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Systematic Review of Safety Management Systems in the United States General Aviation

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Abstract

A safety management system may benefit General Aviation by increasing safety and reducing accident rates. This paper aims to systematically review the existing literature in targeted databases for gaps concerning general aviation safety management systems. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology provided the overall structure. Science Direct®, Embry Riddle Aeronautical University's Scholarly Commons, and the Federal Aviation Administration's (FAA) website were the three publicly available sources. Initial search criteria included PDF research articles (2006-2022), including the terms *safety management system* and *general aviation*. Additionally, keyword searches for the terms *policy, promotion, risk management*, and *assurance* guided the analysis. A final case review was conducted to eliminate faulty connections and false positive word matches. Bias may exist in this project due to the single author and lack of additional reviewers. However, two strategies were employed to maximally reduce unintended bias: (1) software-generated keyword searches and (2) a 1-week delay between reviews. The initial search returned 197 listings. Twenty-nine records remained after multiple rounds of elimination and review. The results suggest that general aviation participants receive minimalistic exposure to the benefits of the safety management system. Seven FAA publications showed little evidence of a safety management system within general aviation. Twenty-two research articles demonstrated a strong understanding of the safety management system's components, especially safety risk management. As a result of this review, it is recommended that the FAA explore the feasibility of incorporating additional safety management system education, awareness, and best practices. Additionally, future research should explore contributing factors related to the benefits of

establishing a safety management system in general aviation operations. This project did not require any funding.

Keywords: safety management system, general aviation, safety assurance, safety policy, safety promotion, safety risk management, systematic review

Introduction

The 2020 General Aviation (GA) accident rate (see Table 1) was 42 times higher than U.S.-based airlines (National Transportation Safety Board [NTSB], 2021). The commercial air carrier service industry experiences much lower accident rates largely in part due to the mandatory requirement to establish a Safety Management System (SMS) in accordance with federal law (Aeronautics and Space, 2021; Federal Aviation Administration [FAA], 2015, 2017). However, a similar requirement does not exist for GA operators. In addition to the lack of a formal requirement to establish an SMS, human error is a common causal factor (Liou et al., 2008). While technology may reduce human error in the future, SMS currently exists and boasts proven performance.

Table 1

2020 Accident Rate Comparison

Activity	Accidents	Flying Hours	Accidents per 100,000 Flight Hours	Comparison to 14 CFR Part 121 Scheduled
14 CFR 121 Scheduled	11	8,331,981	0.132	
14 CFR 121 Nonscheduled	3	566,788	0.529	+400.92%
14 CFR 135 Commuter	5	224,968	2.223	+997.50%
14 CFR 135 On-Demand	40	3,037,404	1.317	+1683.47%
General Aviation	1,085	19,454,467	5.572	+4220.52%

Note: Table 6 shows all values from 2001-2020. The values in Table 1 are summarized and adapted from the *Aviation Accident Rates 2001-2020* [Table] by NTSB, 2021 (https://www.ntsb.gov/safety/Pages/research.aspx).

The SMS may be a solution and warrants exploration. This systematic literature review seeks to qualitatively analyze scholarly content from narrowly targeted databases. To begin, a

working definition of an SMS is essential. According to the FAA, an SMS is "an organization-wide comprehensive and preventive approach to managing safety [that] includes a safety policy, formal methods for identifying hazards and mitigating risk, and promotion of a positive safety culture" (FAA, 2015, p. 1).

Next, it is equally vital to describe the four components of the SMS. *Safety policy* contains the organization's standards, goals, and core duties. *Safety risk management* allows the management team to thoroughly understand a line of effort's hazards and associated risks to improve decision making. *Safety assurance* is the tool an organization uses to assess the system's efficacy. Finally, an SMS is an all-encompassing organizational construct. *Safety promotion* contains the tools for management to communicate clearly and completely with employees about responsibilities, policies, hazards, and risk controls (FAA, 2015).

Purpose Statement

The purpose of this systematic literature review was to identify, categorize, and characterize the literature in narrowly selected databases concerning SMS in GA. The investigation targeted publications with discussion of an SMS by searching for the four components: *safety policy, safety assurance, safety risk management,* and *safety promotion* (FAA, 2015). The primary goal of this review was to uncover and synthesize literature gaps related to implementing an SMS in GA. Highlighting the limitations in the literature may lead to opportunities for additional research, policy development, and possibly an accident rate reduction. The following question led the investigation: Does the current literature (e.g., research articles, advisories, handbooks, manuals, and regulations) in the targeted databases explore implementing an SMS in GA?

Methods

The structure of this qualitative review is inspired by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology (Page et al., 2021). PRISMA is a widely accepted process established to clearly explain a report's purpose, method, and findings (https://www.prisma.io/). For this literature review, the PRISMA process informed how to systematically gather records and organize the report. Two databases and a civil aviation authority's website were searched: ScienceDirect® (www.sciencedirect.com), the Embry-Riddle Aeronautical University Scholarly Commons (https://commons.erau.edu/), and the FAA Handbooks and Manuals webpage (www.faa.gov/regulations_policies/handbooks_manuals). The entire PRISMA process is shown in Figure 4 (see Appendix A).

Eligibility Criteria

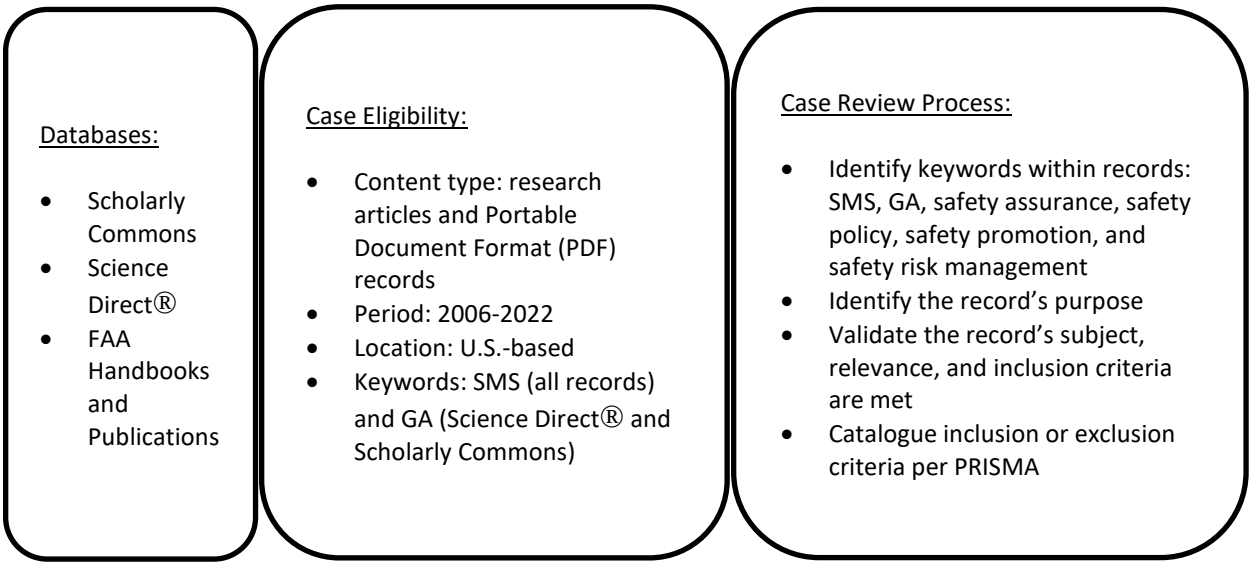
The PRISMA checklist outlines strict criteria, which led to the narrow design of this review. Four main components informed the database searches and inclusion strategy: (1) keywords, (2) location, (3) period, and (4) content type. First, the keyword search included *safety management system* and *general aviation*. Second, the United States GA community was targeted. Third, the period from June 22, 2006, to September 1, 2022, narrowed the field. The beginning of the eligibility period is notable because it was the first year the FAA formalized SMS components via Advisory Circular (AC) 120-92, *Introduction to the Safety Management Systems for Air Operators* (2006). It is also essential to mention that the seminal version of that advisory circular voluntarily applied to certificated and non-certificated air carriers and is now cancelled.

In contrast, AC 120-92B notes the mandatory establishment of an SMS for 14 Code of Federal Regulation (CFR) Part 121 certificate holders (FAA, 2015). Additionally, the

preliminary gap analysis shows that the pertinent aviation regulations lack specific requirements to establish an SMS in GA. Finally, accepted record types included research articles, handbooks, manuals, certification standards, and advisory circulars available in Portable Document Format (PDF). A visual depiction of the search criteria and strategy is depicted in Figure 1.

Figure 1

Search Criteria and Review Strategy



Records from ScienceDirect® and Scholarly Commons comprised all the scholarly research articles, and the FAA's website provided the remaining content. Following the initial search, duplicate returns were removed. While the ScienceDirect® and Scholarly Commons databases allowed for tailored search criteria, the FAA's Handbooks and Manuals website was less accommodating. The same search terms were used, although additional screening was required to narrow the records field. Fortunately, many FAA publications internally referenced pertinent records and provided a path forward. For example, the *Pilot's Handbook of*

Aeronautical Knowledge (*PHAK*) cites the various Airmen Certification Standards (ACS), and each ACS references the *Aeronautical Information Manual* (FAA, 2017, 2018a, 2018b, 2018c, 2019, 2020, 2021d).

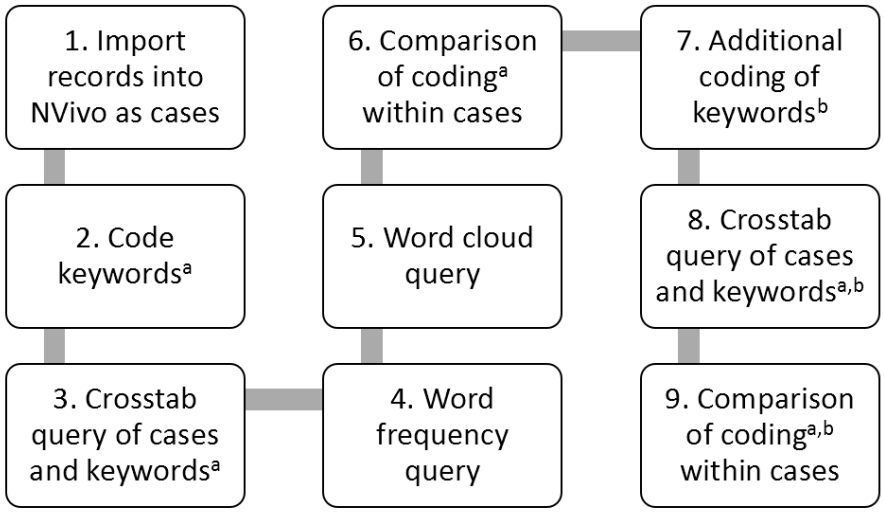
Finally, the selection process concluded by confirming that identified records met the inclusion criteria. For instance, additional care was taken to ensure keyword (e.g., *safety management system, general aviation, policy, promotion, risk management, assurance, accident, reduction,* and *accident rate*) matches positively met the intended purpose of the systematic review instead of returning a false positive word match. In addition, a 1-week delay separated each round of checks to reduce unwanted bias maximally. However, the author independently conducted all searches, reviews, and record screening. The results of the search and exclusion process are cataloged in Figure 4 (see Appendix A), and Table 2 (see Appendix B) lists the final 29 included records.

Data Collection Process

The current project utilized QSR International NVivo (https://lumivero.com/products/nvivo/) software to organize the retained records in Table 2. The first step was importing the documents into the software as cases. After importing the research files into cases, multiple query tools were used for the qualitative analysis. Figure 2 illustrates the entire data collection flow.

Figure 2

Data Collection Flowchart



Note: [a]Safety management system, general aviation, policy, promotion, risk management, and assurance. [b]Accident, reduction, and accident rate.

The second step was using the text search tool to find the terms *safety management system*, *general aviation*, *policy*, *promotion*, *risk management*, and *assurance* within each case. Each of the six keywords, as a qualitative code, were viewed as an indicator of the argument each case made and informed the review process. For example, the third step included running a crosstab query between the cases and six keywords. Using the six keywords as codes and comparing the cross tabulated cases provided insight into how prevalent SMS topics persisted in a case. Table 3 shows the crosstab query's results.

Table 3

Crosstab Query Between 29 Cases and Six Codes

Case	Codes						Total
	Risk Management	Promotion	Policy	Assurance	SMS	GA	
Adjekum et al. (2016)	6	4	4	2	7	1	24
Baugh & Stolzer (2018)	2	1	1	1	3	21	29
Baugh (2020)	13	3	7	10	15	89	137
Boyd et al. (2021)	0	0	0	2	4	59	65
Burgess et al. (2018)	4	0	0	0	3	55	62
Canders (2016)	2	3	1	2	4	2	14
Dickson (2021)	6	20	8	6	20	2	62
FAA (2015)	28	17	59	27	36	0	167
FAA (2017)	42	0	4	6	1	47	100
FAA (2018a)	148	1	3	1	2	1	156
FAA (2018b)	71	1	3	1	2	1	79
FAA (2018c)	148	1	3	1	2	1	156
FAA (2019)	121	1	3	2	2	1	130
FAA (2021c)	24	1	5	1	2	0	33
Harriman et al. (2009)	0	0	0	0	4	19	23
Idowu (2021)	20	0	0	0	1	2	23
Levin et al. (2019)	4	0	0	0	1	7	12
Mendonca et al. (2020)	4	0	0	0	3	6	13
Keller et al. (2021)	11	5	5	2	3	4	30
Mrusek & Douglas (2020)	3	1	2	2	8	4	20
Rankin (2010)	1	0	0	0	6	19	26
Shappell et al. (2010)	1	0	0	4	2	17	24
Teperi et al. (2015)	0	0	0	0	1	1	2
Ucler & Gok (2015)	0	0	1	1	2	7	11
Velazquez & Bier (2015)	8	5	1	6	16	1	37
Velazquez & Bier (2015)	18	6	4	6	10	2	46
Woo (2015)	5	2	3	4	12	1	27
Xue & Fu (2018)	3	1	1	1	13	127	146
Zubowski (2021)	1	0	0	2	10	1	14
Total	694	73	119	90	195	498	1669

Note: Table 3 represents a code's frequency within its respective text.

The crosstab query in Table 3 succinctly provides valuable insights into each case and allows for multiple cases to be compared simultaneously. The high total code count values on the right

suggested a case focused on the subject in each column. Cases with high counts in both GA and SMS suggested the presence of promotion and required additional analysis. The fourth and fifth steps included running a word frequency and word cloud query. Figure 3 illustrates the word cloud, and Table 4 shows the top 10 most frequent words and associated weighted percentages (see Appendix B).

Figure 3

Word Cloud of Top 100 Words with Greater than Four Characters

Next, the sixth step involved examining the coding density values among the cases. Again, the lack of pertinent coding in a case greatly informed the investigation. Seventh, additional keywords (*accident, reduction,* and *accident rate*) were coded to assist with answering this systematic review's research question. The second to final step was running a crosstab query to compare instances of the first-round codes to the second-round codes. Four cases included codes from both rounds. Those values are shown in Table 4.

Table 4

Crosstab Query of First-Round and Second-Round Codes

Code	Case			
	Baugh (2020)	Baugh & Stolzer (2018)	Keller et al. (2021)	Velazquez & Bier (2015a)
Reduction	45	8	14	3
Accident Rate	9	1	1	1
Accident	692	22	16	17
Risk Management	13	2	11	18
Promotion	3	1	5	6
Policy	7	1	5	4
Assurance	10	1	2	6

The crosstab query results in Table 4 show each case's code frequencies. Higher counts suggest more focus on the subject matter under review. The final step in the data collection flow was comparing all the coding within cases and is discussed in the results section.

Results

Following the PRISMA process resulted in a review of three targeted databases and produced 197 initial results. Next, the three database listings were reduced (n = 154), and duplicates were excluded (n = 2). Finally, the review process began with the remaining 78 records. Records (n = 49) were removed for five reasons: (1) not U.S.-based, (2) not GA, (3) SMS not in the text, (4) not in period, and (5) not a research article. Ultimately, a targeted keyword analysis resulted in 29 records comprising the final case listing (see Table 2). The initial research question asked if the literature in the targeted databases and timeframe discusses implementing an SMS in GA. The results show that an SMS may be mentioned tangentially to other topics but is narrowly being explored for implementation in GA. Additionally, a major gap was uncovered during this review: multiple FAA ACS documents address the structure of the

SMS in their front matter. However, the remaining content in each document lacks assessment of the system's application (FAA, 2018a, 2018b, 2018c, 2019, 2021d).

Five of the 29 records included *safety management system* in their titles (Canders, 2016; Dickson, 2021; Rankin, 2010; Woo, 2015; Zubowski, 2021). The Canders' (2016) literature review suggests a peer review process for collegiate pilot training programs like scholarly peer reviews. Dickson's (2021) study also focused on the collegiate pilot school environment by examining SMS training methodologies. Rankin (2010) investigated a plan-do-check-act (PDCA) tool to improve student pilot decision-making during real-world security-related issues. Zubowski (2021) examined the quantitative and qualitative tools available to measure organizational safety culture. Additionally, the Shappell et al. (2010) study looked at GA pilot decision making that led to adverse weather-related mishaps and proposed enhancing primary and recurrent training efforts. Finally, the only record with SMS in the title that directly applied to GA was the Woo (2015) study. In that article, a clear case is made to enhance GA operations within a small flight training school by implementing an SMS and bolstering the safety culture.

Another possible indicator of SMS components (*safety assurance, safety policy, safety promotion,* and *risk management*) promotion is the frequency of use in each text. Table 3 shows the respective term frequency in each record. *Risk management* occurs more than the other components (n = 694), and *promotion* is the least used (n = 73). The FAA's (2015) *Safety Management Systems for Aviation Service Providers* narrowly holds the highest count of all coded keywords (*risk management, promotion, policy, assurance, SMS,* and *GA).* It is important to reiterate that AC-120-92B applies directly to certificated air carriers; GA can participate voluntarily.

Additionally, almost all records include at least one of the six coded keywords. However, Harriman et al. (2009) and Teperi et al. (2015) do not include any of the four components as part of the subject matter, despite including the SMS term within their text. Harriman et al. (2009) centers on reducing risk for light jet operations at GA airports from an emergency response preparedness perspective. Teperi et al. (2015) proposed a new human factors model to improve the air traffic control organizational safety environment. Ultimately, neither case promotes the use of SMS in GA. A case that surprisingly excludes the discussion of an SMS is the PHAK. The text notes that it includes essential information across a wide range of topics and then merely provides an acronym definition for SMS. The redeeming feature is that it thoroughly discusses risk management, aeronautical decision-making, voluntary safety reporting, and other topics associated with a functioning SMS.

The results of the crosstab query revealed that 17 cases mentioned all four SMS components: Adjekum et al. (2016), Baugh (2020), Baugh and Stolzer (2018), Boyd et al. (2021), Canders (2016), FAA (2015, 2018a, 2018b, 2018c, 2019, 2021d), Keller et al. (2021), Mrusek and Douglas (2020), Velazquez and Bier (2015a, 2015b), Woo (2015), and Xue and Fu (2018). Three of the 17 records used *risk management* over 100 times (FAA, 2018a, 2018c, 2019). Alternately, *safety promotion* is used least throughout the examined cases. Twelve records did not mention *promotion,* and eight used the term once. The FAA (2015) had the second most densely used component keyword, *policy* (n = 59). Similarly, *assurance* was the third-highest component keyword in the same record (n = 27).

While the targeted codes and frequency throughout each case may have suggested SMS promotion, there were multiple retained records that included the necessary codes that did not contribute to answering the research question. For instance, Teperi et al. (2015) pertained to an

air traffic management organization, not GA. Similarly, the Ucler and Gok (2015) focused on maintenance, repair, and overhaul facilities. Multiple cases dealt with collegiate flight training programs (Dickson, 2021; Levin et al., 2019; Rankin, 2010). Additionally, numerous cases concerned commercial aviation, not GA (Burgess et al., 2018; Idowu, 2021; Zubowski, 2021). Finally, the Harriman et al. (2009) study looked at airport emergency response and preparedness in conjunction with very light jet operations.

Multiple cases merely defined the SMS or its components and did not robustly expand the discussion toward reducing GA accidents. The most notable category is the FAA's certification standards (2018a, 2018b, 2018c, 2019, 2021d). Each case notes that the ACS fills a role in the risk mitigation strategy. However, pilot applicants are not required to demonstrate an understanding that many of the fundamental underpinnings of their knowledge and performance originate from the SMS component *safety policy.* There may be an explanation for the disconnection; if certified pilots perform according to guidelines and standards, the adjacent SMS components will care for themselves. Unfortunately, that may be a faulty assumption with grave consequences because it depends on a management team to upkeep the *safety assurance* component, which may not be present in many GA situations.

During the second round of review, additional codes were selected to enhance the understanding of SMS component connections to an accident rate reduction. Table 4 shows the four cases identified, including all four SMS components and the second-round codes (Baugh & Stolzer, 2018; Baugh, 2020; Keller et al., 2021; Velazquez & Bier, 2015a). The Keller et al. (2021) study focused on collegiate student pilot fatigue in an environment that utilizes an SMS voluntarily and conducts extensive safety training. The Baugh and Stolzer (2018) case aptly defines the benefits of an SMS and posits that language-related factors may be underreported.

The study also seeks to improve oversight and prevent future accidents. The Velazquez and Bier (2015a) case noted the importance of the SMS and CRM individually while also investigating connections between the two accident reduction strategies. Finally, the Baugh (2020) article appropriately fits into a proactive SMS mindset as it seeks to predict accidents using computer technology. It is important to note that while the SMS terminology is present within each of the articles, the authors are not advocating for an SMS to be established in GA.

Discussion

Three themes surfaced from the included publications. First, the included FAA cases insufficiently report the existence of the SMS as a strategy to reduce GA accident rates. Second, improved *risk management* is the focus of multiple cases. It is appropriately included due to its direct impact on pilot decision-making. Third, many of the individual components of the SMS are present in the reviewed cases. However, the FAA points out that all "four areas are essential for a safety-oriented management system" (2015, p. 9). Fortunately, the literature shows positive signs of continued academic and industry efforts to decrease the accident rate and make GA safer. However, additional opportunities for improvement remain in promoting the SMS to GA operators.

Limitations

It is critical to note that this systematic literature review was conducted with a narrow focus and strict case eligibility conditions. The final records reviewed originated from three databases during a short period. For that reason, there may be literature that promotes the use of an SMS in GA in other databases.

Recommendations

Three recommendations emerged following the review. First, the FAA should consider extending the commercial sector's mandatory SMS strategy to the GA community through increased education, awareness, published best practices, and enhanced assessment criteria. As a result, the GA community may benefit from the increased focus on safety management practices used in the commercial sector. Second, future research in this subject area should identify the factors associated with implementing a formalized SMS in GA operations. For example, GA may contain cultural differences compared to the commercial sector, and those factors may impact the successful adoption of an SMS. Ultimately, there may be additional strengths, weaknesses, and unintended consequences from adopting a widespread SMS in GA. Finally, this project's narrow scope significantly limited the period and database content for review. Future research should use a similar systematic methodology across additional databases to continue addressing this study's research question.

Conclusion

This systematic review aimed to explore the extent to which GA participants are exposed to an SMS and its components through published research and advisories. The preliminary gap analysis showed that GA participants receive minimalistic exposure to the SMS construct and mainly in a voluntary nature. Similarly, additional investigation via the retained cases strongly suggested that formalized SMS structures are lacking within the broader GA community. For example, the ACSs quickly define the SMS and then omit any form of knowledge assessment about the organizational construct. It is critical to note that pilot assessment processes include individual knowledge measurements related to separate SMS components. However, a quintessential pilot training publication omits discussion concerning the importance of SMS

concepts (FAA, 2017). While it may not amount to promotion, many of the individual components of an SMS are extensively covered by multiple documents.

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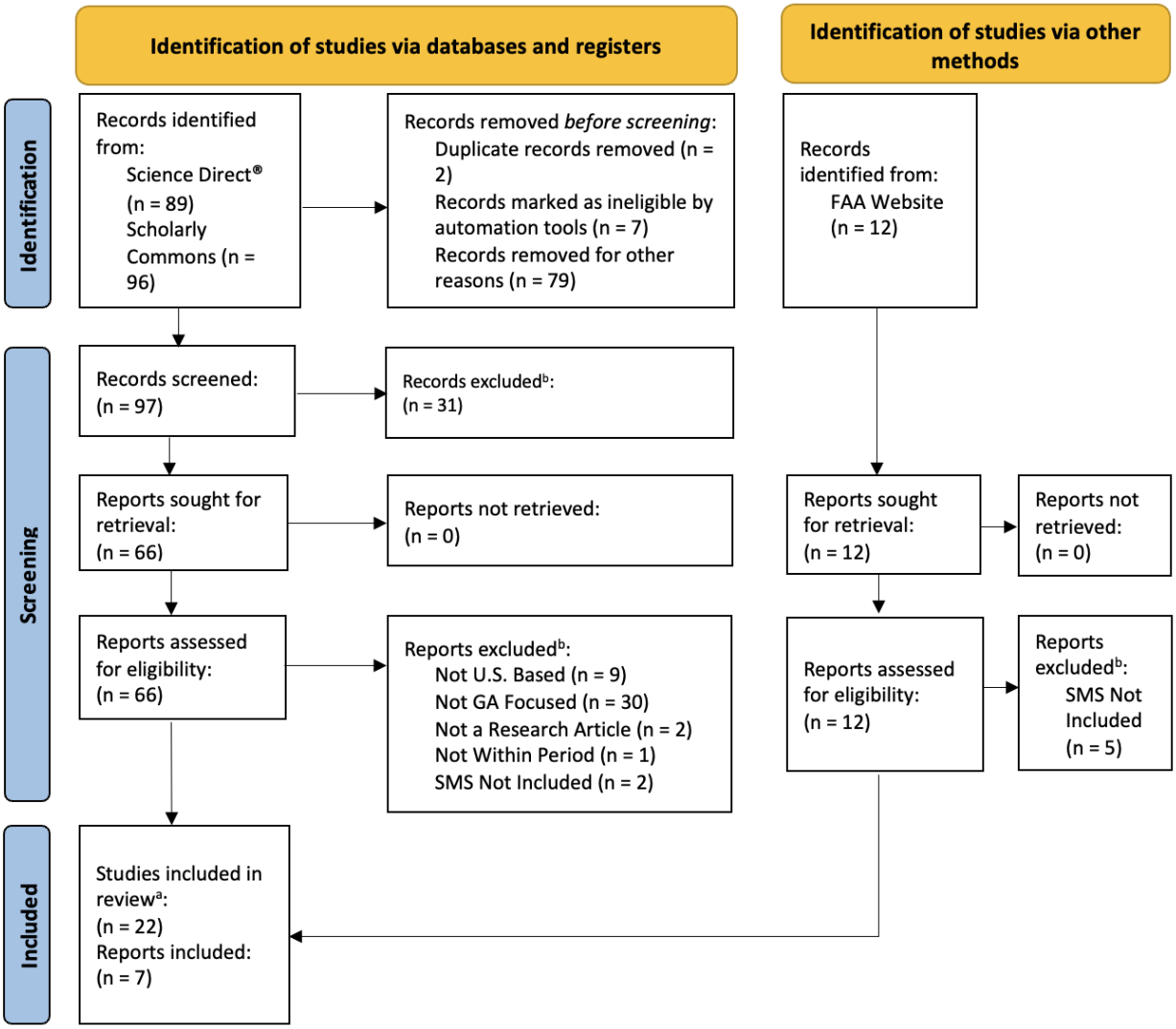
Appendix A

Figure 4

PRISMA Flowchart

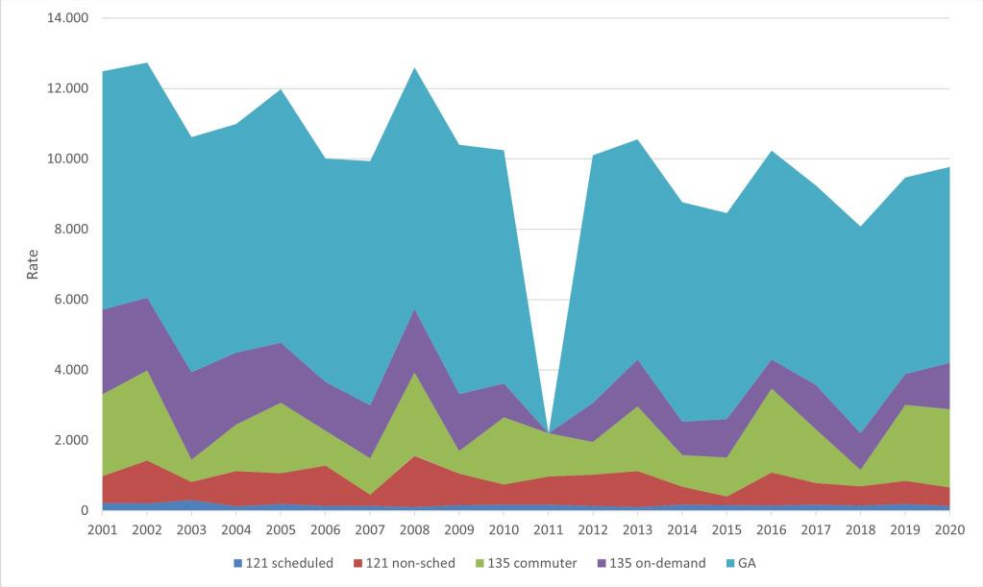


Note: Flowchart constructed using the guidance in The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews by M.J. Page, J.E. McKenzie, P.M. Bossuyt, I. Boutron, T.C. Hoffman, C.D. Mulrow et al., 2022, *BMJ: British Medical Journal (Online)*, *372*(71), https://doi.org/10.1136/bmj.n71.

[a] Included records are shown in Table 2. [b] Excluded records are shown in Table 7.

Figure 5

Accident Rate Per 100,000 Flying Hours



Note: Figure 5 is a visual depiction of the values presented in Table 6. The GA accident rate remains higher than all commercial aviation sectors, especially the 14 CFR Part 121 scheduled air carrier sector that is narrowly visible at the bottom of Figure 1. Data for 14 CFR Part 135 on-demand and GA were not available in 2011. Adapted from *Aviation Accident Rates 2001-2020* by NTSB, 2021 (https://www.ntsb.gov/safety/Pages/research.aspx).

Appendix B

Table 2

Included Records

Records	Record Focus	SMS Components Discussed in the Record
Adjekum et al. (2016)	Examines safety culture in pilot schools	Assurance, policy, promotion, risk management
Baugh (2020)	Proposes predictive model to reduce GA accidents	Assurance, policy, promotion, risk management
Baugh & Stolzer (2018)	Explores ASRS database to discover language-related accidents	Assurance, policy, promotion, risk management
Boyd et al. (2021)	Compares GA accident rates to the more experienced sectors of the industry	Assurance, promotion
Burgess et al. (2018)	Fatalities compared among GA operations	Risk management
Canders (2016)	Literature review of SMS programs in pilot schools and proposal of peer-reviewed SMS	Assurance, policy, promotion, risk management
Dickson (2021)	Compares the SMS using a survey to measure knowledge	Assurance, policy, promotion, risk management
FAA (2015)	Describes Safety Management Systems for Aviation Service Providers	Assurance, policy, promotion, risk management
FAA (2017)	Provides essential knowledge and concepts for pilots	Risk management
FAA (2018a)	Certification Standards for Private Pilots	Assurance, policy, promotion, risk management
FAA (2018b)	Certification Standards for Commercial Pilots	Assurance, policy, promotion, risk management
FAA (2018c)	Certification Standards for Instrument Rating – Airplane	Assurance, policy, promotion, risk management
FAA (2019)	Certification Standards for Airline Transport Pilots	Assurance, policy, promotion, risk management
FAA (2021d)	Certification Standards for Remote Pilot – Small UAS	Assurance, policy, promotion, risk management
Harriman et al. (2009)	Small general aviation airports' emergency response capabilities	Promotion
Idowu (2021)	Evaluates the ACS based on HFACS	Risk management
Keller et al. (2021)	Investigate contributing factors to fatigue in a collegiate pilot training program	Assurance, policy, promotion, Risk management

Note: The third column, *SMS Components Discussed in the Record,* is an alternate display of the crosstab query results shown in Table 3.

Table 2 Continued

Records	Record Focus	SMS Components Discussed in the Record
Levin et al. (2019)	Part of a series investigating fatigue in pilot schools	Policy, risk management
Mendonca et al. (2020)	Evaluates the FRAT in part 141 context	Risk management
Mrusek & Douglas (2020)	Proposes the use of REPAIRER anonymous reporting tool for maintenance personnel	Assurance, policy, promotion, risk management
Rankin (2010)	Proposes PDCA tool for managing general aviation security issues at airport	Policy, promotion, RM
Shappell et al. (2010)	Expand understanding of GA pilot decision-making in hazardous weather	Assurance, risk management
Teperi et al. (2015)	Proposes ATC Human Factors tool	None
Ucler & Gok (2015)	Offers an innovative IT system for GA	Assurance
Velazquez & Bier (2015a)	SMS and CRM comparison	Assurance, policy, promotion, risk management
Velazquez & Bier (2015b)	Importance of undergraduate collegiate SMS study	Assurance, policy, promotion, risk management
Woo (2015)	Safety culture in small flight school	Assurance, policy, promotion, risk management
Xue & Fu (2018)	Proposes the use of the Swiss Cheese Model (SCM)-GA to inspect and investigate	Assurance, policy, promotion, risk management
Zubowski (2021)	Explored available tools to measure safety culture	Risk management, assurance

Table 4

Ten Most Used Words

Word	Length	Count	Weighted Percentage (%)
flight	6	4241	0.93
aircraft	8	4182	0.92
safety	6	3286	0.72
aviation	8	2734	0.60
pilot	5	2439	0.54
management	10	1830	0.40
system	6	1523	0.34
applicant	9	1448	0.32
risk	4	1400	0.31
training	8	1398	0.31

Note: It is valuable to note that *safety*, *management*, *system*, and *risk* are present in the top 10 most used words of the retained documents.

Table 5

Accident Rate Values from 2001 to 2020

Year	14 CFR Part 121 Scheduled Air Carrier	14 CFR Part 121 Non-scheduled Air Carrier	14 CFR Part 135 Commuter Air Carrier	14 CFR Part 135 On-demand Air Carrier	14 CFR Part 91 General Aviation
2001	0.216	0.762	2.330	2.402	6.779
2002	0.203	1.225	2.559	2.061	6.690
2003	0.302	0.517	0.627	2.494	6.682
2004	0.126	1.002	1.324	2.038	6.493
2005	0.182	0.885	2.002	1.704	7.204
2006	0.139	1.138	0.995	1.390	6.347
2007	0.137	0.321	1.028	1.512	6.936
2008	0.102	1.464	2.357	1.810	6.871
2009	0.151	0.901	0.646	1.620	7.080
2010	0.162	0.582	1.907	0.964	6.630
2011	0.166	0.803	1.228	Unavailable	Unavailable
2012	0.133	0.888	0.930	1.107	7.040
2013	0.104	1.020	1.845	1.330	6.259
2014	0.167	0.515	0.895	0.958	6.229
2015	0.154	0.246	1.112	1.094	5.851
2016	0.146	0.936	2.388	0.829	5.934
2017	0.166	0.621	1.530	1.254	5.677
2018	0.149	0.538	0.475	1.041	5.872
2019	0.188	0.660	2.159	0.876	5.582
2020	0.132	0.529	2.223	1.317	5.572

Note: Values retrieved from *Aviation Accident Rates 2001-2020* by NTSB, 2021 (https://www.ntsb.gov/safety/Pages/research.aspx).

Table 6

Excluded Records

Record	Reason for Exclusion
Brooker (2006)	Not within period
Canders (2015)	Not a research article
Chang & Wong (2012)	Not pertinent to GA
Chen & Chen (2014)	Not pertinent to GA
Clark (2010)	Not a research article
Clark (2014)	Not pertinent to GA
Cui & Li (2015)	Not USA based study
Dönmez & Uslu (2020)	Not pertinent to GA
Drogoul et al. (2007)	Not pertinent to GA
Efthymiou et al. (2021)	Not pertinent to GA
Ek et al. (2007)	Not USA based study
FAA (2016)	SMS not included in text
FAA (2020)	SMS not included in text
FAA (2021a)	SMS not included in text
FAA (2021b)	SMS not included in text
FAA (2021c)	SMS not included in text
Filtness et al. (2015)	Not pertinent to GA
Fowler (2019)	Not pertinent to GA
Gao et al. (2021)	Not pertinent to GA
Gerede (2015)	Not USA based study
Hong et al. (2016)	Not USA based study
İNAN (2022)	Not pertinent to GA
Kontogiannis & Malakis (2012)	Not pertinent to GA
Lamb (2019)	Not pertinent to GA
Leveson (2015)	Not pertinent to GA
Mathew et al. (2017)	SMS not included in text
Mendonca & Zimmermann (2021)	Not pertinent to GA
Merkert & Hensher (2013)	Not pertinent to GA
Moretti et al. (2018)	Not pertinent to GA
Munene (2018)	Not pertinent to GA
Novák et al. (2020)	Not USA based study
Odisho (2020)	Not pertinent to GA
Okoh & Haugen (2013)	Not pertinent to GA
Oldam et al. (2017)	Not USA based study
Oster et al. (2013)	Not pertinent to GA

Table 6 Continued

Record	Reason for Exclusion
Pacheco et al. (2014)	Not USA based study
Pantelaki & Papatheodorou (2022)	Not pertinent to GA
Patriarca et al. (2022)	Not USA based study
Pettit (2019)	Not pertinent to GA
Schmid et al. (2018)	Not pertinent to GA
Schreckengast & Drury (2015)	Not pertinent to GA
Schreckengast (2014)	Not pertinent to GA
Servaty-Seib & Brown (2021)	Not pertinent to GA
Strong (2020)	Not pertinent to GA
Teperi & Leppänen (2011)	Not pertinent to GA
Tsuruta (2008)	Not pertinent to GA
Wallace (2016)	Not pertinent to GA
Zhao & Zhang (2019)	Not USA based study