-robert-sumwalt-john-goglia

[2] Federal Aviation Administration (FAA) (2023) 14 CFR Part 139—Certification of Airports. U.S. Department of Transportation. https://www.faa.gov/airports/airport_safety/part139_cert

[3] Federal Aviation Administration (FAA) (2023) Airport Safety Management System: Final Rule. *Federal Register*. https://www.federalregister.gov/documents/2023/02/23/2023-03597/airport-safety-management-system

[4] International Civil Aviation Organization (ICAO) (2016) Annex 19 to the Convention on International Civil Aviation—Safety Management, 2nd Edition, ICAO. https://elibrary.icao.int/reader/250466/&returnUrl%3DaHR0cHM6Ly9lbGlicmFyeS5pY2FvLmludC9wcm9kdWN0LzI1MDQ2NiUzQnNlb01vZGUlM0R0cnVl?productType=ebook&themeName=Blue-Theme

[5] International Civil Aviation Organization (ICAO) (2025) Safety Management Manual (SMM). https://www.icao.int/safety-management/SMI/SMM

[6] Zhu, L. (2019) Safety Detection Algorithm in Sensor Network Based on Ant Colony Optimization with Improved Multiple Clustering Algorithms. *Safety Science*, **118**, 96-102. https://doi.org/10.1016/j.ssci.2019.05.012

[7] U.S. Government Accountability Office (GAO) (2012) Aviation Safety: Additional FAA Efforts Could Enhance Safety Risk Management. GAO. https://www.gao.gov/products/gao-12-898

[8] Young, S., Wells, A. and Wensveen, J. (2019) Airport Planning and Management. 7th Edition, McGraw Hill. https://www.mheducation.com/highered/mhp/product/airport-planning-management-7e-pb.html?viewOption=student

[9] Taheri, H.J. (2025) A KPI-Driven Dashboard Framework for Enhanced Safety Management in Airfield Construction. Preprint. https://engrxiv.org/preprint/view/5432/version/7226

[10] Stroeve, S., Smeltink, J. and Kirwan, B. (2022) Assessing and Advancing Safety Management in Aviation. *Safety*, **8**, Article 20. https://doi.org/10.3390/safety8020020

[11] Piers, M., Montijn, C. and Balk, A. (2009) Safety Culture Framework for the ECAST SMS-WG. European Commercial Aviation Safety Team (ECAST), 1-4. https://www.easa.europa.eu/sites/default/files/dfu/WP1-ECASTSMSWG-SafetyCultureframework1.pdf

[12] U.S. Government Accountability Office (GAO) (2020) Aviation Safety: Actions Needed to Evaluate Changes to FAA's Enforcement Policy on Safety Standards. U.S. Government Accountability Office. https://www.gao.gov/assets/gao-20-642.pdf

[13] Federal Aviation Administration (FAA) (2023) AC 150/5200-37A—Safety Management Systems for Airports. https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5200-37

[14] U.S. Department of Transportation, Office of Inspector General (DOT OIG) (2016) FAA Lacks Sufficient Oversight of the Aircraft Rescue and Firefighting Program. DOT OIG. https://www.oig.dot.gov/sites/default/files/FAA%20Aircraft%20Rescue%20and%20Fire%20Fighting%20Program%20Final%20Report%5E5-31-16.pdf

[15] U.S. Government Accountability Office (GAO) (2014) Aviation Safety: Additional Oversight Planning by FAA Could Enhance Safety Risk Management. GAO. https://www.gao.gov/products/gao-14-516

[16] Graham, A. (2022) Managing Airports. 6th Edition, Routledge. https://doi.org/10.4324/9781003269359

[17] Gilbert, T., Lamont, J. and Bell, A. (2025) Survey of Performance-Based and Risk-Based Oversight Strategies and Methods. FAA William J. Hughes Technical Center. https://rosap.ntl.bts.gov/view/dot/88555/dot_88555_DS1.pdf

[18] Bureau of Transportation Statistics (BTS) (2023) Airline On-Time Performance Data. U.S. Department of Transportation. https://transtats.bts.gov

[19] National Oceanic and Atmospheric Administration (NOAA) (2023) Integrated Surface Database (ISD). National Centers for Environmental Information (NCEI). https://www.ncei.noaa.gov/products/land-based-station/integrated-surface-database

[20] International Civil Aviation Organization (ICAO) (2023) Universal Safety Oversight Audit Programme (USOAP) Continuous Monitoring Manual. 5th Edition, ICAO. https://store.icao.int/en/universal-safety-oversight-audit-programme-continuous-monitoring-manual-doc-9735

[21] Wiegmann, D.A. and Shappell, S.A. (2017) A Human Error Approach to Aviation Accident Analysis: The Human Factors Analysis and Classification System. Routledge. https://dvikan.no/ntnu-studentserver/reports/A%20Human%20Error%20Approach%20to%20Aviation%20Accident%20Analysis.pdf

[22] Federal Aviation Administration (FAA) (2022) Airport Safety Data and Inspections Reports. U.S. Department of Transportation. https://www.faa.gov/airports

[23] Federal Aviation Administration (FAA) (2022) The Operations Network (OPSNET). FAA Operations & Performance Data. https://www.aspm.faa.gov/aspmhelp/index/Operations_Network_(OPSNET).html

[24] International Civil Aviation Organization (ICAO) (2019) Global Aviation Safety Plan 2020-2022. ICAO. https://skybrary.aero/sites/default/files/bookshelf/5783.pdf

[25] Mirzamohammadi, M., Haghighatjoo, M., Taheri, H.J. and Varzeghani, N.M. (2026) Physics-Informed and Transferable Explainable AI Framework for Reliable Prediction of Tunnel-Induced Settlement in Coastal Environments. *Discover Artificial Intelligence*, **6**, Article No. 558. https://doi.org/10.1007/s44163-026-01108-3

Abbreviations

The following abbreviations are used in this manuscript:

FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
SMS	Safety Management System
ARFF	Aircraft Rescue and Firefighting
OPSNET	Operations Network
BTS	Bureau of Transportation Statistics
NOAA	National Oceanic and Atmospheric Administration
USOAP	Universal Safety Oversight Audit Programme
SSP	State Safety Programme
EI	Effective Implementation
IFR	Instrument Flight Rules