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The Status of Safety Management Systems and Fatigue Risk Management Systems at Collegiate Flight Training Institutions

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The purpose of this study was to determine the status of Safety Management Systems (SMS) and Fatigue Risk Management Systems (FRMS) development and implementation at Collegiate Flight Training Organizations across the United States. The research questions focused on demographics, organizational support, and the components of SMS and FRMS at collegiate flight schools. The research followed the model of a previous study published in 2017 by Robertson et al. (2017). Overall, most SMS components increased in implementation or remained unchanged since 2017. The FRMS implementation was relatively low when compared to SMS implementation.

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Introduction

Safety Management Systems (SMS) continue to gain traction in various aviation industry areas and are now regulatory for Part 139 airports. While airlines have been using SMS for nearly 20 years and under regulation for nine years, flight training institutions still lack regulatory requirements for SMS implementation. Robertson et al. (2017) investigated the status of SMS development and implementation in collegiate flight institutions. Given the increased popularity and regulatory demands of SMS in the industry, this is an excellent time to revisit the Robertson et al. (2017) study, adding an investigation into the implementation of Fatigue Risk Management Systems (FRMS).

Fatigue poses a serious issue in aviation safety management, as it can lead to decreased performance and a higher risk of errors among pilots and other personnel (ICAO, 2011). It diminishes situational awareness and accuracy in decision-making, both of which are essential for safe aviation operations (Bongo & Seva, 2021). Previous studies indicate that collegiate students struggle to achieve a sufficient quantity and quality of sleep, resulting in fatigue (Keller et al., 2020; Levin et al., 2019). According to Keller et al. (2022), flight training programs must incorporate training and education focused on fatigue to mitigate associated risks. Consequently, many organizations have begun integrating Fatigue Risk Management (FRM) into their SMS to tackle this issue. However, the absence of FAA regulatory requirements for Part 141 programs allows these programs to avoid establishing SMS and FRMS programs. This study aims to delineate the status of UAA-member Part 141 collegiate aviation flight programs in developing and implementing FRMS at their respective institutions.

Research Questions

This study aims to determine the status of SMS and FRMS development and implementation at UAA-member collegiate flight schools across the US. The following four research questions were used to assess the status of the development and implementation of SMS and FRMS at collegiate flight schools, with the first three coming from the original study by Robertson et al. (2017):

1. What are the SMS demographics of collegiate flight schools?
2. What level of organizational support is reported for SMS by collegiate flight schools?
3. What progress is being made toward the development or implementation of the components of SMS at collegiate flight schools?
4. What progress is being made toward the development or implementation of the elements of FRMS at collegiate flight schools?

Literature Review

Sleep & Fatigue

The aviation industry has recognized fatigue as a critical human-factors-related safety issue due to its impact on pilot performance. In fact, the NTSB has identified fatigue as a contributing factor in 23% of aviation accidents between 2001 and 2012 (Romero et al., 2020). The International Air Transport Association (IATA) reported that pilot fatigue contributed to 31 aircraft accidents in commercial aviation between 2005 and 2022 (Sieberichs et al., 2024). Notably, from 2012 through 2022, approximately 73% of all fixed-wing general aviation accidents involve human error as a probable error or contributing factor. Moreover, 14% of these accidents are associated with flight training operations, including Part 141 operations (Keller et al., 2022). The aviation industry is particularly susceptible to the consequences of fatigue because of continuous operations. The International Civil Aviation Organization (ICAO) defines fatigue as:

> a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety related duties. (ICAO, 2011, p. 1-1)

In other words, fatigue can be defined as a state of mental and physical exertion that requires sleep for the body to recover (ICAO, 2011). The National Transportation Safety Board (NTSB) has identified fatigue as a safety hazard because fatigue hinders a person's ability to remain awake, sharp, and vigilant when completing their duties (Keller et al., 2020). A pilot may experience common symptoms of fatigue such as (1) inattention, (2) reduced cognitive ability, (3) decreased memory, (3) impaired judgment, and (4) decreased reaction time (Levin et al., 2019).

Specifically, fatigue degrades a pilot's ability to anticipate events, plan, and make sound decisions, as documented by the NTSB's pilot error statistics. The NTSB reported that pilots who experienced fatigue were 40% more likely to make errors (Keller et al., 2020). Moreover, the data indicates that errors of omission increased by 75%, and errors while monitoring automation increased by 136% among pilots who were experiencing fatigue (Keller et al., 2020). Typically, the errors committed by pilots experiencing fatigue were related to (1) spatial disorientation, (2) manual dexterity, (3) cognitive processing, and (4) critical thinking skills (Levin et al., 2019). Nevertheless, it is evident that pilot fatigue significantly impacts flight safety.

Fatigue mitigation strategies include proper nutrition, exercise, and a consistent sleep routine (Levin et al., 2019). These strategies may be difficult for pilots to implement due to their irregular work schedules and moving to different time zones worldwide. Pilots may also use self-assessment tools, such as a Flight Risk Assessment Tool (FRAT) and the IM SAFE (illness, medication, stress, alcohol, fatigue, and emotions) checklist, to assist in determining if they are fatigued and fit for flight (FAA, 2022). Also, Part 121 certificate holders can develop effective fatigue mitigation strategies for their pilots by developing their Fatigue Risk Management System (FRMS).

Fatigue Risk Management System (FRMS)

ICAO defines a FRMS as:

> A data-driven means of continuously monitoring and managing fatigue-related safety risks, based upon scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness. (ICAO, 2011, p.1-1)

FRMS builds upon Safety Management Systems (SMS) principles that allow organizations to maintain parity between safety, productivity, and costs. The cornerstone of SMS and FRMS is promoting an effectual safety reporting culture (ICAO, 2011). The Federal Aviation Administration (FAA) requires each Part 121 certificate holder to have an approved Flight Risk Management Plan (FRMP). The FRMS is an alternative method of compliance (AMOC) to the limitations provided by the FAA concerning duty time for crewmembers ("Flight and Duty Limitations," 2012; FAA, 2013). The FRMS, when used as an AMOC, must clearly demonstrate that it meets or exceeds the fatigue management guidelines provided by the FAA (FAA, 2013).

FRMS adopts a varied approach to managing fatigue risk. The minimum required components of an FRMS are (1) policy and documentation, (2) fatigue risk management processes, (3) safety assurance processes, and (4) promotion processes (ICAO, 2011). The FRMS is an iterative process that begins with data collection and ends with an assessment that results in improvements to the system. The first two steps in the FRMS process involve collecting data and identifying fatigue risks. The final two steps in the process incorporate developing and implementing effective fatigue mitigation strategies, with the concluding step assessing these strategies for efficacy (ICAO, 2011). It is imperative that the data is shared between the SMS and FRMS because the goal of both systems is to identify and mitigate safety risks within an organization. The safety data generated within the FRMS is also a component of the SMS.

Safety performance indicators (SPIs) are specific measures that need to be continually monitored and may pinpoint fatigue hazards (Gander et al., 2014). SPIs are also used during the assessment process to determine if the FRMS meets its objectives. Generally, SPIs are organized into two categories based on the data collection type. Operational SPIs are based on data related to the operations of the Part 121 certificate holder, such as the crewmembers' schedules (Gander et al., 2014). Crewmember SPIs involve data personally related to the crewmember, such as sleep loss or diminished quality of sleep (Gander et al., 2014). SPIs are integral to the first two phases of the FRMS process. SPIs guide which data should be collected and how the data should be analyzed. Although the FRMS possesses an internal monitoring process to determine the program's efficacy, the aviation community has conducted research regarding fatigue and its impact on safety, as well as the use of FRMS as a mitigation strategy.

FRMS – Commercial Operators

The common goal of fatigue management is to reduce sleep loss and increase sleep quality (Gander et al., 2019). More research is needed to determine the amount of sleep recovery necessary for pilots after experiencing persistent sleep restriction (Gander et al., 2019). That is, the aviation industry has not yet determined the duration of each recovery sleep event, along with the number of consecutive recovery sleep events necessary to recover from persistent sleep restriction. The aviation industry often operates around the clock, significantly contributing to sleep restriction and fatigue. In addition, extended workloads, early departures, late arrivals, multiple flight legs, and varied time zones impact fatigue for pilots flying for Part 121 carriers (Mendonca et al., 2019). Research has shown that quality sleep in sufficient amounts is the best strategy to avoid fatigue; however, controlled napping before and during flight, proper nutrition, and regular exercise are also effective tools. Caffeine use is an unhealthy response to fatigue, yet it is the primary strategy pilots use to combat fatigue (Mendonca et al., 2019). Much more research is needed to ascertain the most effective means for combating fatigue. To that end, larger and more diverse data sets are needed to determine which factors need to be modified to improve the effectiveness of SPIs (Gander et al., 2014). Although much has been learned about fatigue and effective fatigue mitigation strategies, little progress has been made in this area for collegiate flight training.

Fatigue & Collegiate Flight Training

The causes of fatigue experienced within collegiate flight training differ from those experienced by Part 121 pilots. Nonetheless, there are some similarities, such as poor quality of sleep, long work hours, and irregular sleep schedules (Romero et al., 2020). Collegiate flight training students are younger than Part 121 pilots and may not have developed effective lifestyle habits that inhibit fatigue. For example, nearly 30% of college students report getting insufficient sleep (Romero et al., 2020). In another survey, 66% of the students reported insufficient sleep (Levin et al., 2019). In fact, 95% of collegiate flight students and instructors indicate that fatigue has negatively impacted their flight training (Romero et al., 2020; McDale & Ma, 2008). Another research study found that half the flight training students admitted they had difficulty staying awake during a training flight due to fatigue (Mendonca et al., 2019). Of these responses, 78% of the students stated they had made mistakes during a training flight because of diminished situational awareness and judgment (Mendonca et al., 2019). During additional research, approximately 60% of the student participants indicated in the Collegiate Aviation Fatigue Inventory (CAFI) that they had experienced mental and physical symptoms of fatigue during flight training (Mendonca et al., 2021). Collegiate flight training students must balance their academic workload along with their flight training, while many work part-time jobs as well. Due to this extensive workload, flight training students often do not get sufficient sleep, and their sleep quality is often poor due to living arrangements that are not conducive to proper sleep. Research indicates that half of the students surveyed go to bed between 11:00 pm and midnight when they have school the next day, and more than half stated that their sleep is often interrupted at least once during the night (Romero et al., 2020).

Effective lifestyle habits are essential for reducing fatigue, yet many flight training students have not developed these habits. Half the flight training students do not exercise regularly, and over half stated they have unhealthy eating habits (Levin et al., 2019). Most flight training students and flight instructors indicated in research surveys that adequate sleep and a healthy lifestyle are the primary personal solutions to mitigate fatigue (Levin et al., 2019; McDale & Ma, 2008). Flight instructors responded similarly by attributing fatigue to long workdays and insufficient sleep as the primary contributors to fatigue (McDale & Ma, 2008). Flight instructors favored solutions to fatigue, such as a place to rest at work, increased pay to allow instructors to reduce their workload, and training that helps instructors understand fatigue and how to manage it (McDale & Ma, 2008). The overall theme of the research findings indicates that fatigue negatively impacts the safety of collegiate flight training. Much has been done to develop and implement effective fatigue risk mitigation strategies for Part 121 certificate holders, yet this is not true for collegiate flight training. In fact, 85% of students and flight instructors stated in a research survey that they had received no fatigue-related training (Keller et al., 2020). However, collegiate flight training can use the principles encapsulated in the FRMS model to develop an effective fatigue risk management program that satisfies the needs of collegiate flight training. Specifically, there is a need for improved training and education efforts that include crucial topics such as the causes of fatigue, fatigue awareness, effective sleep strategies, time management, and healthy lifestyle habits (Keller, 2022).

Methodology

This study used a survey instrument approved by the Southern Illinois University Carbondale (SIUC) Institutional Review Board (IRB) to address the four research questions. At the time the survey was distributed, the study population comprised 115 University Aviation Association (UAA) member institutions. The UAA is committed to advancing higher education institutions (HEI) and providing degree-granting aviation programs across various aviation segments. The sample of 95 safety officers came from a list maintained by the UAA Safety Committee. The selected safety officers represented 19 HEIs with active safety programs. The researchers sent two rounds of email communication to the 95 safety officers requesting participation in the survey. Of the 95 safety officers contacted, 21 safety officers from 19 HEIs completed the survey, resulting in a 22% response rate.

Advisory Circular (AC) 120-92B was a guiding framework for developing the survey items (FAA, 2015). While initially developed to assist airlines in meeting regulatory requirements within 14 CFR Part 121 operations, this AC offers a concise and thorough overview of SMS, including its components and the specific elements that underpin SMS, forming the foundational structure of the survey. Robertson et al. (2017) played a critical role in refining the survey instrument, leveraging the knowledge of safety professionals within the flight training domain. Additionally, recognized safety specialists from Embry-Riddle Aeronautical University, Southern Illinois University, and the University of North Dakota evaluated the survey for validation.

Determining SMS and FRMS Implementation

This study created a classification system using AC 120-92B, the current Advisory Circular at that time, as a guide to assess the extent of SMS and FRMS implementation in pilot training programs for managing safety initiatives. The classification system utilized the four components of SMS as a foundational structure and then incorporated the specific elements associated with each SMS component. For example, an HEI with a pilot training program that integrates all four SMS components and their respective elements could possess a fully implemented SMS. This information enables the calculation of an overall degree of SMS and FRMS implementation across the participating HEIs through pilot training programs. For instance, safety risk management (SRM) consists of five separate components. If all five SRM components are present in all 19 participating institutions, as reported by the 21 participating safety officers, the SRM implementation score is determined to be 100%. Similar scoring applies to FRMS implementation.

Acknowledging the limitations in calculating implementation scores, which consist of two factors limiting the use of these scores, is critical. The first limiting factor is that the SMS elements specified in Appendix A originate from AC 120-92B, which serves as a guide rather than a regulatory framework. The purpose of creating AC 120-92B is to assist 14 CFR Part 121 operators in executing and administering an SMS, not to dictate methods used. Further, the elements of FRMS specified in Table 1 originate from AC 120-103A, which, like AC 120-92B, acts as a guiding document and not a regulation regarding the implementation of FRMS. It is also important to note that the method used to assess SMS and FRMS implementation lacks validation. Nevertheless, additional research may demonstrate its relevance as a tool for gauging overall SMS and FRMS implementation in pilot training schools or any other sector within the aviation industry.

The second limitation stems from the variability in SMS and FRMS elements among different institutions. For instance, the survey prompts respondents to enumerate all elements utilized in safety promotion. One of the listed items is using safety stand-downs as a promotional factor. While it is acknowledged that safety stand-downs can be a valuable promotional tool, they are not mandatory for achieving a fully implemented SMS. Therefore, there is a limitation in achieving a perfect implementation score of 100%. Regardless, the scoring system retains its significance as a general guide for evaluating the overall implementation status of SMS and its components. The four components of SMS and FRMS, and the associated elements that safety programs should incorporate for SMS and FRMS implementation, are outlined in Appendix A. Certain elements and processes listed under safety promotion may be optional for SMS implementation.

Other limitations include the potential for bias in self-reported data and the small sample size. The participants self-reported all data collected in this study, meaning there is potential bias in the reported information. Additionally, the initial sample was intentionally small, as this replicates the 2017 study conducted by Robertson et al., which focused on safety officers associated with UAA-member institutions. The 22% response rate further restricts the generalizability of the results.

Results

The survey was divided into four sections that collectively answered the four research questions. The initial part pertains to general SMS demographics, the second involves the level of management commitment to SMS activities, the third relates to the advancement of collegiate flight schools in implementing SMS, and the final part relates to implementing FRMS elements.

The two rounds of email resulted in participation from fewer than half of the population. Of the 95 safety officers emailed, 21 responded to the survey, generating a response rate of 22%.

Part 1 - SMS Demographics

This study aims to gather general SMS demographic data regarding Part 141 collegiate flight programs. Such information is valuable for tracking the adoption of SMS across the collegiate aviation sector. Similar to the research conducted by Robertson et al. (2017) on implementing SMS within airport operations, this study seeks to expand the line of research by observing SMS implementation in collegiate flight schools.

Basic Institutional Demographics

The survey aimed to ascertain the general demographic information about SMS and FRMS at collegiate flight schools. Participants shared essential details about their school in the initial phase, including its name, certification as a Part 141 pilot school, and whether it offers flight instruction directly or through a third-party provider. The identities of the 19 participating institutions were anonymized to maintain their confidentiality. Of the 21 survey respondents, all indicated that their institutions were classified as Part 141 pilot schools. Five (23.8%) of those institutions indicated that they provide flight training to pilots through a third party.

General SMS Demographic Information

The next section of the survey prompted participants to specify their familiarity with SMS to collect demographic information regarding SMS within the participating institutions. Additionally, participants provided details regarding the extent of SMS utilization within their respective pilot training programs. Finally, participants indicated the anticipated timeline for implementing SMS within their organizations.

Table 1 displays the respondents' level of familiarity with SMS. Among the 21 safety officer respondents, all reported being “Knowledgeable” of SMS, and 10 (46.62%) indicated they were “Very Knowledgeable” about SMS or an “SMS expert.” The data shows that all participants have at least a foundational level of knowledge regarding SMS. Additionally, the data suggests a strong overall competency in SMS among the surveyed safety officers, although there is still room for improvement.

Table 1
Safety Officer Knowledge of SMS

Degree of SMS Familiarity	n
No Knowledge	0
Some Knowledge	3
Knowledgeable	8
Very Knowledgeable	7
SMS Expert	3

The participants described the degree of SMS development and implementation at their respective institutions. Their responses to this survey question are shown in Table 2. When the surveys were submitted, six respondents (28.57%) indicated they had fully implemented SMS. Nearly half of the sample population (n = 9, 42.9%) had not yet fully incorporated SMS into their pilot training programs, and six (28.57%) participants were not using SMS to manage their safety programs at all. The results suggest that some institutions may encounter challenges in adopting SMS. Furthermore, the number of participants who do not use SMS at all indicates potential gaps in safety management practices. Overall, the data highlights a need for increased support and training to promote full SMS adoption by Part 141 institutions.

Table 2
SMS Involvement

Degree of SMS Development/Implementation	n
SMS is Not Under Development	6
SMS is Under Development	7
Some SMS components functional	2
SMS is Fully Implemented	6

The final question regarding SMS demographics prompted the survey respondents to forecast when their organization intended to fully implement SMS. Table 3 displays the anticipated timeframe of when the organizations planned to implement an SMS and have an SMS fully in place. Six (28.57%) of the organizations did not answer the question since they already had a fully functional SMS. Only four (19.0%) participants indicated that their institutions would fully implement SMS within a year of the survey. The data highlights the variance in adoption rates between institutions.

Table 3
Projected SMS Implementation

Number of Years Until Full SMS	n
Unsure	4
Within 1 year	4
Within 2 to 3 Years	2
More than 3 Years	5
Did Not Answer	6

Part 2 - Management Commitment

The second section of the survey sought to evaluate the dedication of managers within the participating pilot training schools toward SMS. The level of management commitment was measured by evaluating various management activities related to SMS and soliciting feedback from the survey respondents to assess the level of commitment to SMS demonstrated by their managers.

SMS-related Activities

Survey respondents were asked to select applicable items from a list of actions meant to represent an institution's commitment to safety in the context of SMS. Table 4 illustrates the breakdown of the different SMS activities utilized by respondents in their IHEs. Because the survey had 21 respondents, each activity had a maximum participation level (n) of 21. Based on the responses, most research participants used all listed SMS activities. Investments in human and financial resources (n = 17, 72%) received the fewest responses in this category. These results are nearly identical to the Roberston et al. (2017) study, showing that management commitment among the surveyed IHEs remained strong and relatively unchanged. However, the need for additional human and financial resource investments remained an issue.

Table 4
Activities that Represent Management Commitment to SMS

SMS Activity	n
Invests human and financial resources	17
Proactive in preventing accidents	20
Consistently enforces safety procedures	20
Views regulatory violations seriously	21
Involved in safety activities	20

Management's Commitment to Implement SMS

The safety officers who participated in the survey assessed their managers' commitment to implementing SMS at their institution using a rating scale ranging from 0 to 10, with 0 representing no commitment and 10 representing total commitment. The question received 21 responses, with the mean response being 7.1 on a 0 to 10 scale and a standard deviation of 2.7. These results indicate that, on average, safety officers believed their respective managers were strongly committed to implementing SMS at their institutions. Furthermore, these results are relatively unchanged compared to those of Robertson et al. (2017).

Part 3 - SMS Implementation

The final section of the survey intended to assess the extent to which SMS is put into practice within the participating institutions. The assessment relied on the framework provided by the four components of SMS and their associated elements. An evaluation was conducted to measure the degree of SMS implementation of the various components and elements of SMS used at the participating schools.

Safety Policy

In the survey's safety policy section, respondents were prompted to identify the elements associated with the safety policy they incorporated into their safety programs. The results of this question are displayed in Table 5. Twenty of the 21 respondents (95%) indicated they had developed a safety policy statement, and 19 (90%) indicated they had identified a safety committee. Developing an implementation plan was the least common, with seven replies (33%) indicating a possible gap between policy creation and execution. The percentage of overall implementation of the safety policy component across the participating pilot training schools is 73.81%.

Table 5
Safety Policy Implementation

Safety Policy Activity/Process	n
Completed gap analysis	9
Developed an implementation plan	7
Developed a safety policy statement	20
Developed a set of SMS objectives	18
Identified an accountable executive	17
Identified an SMS manager/coordinator	17
Identified a safety committee	19
Developed an emergency response plan	17
Total Safety Policy Implementation Score	73.81%

Safety Risk Management

This section asked respondents to examine their SMS and identify which elements and processes related to SMS they had established at their respective institutions. The results of this inquiry are displayed in Table 6. Of the 21 participants, 19 (90.48%) had established a method or methods for identifying hazards, and 18 (85.71%) of the respondents indicated that they tracked and documented hazards. Only eight (38.10%) respondents reported having a formalized 5-step SRM process at their institution, highlighting a significant gap in the formal implementation of the complete 5-step SRM process. The overall SRM implementation score across the pilot training programs is 72.45%, suggesting that foundational SRM processes are in place but with room for improvement.

Table 6
SRM Implementation

SRM Activity/Process	n
Hazard Identification	19
Hazard Tracking and Documentation	18
Risk Analysis	16
5-step SRM Process	8
Safety Risk Assessment	15
Total SRM Implementation Score	72.45%

Safety Assurance

The next question evaluated the extent of safety assurance activities implemented at the participating institutions. To accomplish this, survey respondents identified which elements and processes they had in place regarding the safety assurance component. Table 7 illustrates the outcomes of this inquiry and the implementation score for the safety assurance component.

Table 7
Safety Assurance Implementation

Safety Assurance Activity/Process	n
Confidential Hazard Reporting System - Paper	6
Confidential Hazard Reporting System - Web	19
Trend Analysis Capability	13
Safety Performance Monitoring	10
Continuous monitoring of Safety Controls	9
Flight Data Monitoring Analysis	13
SMS Audits/Evaluations	8
Safety Culture Assessments	14
Total Safety Assurance Implementation Score	54.77%

Twenty (95.24%) of the 21 respondents indicated that they had a confidential hazard reporting system. The safety assurance elements are implemented in approximately 55% of the pilot training schools that responded, compared to approximately 44% observed by Robertson et al. (2017). The relatively low overall implementation rate of safety assurance elements (55%) suggests that while hazard reporting is widely adopted, other critical aspects of safety assurance may be lacking. The safety assurance activities with the lowest response rates included continuous monitoring of safety controls, SMS audits, and paper hazard reporting systems. Paper reporting systems appear redundant in most cases, as 19 of the 21 respondents indicated using a web-based hazard reporting system. Continuous monitoring of safety controls and SMS audits requires significant time commitment for safety personnel, which likely contributed to their lower response rates.

Safety Promotion

The next component evaluated in this research is the implementation of safety promotion activities. The results of this survey question are displayed in Table 8. Seventeen (81%) respondents indicated that they held employee safety meetings. However, only seven (33%) reported having regularly scheduled SMS training for their employees. According to the results, safety stand-downs are utilized by twelve (57%) respondents, and nine out of those twelve (75%) indicated that they hold regular safety meetings for both students and employees. A safety stand-down typically involves pausing operations for safety-related training. The data suggests that while safety promotion activities were present, their implementation was inconsistent across the participating institutions. There appears to be a strong focus on communication but a significant gap in ongoing training. The somewhat low implementation rate of 49.73% across the sample of pilot training programs illustrates that there is substantial room for improvement in fully integrating safety promotion efforts.

Table 8
Safety Promotion Implementation

Safety Promotion Activity/Process	n
Specialized SMS Training	7
Regular SMS training – Employees	7
Regular SMS training – Students	4
Safety bulletin boards	12
Safety newsletters	12
Employee safety meetings	17
Student safety meetings	15
Safety awards program	8
Safety stand-downs	12
Total Safety Promotion Implementation Score	49.73%

Fatigue Risk Management System

The last component assessed for this research is the implementation of FRMS activities. The results of this survey question are displayed in Table 9. Fourteen (67%) of the respondents indicated that they monitor the flight duty period for instructors, while ten (48%) reported monitoring the flight duty period for students. The discrepancy between monitoring instructors' flight duty periods (67%) and doing the same for students (48%) suggests inconsistencies in fatigue management practices. Only nine (43%) respondents indicated using a flight risk assessment tool (FRAT). Additionally, six (29%) respondents provided fatigue awareness training, and four (19%) promoted fatigue awareness. None of the respondents indicated that they collected sleep data from either students or instructors.

Overall, the results suggest that FRMS activities are absent in most of the respondents' flight training schools, with an implementation rate of only 19.36%. This overall implementation rate indicates that FRMS activities are significantly lacking among the participating institutions. Furthermore, the low adoption of some FRMS components, such as using a FRAT or collecting sleep data, highlights gaps in proactive fatigue mitigation. Note that FRMS is relatively new compared to SMS, which is likely contributing to its low implementation rate. The low adoption rate could also be attributed to safety officers lacking the additional resources needed to develop and maintain an FRMS in addition to their existing SMS. Regardless, the significant lack of FRMS activities supports the need for further research.

Table 9
FRMS Implementation

FRMS Activity/Process	n
Fatigue Safety Action Group	2
FRMS Policy	2
FRMS Objectives	1
Fatigue Specific Reporting System	1
Process to Identify Fatigue Hazards and Risks	5
Utilize HFACS	5
Flight Risk Assessment Tool (FRAT)	9
FRMS Safety Performance Indicators	1
FRMS Documentation	1
Fatigue Awareness Training	6
Fatigue Awareness Promotion	4
Flight Duty Period for Students	10
Flight Duty Period for Instructors	14
Collect Sleep Data on Students	0
Collect Sleep Data on Instructors	0
Total FRMS Implementation Score	19.36%

Discussion

Research Question 1

The primary demographic information of the participating pilot training schools was determined through the first question. The participants rated their knowledge of SMS, the results of which are listed in Table 10. The number of respondents (n = 21) for the current study was lower than the number of respondents (n = 28) for the original study by Robertson et al. (2017). The percentage of respondents who reported their SMS familiarity as knowledgeable or better remains unchanged from the original study of Robertson et al. (2017), at 85.71% (n = 18). All respondents in the current survey and the Roberston et al. (2017) study indicated having some knowledge of SMS. Additionally,14% (n = 3) of respondents identified as an "SMS Expert" in the current study, compared to 0% of respondents claiming to be experts in 2017. While the percentage of fully implemented SMS increased by approximately 11%, with 28.57% (n = 6) currently reporting their SMS involvement as "SMS is Fully Implemented" compared to 17.86% (n = 5) in 2017, this change appears to be negligible, and due to a shift in sample size.

The data suggests that knowledge of SMS among participants has remained consistent since the original study by Robertson et al. (2017), with more participants (14%) identifying as “SMS Experts” compared to none in the 2017 study. However, the overall increase in fully implemented SMS programs is relatively low and may be attributed to the smaller sample size as opposed to significant improvements across the participant institutions. The data indicates that although there has been some growth in SMS knowledge and implementation, the growth rate remains slow, and further efforts may be needed to increase SMS adoption across Part 141 institutions.

Table 10
Safety Officer Knowledge of SMS

Degree of SMS Familiarity	Previous		Current	
	n	%	n	%
No Knowledge	0	0.00%	0	0.00%
Some Knowledge	4	14.29%	3	14.29%
Knowledgeable	11	39.29%	8	38.10%
Very Knowledgeable	13	46.43%	7	33.33%
SMS Expert	0	0.00%	3	14.26%
Total	28		21	

Table 11 shows that the percentage of respondents not developing SMS and appearing to have no intention to start has remained relatively unchanged since 2017. Twenty-one percent (n = 6) of respondents in 2017 responded "N/A" when asked about a timeline for SMS implementation. If we adjust that number to exclude those that had fully implemented SMS in 2017, that percentage drops to 14% (n = 4). The current survey shows 19% of respondents (n = 4) as "Unsure" about their timeline to implement SMS. The response seems to confirm the reluctance to change in institutional safety programs noted by Roberston et al. in 2017. Of the four who indicated "Unsure" in the current survey, all (100%) reported their SMS knowledge as "Knowledgeable" or greater. Therefore, the participants who responded "Unsure" when asked about SMS implementation timelines appear to have the knowledge needed to implement an SMS. Although there are many reasons why an organization chooses not to transition their safety program to an SMS, the survey results suggest that lack of knowledge, at least among this sample, is not one of them. The findings reinforce the conclusions of Robertson et al. (2017) regarding the hesitancy of institutions to modify their existing safety programs despite having the necessary knowledge to do so.

Table 11
SMS Involvement

Degree of SMS Development/Implementation	Previous		Current	
	n	%	n	%
SMS is Not Under Development	6	21.43%	6	28.57%
SMS is Under Development	9	32.14%	7	33.33%
Some SMS components functional	8	28.57%	2	9.52%
SMS is Fully Implemented	5	17.86%	6	28.57%
Total	28		21	

Regarding the four respondents who selected "Unsure" when asked about projected SMS implementation timelines, 75% (n = 3) contracted their flight training to a third party. Similarly, 75% (n = 3) of respondents who reported using third-party flight training and did not already have SMS in place (n = 4) also indicated being "Unsure" about the timeline for SMS implementation. Of the five respondents with third-party contractors providing flight training, only one (20%) reported having a fully implemented SMS. Conversely, 83% (n = 5) of respondents who indicated having a fully implemented SMS do not use third-party contractors for their flight training.

Table 12
Projected SMS Implementation

Number of Years Until Full SMS	Previous		Current	
	n	%	n	%
Not Applicable/Unsure	9	32.14%	4	19.05%
Within 1 year	8	28.57%	4	19.05%
Within 2 to 3 Years	9	32.14%	2	9.52%
More than 3 Years	1	3.57%	5	23.81%
Did Not Answer	1	3.57%	6	28.57%
Total	28		21	

Research Question 2

The survey's second section pertains to management's commitment to implementing SMS programs within their respective institutions. All respondents (n = 21) indicated that management views regulatory violations seriously, a slight increase from the previous study. In addition, 95% (n = 20) of respondents reported that management was proactive in preventing accidents, consistently enforcing safety procedures, and being involved with safety activities. These results indicate the participating institutions' high level of engagement in safety culture. However, the slightly lower response (81%, n = 17) regarding investments in human and financial resources suggests that while management prioritizes SMS, there may still be challenges in fully supporting successful implementation.

Table 13
SMS Activities at Pilot Training Schools

SMS Activity	Previous		Current	
	n	%	n	%
Invests human and financial resources	19	67.86%	17	80.95%
Proactive in preventing accidents	25	89.29%	20	95.24%
Consistently enforces safety procedures	24	85.71%	20	95.24%
Views regulatory violations seriously	26	92.86%	21	100.00%
Involved in safety activities	24	85.71%	20	95.24%
Total	28		21	

The survey data in Table 13 follows the same trend observed in the previous study by Robertson et al. (2017), which indicates that flight training institutions seem concerned with things that affect their financial standing, such as regulatory violations and accidents. At the same time, the lowest level of commitment by members of management (See Tables 4 and 13) was "Invests in human and fiscal resources."

Other forms of financial commitment were observed when looking at safety program elements. Employee safety meetings had the highest participation of all responses (81%, n = 17) when asked about safety promotion. While this option does not represent a substantial financial commitment, a safety meeting is a non-revenue activity and, by extension, represents some financial commitment. By contrast, other safety promotions with a more noticeable impact on finances received lower response rates, such as safety stand downs (n = 12) and specialized training for safety staff (n = 7). The results shown in Table 13 indicate that management is highly committed to implementing and overseeing SMS programs, which are mainly proactive, compared to traditional safety programs, which are typically reactive. Still, continued investment of resources could further strengthen SMS activities.

Research Question 3

SMS comprises four components: safety policy, safety risk management (SRM), safety assurance, and safety promotion. The third section of the study assesses how and to what degree the participating institutions are implementing each component.

Safety Policy

The safety policy implementation score, shown in Table 14, increased from 64.73% in the previous study to 73.89% in the present study. "Identifying a safety committee" had the most significant increase in implementation, from 57% (n = 16) in the previous study to 90% (n = 19) in the current study. In contrast, a 5% decrease from the previous study in the number of flight training programs that identified an SMS manager or coordinator was observed. The decrease may indicate that flight training programs rely more on committees to manage their SMS systems than a single manager or coordinator.

The number of flight training programs reporting they had developed a set of SMS objectives had a significant 22% increase. The increase may be due to the length of time that SMS has been implemented. In the previous study, 64% (n = 18) of respondents indicated they were more than one year away from full SMS implementation, while only 52% (n = 11) of present respondents indicated the same time frame. The increased number of schools with fully implemented SMS programs supports the increased implementation score for the safety policy component.

The number of respondents who indicated they had "Developed an implementation plan" dropped from 50% (n = 14) previously to 33% (n = 7) currently. While this comparison appears concerning, a deeper dive into the data reveals little change. Of the 14 who did not indicate the presence of an implementation plan in the current study, (a) two indicated that they already had a fully implemented SMS, (b) two indicated transitioning to an SMS, with some SMS components functional, (c) five indicated currently having a safety program, and SMS was under development, and (d) five indicated the presence of a safety program, and SMS was not under development. Suppose the presence of an implementation plan is assumed for those respondents who indicated that they currently have a fully implemented SMS. In that case, the percentage of respondents who have or had an implementation plan at one point due to having already implemented SMS rises to 42.86% (n = 9) compared to 50% (n = 14) in the previous study. Overall, the data indicates continued advancement in SMS adoption at Part 141 programs, with more institutions embracing structured safety policies and objectives.

Table 14
Safety Policy Implementation

Safety Policy Activity/Process	Previous		Current	
	n	%	n	%
Completed gap analysis	8	28.57%	9	42.86%
Developed an implementation plan	14	50.00%	7	33.33%
Developed a safety policy statement	22	78.57%	20	95.24%
Developed a set of SMS objectives	18	64.29%	18	85.71%
Identified an accountable executive	19	67.86%	17	80.95%
Identified an SMS manager/coordinator	24	85.71%	17	80.95%
Identified a safety committee	16	57.14%	19	90.48%
Developed an emergency response plan	24	85.71%	17	80.95%
Total Safety Policy Implementation Score	28	64.73%	21	73.81%

Safety Risk Management

The SRM component of SMS experienced the most significant increase in implementation, rising from 57.86% in the previous study to the present implementation score of 72.45%, as shown in Table 15. Highlighting a substantial improvement in implementation. Among the various elements of SRM, hazard tracking and documentation saw the most significant increase, from 64% (*n* = 18) in the previous study to 86% (*n* = 18) in the current study. The safety risk assessment element saw a similar increase, from 50% (*n* = 14) in 2017 to 71% (*n* = 15) in the present data, suggesting that more institutions are incorporating structured processes for evaluating risks. Overall, the data indicates a move to a more proactive SRM system.

The notable increase in Hazard Tracking and Documentation appears to be the most significant among the SRM components. As noted in the previous study by Roberson et al. (2017), only 75% (*n* = 18) of those respondents who practiced hazard identification reported tracking and documenting those hazard trends over time. In the current study, 94% (*n* = 18) of those who practiced hazard identification (*n* = 19) tracked and documented that information to identify hazard trends. Considering that trend analysis is one of the last stages in safety risk management (Robertson et al., 2017), this increase identifies significant progress in developing and implementing SRM in collegiate flight schools. The data indicates that pilot training programs are moving beyond basic hazard identification toward more comprehensive risk management practices, reflecting a strong safety culture and a more data-driven approach to mitigating risks.

Table 15
SRM Implementation

SRM Activity/Process	Previous		Current	
	n	%	n	%
Hazard Identification	24	85.71%	19	90.48%
Hazard Tracking and Documentation	18	64.28%	18	85.71%
Risk Analysis	19	67.86%	16	76.19%
5-step SRM Process	6	21.43%	8	38.10%
Safety Risk Assessment	14	50.00%	15	71.43%
Total SRM Implementation Score	28	57.86%	21	72.45%

Safety Assurance

Overall, the safety assurance component of SMS saw a conservative increase in implementation score from 44.20% in 2017 to 54.77%, as shown in Table 16. The most significant increase and decrease were related to the transition from paper-based confidential hazard reporting systems to digital-based systems. In both studies, nearly all respondents had a confidential reporting system in place. Only 54% (*n* = 15) of respondents utilized digital reporting systems in 2017 compared to 90% (*n* = 19) in the current study. In contrast, 57% (*n* = 16) of respondents in the 2017 study indicated using paper-based systems compared to 29% (*n* =

6) in 2023. With web-based applications increasing in popularity and ease of access, future studies may show a continued shift from paper to web-based reporting systems.

Flight data monitoring (FDM) analysis increased notably from 29% (*n* = 8) in 2017 to 62% (*n* = 13) in the present data. The increase shows a commitment to increasing safety within the represented flight training programs. Possible reasons for the increase could include increased use of fully integrated digital cockpit displays, more widespread knowledge of these systems' capabilities, or increased interest after seeing what early adopters have done with data. The processes involved in safety assurance, particularly those involving monitoring and analysis, are often the last ones to be implemented. It is also important to note that the FDM analysis takes time, skilled personnel, and resources. The fact that such a substantial increase in FDM analysis was observed is highly encouraging. Further research is needed to determine how different institutions utilize their FDM findings regarding policies and operations.

The implementation percentage for continuous monitoring of safety controls remained unchanged between the two studies. In 2017, 42.86% (*n* = 12) reported implementing continuous monitoring of safety controls compared to 42.89% (*n* = 9) in the present study. The lack of increase could indicate challenges in maintaining long-term oversight processes, possibly due to resource constraints or a lack of standardized procedures. While progress has been made, there is still room for improvement in fully integrating safety assurance components across Part 141 programs.

Table 16
Safety Assurance Implementation

Safety Assurance Activity/Process	Previous		Current	
	n	%	n	%
Confidential Hazard Reporting System - Paper	16	57.14%	6	28.57%
Confidential Hazard Reporting System - Web	15	53.57%	19	90.48%
Trend Analysis Capability	14	50.00%	13	61.90%
Safety Performance Monitoring	9	32.14%	10	47.62%
Continuous monitoring of Safety Controls	12	42.86%	9	42.86%
Flight Data Monitoring Analysis	8	28.57%	13	61.90%
SMS Audits/Evaluations	7	25.00%	8	38.01%
Safety Culture Assessments	18	62.29%	14	66.67%
Total Safety Assurance Implementation Score	28	44.20%	21	54.77%

Safety Promotion

The implementation score for the safety promotion component of SMS, shown in Table 17, remained nearly the same between the two studies, with 48.02% in 2017 and 49.73% in 2023. The reported use of safety stand-downs increased significantly from 36% (*n* = 10) in 2017 to 57% (*n* = 12) in the present study, indicating a possible stronger emphasis on temporarily pausing operations for dedicated safety training. The use of safety bulletin boards declined by

25% between 2017 and 2023. Similarly, regular SMS training for students decreased from 39% (*n* = 11) in 2017 to 19% (*n* = 4) in 2023. These declines raise concerns, suggesting a shift away from traditional forms of communication and structured SMS training. The only other component with significant change is safety newsletters, with 39% (*n* = 11) reporting using safety newsletters in 2017 compared to 57% (*n* = 12) in 2023. The data indicates that institutions may be relying more on structured, periodic safety communication.

Similarly, a shift from paper reporting systems to web-based reporting systems was observed, but a shift from safety bulletin boards is notable. While it might be tempting to infer an increase in analog promotion methods when noting the increased use of safety newsletters, as of this writing, a newsletter is likely. Further research is needed to determine if modern social media applications like Instagram are replacing promotional tools like bulletin boards. The effectiveness of social media and short video format content as a safety promotion tool for higher education aviation institutions is also worthy of further study.

Table 17
Safety Promotion Implementation

Safety Promotion Activity/Process	Previous		Current	
	n	%	n	%
Specialized SMS Training	10	35.71%	7	33.33%
Regular SMS training – Employees	8	28.57%	7	33.33%
Regular SMS training – Students	11	39.29%	4	19.05%
Safety bulletin boards	23	82.14%	12	57.14%
Safety newsletters	11	39.29%	12	57.14%
Employee safety meetings	25	89.29%	17	80.95%
Student safety meetings	19	67.86%	15	71.43%
Safety awards program	4	14.29%	8	38.10%
Safety stand-downs	10	35.71%	12	57.14%
Total Safety Promotion Implementation Score	28	48.02%	21	49.73%

Table 18
Fatigue Risk Management Implementation

Fatigue Risk Management Systems	Current	
	n	%
Fatigue safety action group	2	9.52%
FRMS policy	2	9.52%
FRMS objectives	1	4.76%
Fatigue specific reporting system	1	4.76%
Process to identify fatigue hazards and risks	5	23.81%
Utilize human factors analysis and classification system (HFACS)	5	23.81%
Flight risk assessment tool (FRAT)	9	42.86%
FRMS safety performance indicators	1	4.76%
FRMS documentation	1	4.76%
Fatigue awareness training	6	28.57%
Fatigue awareness promotion	4	19.05%
Flight duty period for students	10	47.62%
Flight duty period for instructors	14	66.67%
Collect sleep data on students	0	0.00%
Collect sleep data on instructors	0	0.00%
Other (please specify)	1	4.76%
Total Safety Promotion Implementation Score	21	18.45%

Research Question 4

Table 18 displays the results for the final section of the survey that evaluated the implementation of FRMS in collegiate flight training schools. The previous study by Robertson et al. (2017) did not assess FRMS as the concept was relatively new then; thus, there are no previous results to compare. The following is a descriptive report of the status of FRMS implementation as reported by the participants.

The overall implementation score of FRMS at 18.45% was relatively low compared to the SMS implementation scores, indicating that the implementation of FRMS is still in its early stages. The highest implementation scores were for flight duty periods for students (n = 10, 47.62%) and instructors (n = 14, 66.67%). Flight duty periods typically include policies directing rest periods and documentation of time worked, thereby making them easier to implement and manage. None of the respondents indicated that they collect sleep data for students or instructors. One institution (4.76%) marked "other," specifying they emphasized fatigue during instructor/pilot and student safety meetings.

One of the highest implementation scores was for the FRAT at 42.86% (n = 9). A FRAT is relatively easy to implement and does not bring a significant fiscal impact, which may account for the higher implementation score. While the use of FRATs was not assessed by Roberton et al. (2017), it is worth noting that the concept of a FRAT predates FRMS. FRATs are not exclusively

FRMS tools but have their roots in SMS. The FAA discusses the concept of a FRAT as early as 2007 in their Information for Operators (InFO) publication (FAA, 2007). InFO 07015 states the importance of a FRAT as an SMS tool. Given that FRATs predate the prevalence of FRMS, the high percentage of FRAT implementation compared to other tools is understandable.

Overall, while some components of FRMS, such as flight duty period tracking and FRAT use, are being implemented, other strategies, such as sleep data collection, are lacking. Considering that collegiate flight students tend to have poor sleep quality and irregular sleep schedules, the low adoption of FRMS is concerning (Romero et al., 2020). With 95% of collegiate flight students and instructors reporting that fatigue has negatively impacted their flight training, the need for more significant institutional commitment to FRMS development through potential policy changes, training, and increased awareness of fatigue-related risks in flight training environments is critical to ensure safe operations (Keller et al., 2022; McDale & Ma, 2008; Romero et al., 2020).

Future Research

The SMS and FRMS data reported in this study are descriptive and represent a snapshot of implementation during 2021-2022. Therefore, a follow-up study should be conducted in three to five years to generate comparative data on SMS and FRMS implementation utilizing an updated classification system to correspond with the current SMS AC 120-92D and FRMS AC 120-103A. Considering that some Part 141 programs contract out their flight training to third-party providers, it is recommended that a separate study be conducted to identify barriers to implementing SMS and FRMS among these specific institutions. Additionally, exploring Part 141 institutional factors such as financial constraints, policy challenges, and administrative resistance may help identify barriers to SMS and FRMS implementation and thus help identify potential solutions.

Although SMS and FRMS are closely related, the FAA continues to treat them as separate systems. Future research should investigate potential impacts on the effectiveness of SMS and FRMS if they were treated as a single system. Furthermore, additional research should evaluate the implementation of FRMS elements listed in ICAO Doc 9966 that were not assessed in this study.

Conclusion

Considering the data, it can be concluded that college flight programs are doing well with SMS implementation. Overall, knowledge of SMS has increased among the management of college flight programs. Participants reporting as "knowledgeable" of SMS increased from 2017 to the current study. Additionally, the SRM implementation score increased by over 15%. Further, safety policy and safety assurance implementation scores increased by approximately 10% each, while safety promotion implementation remained relatively unchanged. Overall, most components' scores increased or remained unchanged, demonstrating a solid commitment to safety. Conversely, the FRMS implementation score was relatively low at 18.45% compared to SMS implementation scores. The difference in implementation rates between the two systems may be due to FRMS being created after SMS. The fact that the FAA treats SMS and FRMS as two independent systems is also a possible reason for low FRMS implementation rates.

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Appendix A

Table A1
SMS Components and Related Elements

Safety Policy	Safety Risk Management	Safety Promotion	Safety Assurance
• Completed gap analysis • Implementation plan • Safety policy statement • SMS objectives • Identified accountable executive • Identified SMS manager/coordinator • Identified safety committee • Emergency planning and response	• Hazard identification • Hazard tracking and documentation • Risk analysis • 5-Step SRM process • Conducted safety risk assessments	• Specialized SMS training • Regular SMS training – Employees • Regular SMS training – Students • Safety bulletin boards • Safety newsletters • Employee safety meetings • Student safety meetings • Safety awards program • Safety stand-downs	• Confidential hazard reporting system – Web • Confidential hazard reporting system – Paper • Trend analysis • Safety performance monitoring • Continuous monitoring of safety controls • Flight data monitoring analysis • SMS audits or evaluations • Safety culture assessments

Table A2
FRMS Components and Related Elements

Policy and Documentation	FRMS Processes	Promotion Processes	Safety Assurance
• Policy • Objectives • Flight Duty Periods • Creating a Fatigue Safety Action Group	• Identification of hazards • Risk Assessment • Use of HFACS	• Training programs	• Fatigue Specific Reporting System • FRMS performance monitoring