U.S. Department of Transportation

FEDERAL AVIATION ADMINISTRATION

Safety Management Systems
Final Rule

Regulatory Impact Analysis
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Executive Summary

The Federal Aviation Administration (FAA) is amending its regulations to extend the applicability of 14 Code of Federal Regulations (CFR) part 5, Safety Management Systems, to certain design and production certificate holders under part 21, air carriers operating commuter and on demand service under part 135, and Letter of Authorization (LOA) holders operating commercial air tours under § 91.147. The rule also updates the requirements of 14 CFR part 5. This document provides an analysis of the impact of these regulatory changes.

In summary, the FAA estimated quantified annualized costs of $47.4 million using a 7 percent discount rate over a 5-year period of analysis. The costs represent the value of resources that regulated entities would need to develop and implement a safety management system. Mitigation costs, which are yet to be identified and thus unknown, are not quantified. The benefits are the value that would result from avoided fatalities, serious injuries, aircraft damage, and investigation costs, which the FAA evaluated qualitatively because it lacks data on the effectiveness of SMS.

Background and Summary of Regulation

A safety management system (SMS) enables an organization to identify safety hazards, prioritize and manage safety risk, and monitor the effectiveness of safety risk controls. Under 14 CFR part 5, an SMS includes a safety policy, safety risk management, safety assurance, and safety promotion. How an entity implements these four components depends on the size, scope, and operational or technical complexity of its operations or products.

On January 8, 2015, the FAA published a final rule requiring air carriers operating under 14 CFR part 121 to develop and implement an SMS.[1] The final rule added part 5 to 14 CFR, creating requirements for SMS applicable to part 121 operators.

In January 11, 2023, the FAA proposed extending those requirements to certain design and production approval holders, consistent with the Aircraft Certification, Safety, and Accountability Act,[2] recommendations of the National Transportation Safety Board (NTSB), and international standards under the International Civil Aviation Organization (ICAO). Additionally, the FAA proposed extending SMS requirements to part 135 (consistent with NTSB recommendations and ICAO) and LOA holders under § 91.147 (consistent with NTSB recommendations), and several updates to part 5, including sharing of hazard information. The FAA also published a preliminary regulatory impact analysis (RIA).

In this final rule, the FAA promulgates the proposed requirements with several changes. The FAA lengthened compliance schedules by 12 months, required the system description only from design and manufacturing (part 21) organizations, and excepted certain single pilot operations from SMS requirements that would not be applicable to one person. This final RIA also updates for the lengthened compliance schedules and revised applicability for the system description.

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[1] See Final Rule, Safety Management Systems for Domestic, Flag, and Supplemental Operations Certificate Holders, 80 FR 1308 (Jan. 8, 2015).
[2] The citation for the act is: Sec. 102, Pub. L. 116-260, 134 Stat. 2309.

The FAA does not have information on those operators who may be excepted from the requirements that would not be applicable to one person.

Baseline for the Analysis

The baseline for the analysis of incremental benefits and costs of the rule includes existing regulations and standards, existing practices, affected entities, and current risks of aircraft accidents and incidents. The FAA already requires Part 121 operators to implement an SMS. The FAA also provides a voluntary SMS program for certificate holders under parts 21, 135, and 145. The FAA's voluntary SMS programs are based on the requirements in part 5. There are 5 aircraft design and manufacturers and 40 part 135 operators in active conformance (full implementation of the certificate holder's SMS) under the voluntary programs. In addition, some part 121 operators have covered their part 135 operations and part 145 repair station services under their SMS. Finally, certain design and production approval holders (and certificated repair stations[3]) subject to requirements of the European Union Aviation Safety Agency (EASA) (applicable March 7, 2023) are required to develop and implement an SMS under that agency's SMS requirements.

The FAA estimated that the rule would apply to approximately 65 aircraft design and production approval holders. Also, there are approximately 1,848 part 135 operators that would be required to implement an SMS, which includes 203 entities that also hold an LOA to conduct commercial air tours under § 91.147. Additionally, there are 715 LOA holders operating under § 91.147 that are not associated with a part 135 certificate that would be required to implement an SMS under the rule.

With respect to aircraft accidents, although risks associated with regularly scheduled commercial air carriers in the United States are low, there have been accidents involving fatalities and serious injuries. Under part 135, there has been an average of 43 accidents and 24 fatalities annually from 2015 to 2019, mostly in on demand operations. There have also been recent fatal accidents involving air tours conducted under § 91.147 (an average of 7 accidents and 3 fatalities annually from 2015 to 2019).

Benefits

The benefits of the rule would include the value of the reductions in safety risks associated with requiring additional entities to implement SMS. The information available for estimating such benefits include data on accident consequences, accident investigation reports identifying the probable causes, and information on the values associated with avoiding consequences. The FAA relied on aviation accident data from the NTSB for the years 2015 to 2019 (the most recent available at the time of the analysis) and standard values for estimating avoided consequences including fatalities, serious injuries, property damage, and investigation costs.

The FAA evaluated benefits by determining average annual aviation accident consequences, the share of those consequences that could be mitigated under the rule, and the probability of

[3] The rule will not apply to repair stations.

mitigation. The FAA determined the share of consequences that could potentially be mitigatable by the rule by looking at the causes of individual accidents. Requiring design and production certificate holders to implement SMS has the potential to mitigate accidents in all segments of operations. Requiring part 135 operators and § 91.147 LOA holders to implement SMS has the potential to mitigate accidents in operations conducted under part 135 and § 91.147. The probability of mitigation is uncertain.

The FAA identified 11 accidents of which the risk could have been mitigated through an effective SMS in design and production. The FAA also identified 35 part 135 accidents and 4 § 91.147 accidents of which the risk could have been mitigated through an effective SMS. Because the FAA focused on accidents involving fatalities and injuries, not all accidents indicative of the potential for benefits from the rule may have been identified. Additionally, requiring SMS for certain part 21 certificate holders may have beneficial impacts beyond the United States (i.e., to citizens of foreign countries).

Costs

To estimate compliance costs, the FAA developed average onetime SMS development costs and recurring SMS implementation costs. Then, the FAA extrapolated these costs to entities that would fall under the expanded applicability of part 5 who would not already be required to implement an SMS and are not already implementing an SMS voluntarily. To develop these estimates, the FAA conducted limited outreach to industry participants in the FAA's voluntary SMS program to obtain data on implementation costs. In order to properly scale costs for company size, the FAA calculated these costs per employee for certificate holders under part 21 and per aircraft for operators under part 135 and § 91.147. The FAA then extrapolated the costs based on number of employees or number of aircraft. The FAA estimated only minor costs for entities that have already implemented an SMS voluntarily or under existing requirements for part 121.

There are a number of uncertainties in the analysis, including that costs are based on information from a small sampling. As a result, costs could be lower or higher than estimated. The outreach indicated a high level of variability depending on the individual circumstances of the entity (e.g., existing processes and capabilities). For this analysis, the FAA intends for the estimates to represent an average across entities.

Summary of Benefits and Costs

Table 1 provides a summary of annualized and 5-year present value costs using 3 percent and 7 percent discount rates.

Table 1. Summary of Costs[1] (Millions $2022)

Category	Annualized	Present Value (5 Years)
3% Discount Rate		
Part 21[2]	$4.9	$22.5
Part 135	$35.9	$164.5
§ 91.147	$7.2	$33.2
Part 121	$0.05	$0.2

Table 1. Summary of Costs[1] (Millions $2022)

Category	Annualized	Present Value (5 Years)
Total	$48.1	$220.4
7% Discount Rate		
Part 21[2]	$4.9	$20.1
Part 135	$35.3	$144.9
§ 91.147	$7.1	$33.9
Part 121	$0.05	$0.2
Total	$47.4	$194.5
1. Based on quantified impacts. Excludes costs of mitigation. 2. Includes FAA administrative costs.		

Regulatory Alternatives

The FAA considered two alternatives to the rule:

- Alternative 1: Extend applicability of part 5 to include most design and production approval holders under part 21, with some exclusions
- Alternative 2: Exclude from the applicability of part 5 the part 135 operators that use only one pilot-in-command in their operations and § 91.147 LOA holders that conduct less than 100 flights per year.

The FAA considered an alternative to the part 21 applicability based on recommendations from a part 21 SMS Aviation Rulemaking Committee. Under Alternative 1, the SMS requirements would apply beyond holders of both a type and production certificate for the same product and would include most design and production approvals holders. This alternative would exclude design and production approval holders of products, articles, or changes to existing type certificated products that are not typically used for carrying passengers or property for compensation or hire. Also, as part of this alternative, the FAA considered a process that would allow design and production approval holders to apply to be excluded from SMS requirements if their article or approved product alteration would have little or no effect on the continued safe flight or landing of the aircraft.

Under Alternative 1, the FAA estimated that over 3,000 more entities would be required to implement SMS. Additionally, over 3,000 entities (would likely apply to be excluded from the SMS requirements.

Alternative 1 would increase benefits through SMS implementation by the approximately 3,000 entities who design or produce certain safety-critical parts under any design or production approval. The alternative would also hold entities who design and produce interchangeable safety-critical parts to the same SMS standard required of entities holding both a type certificate and a production certificate for the same product. However, as of the date of this analysis, the FAA was not able to estimate these risks or benefits due to a lack of specific data and lack of certainty at this time.

The FAA estimated that costs could be $37 million for Alternative 1, using a number of assumptions because it does not have information for these entities on the size of their aviation design and production processes. The costs would include SMS development and implementation costs, costs to apply for an exception from the requirement to implement SMS, and FAA review and approval costs. Compared to the rule, the increase in costs is approximately $32 million (annualized using a 7% discount rate).

The FAA considered an alternative for part 135 and § 91.147 that would limit the number of small operators affected. Under Alternative 2, the FAA considered excluding from the applicability of part 5 the part 135 operators that use only one pilot-in-command in their operations and the § 91.147 LOA holders that conduct fewer than 100 flights per year. The FAA estimated that 1,300 part 135 operators would be affected under Alternative 2 compared to 1,848 under the rule. The FAA does not have data on the number of § 91.147 LOA holders that conduct less than 100 flights per year. As an estimate, the FAA used LOA holders with one aircraft listed on the LOA. The FAA estimated that 338 § 91.147 LOA holders would be affected under Alternative 2 compared to 715 under the rule.

The reduced applicability under Alternative 2 would lower both benefits and costs. For part 135, costs would be $3.0 million lower compared to the rule. For § 91.147, costs would be $1.6 million lower compared to the rule. With respect to benefits, one of the potentially mitigatable accidents involved an operator that used only one pilot-in-command. These types of operators would not be required to implement an SMS.

Table 2 provides a summary of the analysis of alternatives. The uncertainty associated with the analysis of benefits and costs of the rule also applies to the estimates of the alternatives. Section IV of the preamble to the rule provides the agency's rationale for selecting the option.

Table 2. Summary of Alternatives Analysis

Scenario	Change from Rule		
	Affected Entities	Benefits	Costs (Millions)
Alternative 1: Extend applicability to include additional design and production approval holders under part 21	SMS: +3,000 Exception: +3,000	Data not available to quantify change in risk	+$32.0
Alternative 2: Limit applicability for certain part 135 operators (exclude operators that use only one pilot-in-command) and § 91.147 LOA holders (exclude fewer than 100 flights per year)	Part 135: -548 § 91.147: -377	Lower (would not mitigate risks identified in 1 part 135 accident)	Part 135: -$3.0 § 91.147: -$1.6

1.0 Introduction

The Federal Aviation Administration (FAA) is amending its regulations to extend the applicability of 14 Code of Federal Regulations (CFR) part 5, Safety Management Systems, to certain aircraft design and production certificate holders under part 21, air carriers operating commuter and on demand service under part 135, and Letter of Authorization (LOA) holders operating commercial air tours under § 91.147. The rule also updates the requirements of 14 CFR part 5. This document provides the FAA's analysis of the impact of the rule.

1.1 Background

A safety management system (SMS) provides an organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls.[4] In 2015, the FAA issued a final rule to require air carriers authorized to conduct operations under 14 CFR part 121 to develop and implement an SMS in accordance with the requirements adopted in 14 CFR part 5.[5] Under part 5, an SMS includes the following essential components:

- Safety policy
- Safety risk management
- Safety assurance
- Safety promotion
- Documentation and recordkeeping.

Safety policy establishes the entity's commitment to safety, its safety objectives, and the policies, procedures, and organizational structures necessary to accomplish these objectives. The policy delineates management and employee responsibilities for safety. The policy also identifies an accountable executive and requires that executive to accomplish a regular review of the safety policy, which assures that the executive is actively engaged in the oversight of safety performance. [6]

Safety risk management requires that an entity understand its aviation-related systems and develop processes for identifying any hazards associated with those systems. Once entities identify hazards, they must follow their safety risk management processes to analyze and assess the risk of these hazards, as well as institute controls to reduce or eliminate the risk.[7]

Safety assurance is the monitoring process and assures the performance and effectiveness of safety risk controls established under safety risk management. Safety assurance also serves to identify potential hazards as well as to assure the entity meets its safety objectives through the collection, analysis, and assessment of data regarding the entity's performance. [8]

Safety promotion requires an entity to implement a combination of training and communication of safety information to enhance the entity's safety performance. Safety promotion may include

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[4] Currently defined at 14 CFR § 5.5.
[5] See 80 FR 1308.
[6] The requirements for safety policy are contained in subpart B of part 5.
[7] The requirements for safety risk management are contained in subpart C of part 5.
[8] The requirements for safety assurance are contained in subpart D of part 5.

formal safety training for employees and a formal process for communicating safety information.[9]

Finally, documentation of SMS requirements, processes, and outputs is necessary to conduct a meaningful analysis under safety risk management, to review safety assurance activities, and for the FAA to review for compliance during inspections. Documentation and recordkeeping also ensure that safety-related decisions are consistent with safety policies and goals and provide historical information that can be used to make future safety-related decisions.[10]

How an entity implements an SMS depends on the characteristics (e.g., size, complexity) of its operations or products. The SMS components are based on the International Civil Aviation Organization (ICAO) SMS framework. In general, the SMS requirements in 14 CFR part 5 define what must be accomplished, not how it must be accomplished, and enable an entity to adapt processes to fit its operations.

Currently, part 119 certificate holders authorized to conduct operations under part 121 are required to implement an SMS in accordance with part 5. Under 14 CFR part 139, certain airport certificate holders must also implement an SMS.[11]

1.2 Summary of the Regulation

The FAA is amending the applicability of the existing SMS requirements in 14 CFR part 5 to include:

- Design and production approval holders under part 21 that hold both a type certificate and a production certificate for the same product,[12] including type certificate holders who allow other persons to use their type certificate to manufacture that same product under a production certificate, and production certificate holders who produce a product under a licensing agreement
- Air carriers operating commuter and on demand air service with part 135 certificates
- Persons conducting commercial air tour operations under a § 91.147 LOA.

The rule also revises 14 CFR part 5 to require:[13]

- An organizational system description (part 21 only)[14]

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[9] The requirements for safety promotion are contained in subpart E of part 5.
[10] The requirements for SMS documentation and recordkeeping are contained in subpart F of part 5.
[11] See "Airport Safety Management System," 88 FR 11642 (Feb. 23, 2023).
[12] This applicability extends to holders of and applicants for a production certificate who are holders or licensees of the type certificate for that product.
[13] The rule would eliminate the implementation plan that part 121 operators currently submit under part 5. Instead, the rule would require declaration of compliance (included in the compliance statement at certification) for parts 121, 135, and § 91.147; part 21 approval holders would be required to submit an implementation plan.
[14] The organizational system description summarizes the processes, procedures, activities, personnel, equipment, and facilities that impact the aviation safety of the products and services provided by the organization. This includes, but is not limited to activities, processes, and procedures for design and certification, production, and continued operational safety. An organizational system description defines the boundaries of where SMS is applied in an organization.

- A code of ethics[15]
- Analysis of interfaces to the system in safety risk management
- Hazard information sharing[16]
- Modification of the confidential employee reporting program to remove any concern of reprisal for reporting
- A summary of the confidential employee reports every six months (part 21 only).

The FAA determined that part 121 operators would be required to make only minor changes to their existing SMS for compliance with these requirements.

The FAA published a notice of proposed rulemaking (NPRM) and preliminary regulatory impact analysis (RIA) on January 11, 2023 (88 FR 1932) and received 186 comment submissions. In consideration of public comments, the FAA made a number of changes to the final rule, including:

- Lengthened compliance schedules
- Applying the system description requirement to design and manufacturing (part 21) organizations only
- Excepting certain single pilot operations from SMS requirements that would not be applicable to one person.

For operators with part 135 certificates and § 91.147 LOA holders, the final rule provides an additional 12 months for implementation of an SMS compared to the proposal. For design and manufacturing organizations, the final rule requires an implementation plan within six months, and two and one-half years for implementation. In comparison, the proposed rule would have required an implementation plan by December 2023 and one year for implementation.

In the final rule, the system description only applies to design and manufacturing organizations. Also, the FAA revised the regulatory language to require only a summary of information in the system description, remove the interfacing persons requirement, and rename "system description" to "organizational system description."

Also in the final rule, the FAA is excepting certain organizations – those with a single pilot who is the sole individual performing all necessary functions in the conduct and execution related to, or in direct support of, the safe operation of the aircraft – from SMS requirements that would not be applicable for one person. These exceptions are:

- Components of the safety policy related to reporting of safety hazards, disciplinary action, and communication [§ 5.21 (a)(4) and (5), and 5.21(c)]
- Safety accountability and authority for management and employees [§ 5.23(a)(2), (3), and (b)]

[15] A code of ethics would apply to all employees, including management personnel and officers, and clarify that safety is the organization's highest priority, as required by section 102(f) of the Aircraft Certification, Safety, and Accountability Act (Public Law 116-260, December 27, 2020).
[16] Hazard information sharing means providing notice of a hazard to the interfacing person or persons who could address the hazard or mitigate the risk.

- Designation and responsibilities of required safety management personnel [§ 5.25(b)(3) and (c)]
- Coordination of emergency response planning [§ 5.27(a) and (b)]
- A confidential employee reporting system [§ 5.71 (a)(7)]
- Safety communication [§ 5.93]
- Retention of safety communication records under § 5.93 [§ 5.97(d)].

This final RIA also updates for the lengthened compliance schedules and revised applicability for the system description. The FAA does not have information on those operators who may be excepted from the requirements that would not be applicable to one person. See the preamble to the final rule for more detail on these changes and response to comments on benefits and costs.

1.3 Regulatory Alternatives

The FAA considered two alternatives to the rule. Alternative 1 would extend the applicability of the SMS requirements in part 5 to include design and production approval holders under 14 CFR part 21 beyond holders of both a type certificate and production certificate for the same product. Alternative 2 would exclude from the applicability of part 5 the part 135 operators that use only one pilot-in-command in their operations, and the § 91.147 LOA holders that conduct less than 100 flights per year. Section 7 of this document discusses these alternatives in more detail. Section IV of the preamble to the rule provides the Agency's rationale for the selected option.

1.4 Scope of the Analysis

The FAA analyzed the potential benefits and costs of the rule, including safety benefits, compliance costs, and government administrative costs. For this analysis, the FAA used recent[17] information on aviation accident causes and consequences and information from a variety of sources on the potential implementation costs. The FAA quantified costs over a five-year period in year 2022 dollars and evaluated benefits qualitatively.

[17] The FAA did not include the most recent years of data due to the disruption to aviation that occurred during the public health emergency concerning the novel coronavirus disease.

2.0 Need for the Regulation

This section describes the need for the regulation, including a description of the problem, the statutory mandate to address the problem, and the NTSB recommendations that the rule implements.

2.1 Description of Problem

The purpose of an SMS is to reduce incidents and accidents by aiding organizations in identifying hazards and mitigating those hazards before they lead to an incident or accident. Over the last few decades, accidents involving commercial aviation operators have decreased. Despite an overall reduction in accidents, the FAA has determined that many of the accidents involving part 135 and § 91.147 operators were due to human factors and decision-making. The fact that an SMS might have effectively mitigated these accidents highlights opportunities for systemic improvement to safety.

According to NTSB data, from 2015 to 2019, 215 accidents involved part 135 operators with a total of 121 fatalities; during that same timeframe, 33 accidents involved air tour operators operating under § 91.147, with a total of 16 fatalities. Of accidents resulting in fatalities (and serious injuries), the FAA identified 35 accidents under part 135 and 4 accidents under § 91.147 that SMS implementation could have mitigated. The FAA also identified 11 such accidents involving design and production issues that SMS implementation could have prevented. However, SMS would be unlikely to be a completely mitigating factor for all of the identified accidents.

2.2 Statutory Mandate

The Aircraft Certification, Safety, and Accountability Act (Public Law 116-260, December 27, 2020) requires the FAA Administrator to initiate rulemaking to require that manufacturers that hold both a type certificate and a production certificate for which the United States is the State of Design and State of Manufacture, have in place an SMS that is consistent with the standards and recommended practices established by ICAO. The regulations are required to, at a minimum:

- Ensure such systems are consistent with, and complementary to, existing SMS
- Require a certificate holder's SMS to include a code of ethics that clarifies safety is the organization's highest priority
- Include provisions that would permit operational feedback from operators and pilots qualified on the manufacturers' equipment to ensure that the operational assumptions made during design and certification remain valid
- Include provisions for the FAA's approval and oversight of a certificate holder's regulatory compliant SMS
- Require an SMS to include a confidential employee reporting system through which employees can report hazards, issues, concerns, occurrences, and incidents without concern for reprisal
- Require such certificate holders to adopt an SMS not later than four years after enactment of the Act.

The Administrator must also implement a systems approach to risk-based surveillance by defining and planning continuous inspections, audits, and monitoring activities, to ensure that design and production approval holders of aviation products meet and continue to meet SMS requirements. The Administrator must also engage with ICAO and foreign civil aviation authorities to help encourage the adoption of SMS globally.

2.3 NTSB Recommendations

Between 2007 and November 2021, the NTSB published 18 recommendations regarding SMS for aviation.[18] These recommendations covered commercial operations under 14 CFR parts 121 and 135; revenue passenger carrying business operations under part 91; and certificate holders under parts 21 and 145. The NTSB issued eight of those recommendations to the FAA.[19] Recently, the NTSB made multiple recommendations as a result of its investigation into PenAir flight 3296, including that the FAA require organizations that design, manufacture, and maintain aircraft to establish an SMS.[20] Furthermore, the NTSB's 2021-2023 Most Wanted List of transportation safety improvements recommended that the FAA should "Require and Verify the Effectiveness of Safety Management Systems in all Revenue Passenger-Carrying Aviation Operations."[21] This rulemaking implements these recommendations.

[18] See NTSB's Case Analysis and Reporting Online system, available at: https://data.ntsb.gov/carol-main-public/basic-search.

[19] See NTSB Safety Recommendations: A-07-010 (2007), A-09-089 (2009), A-09-016 (2009), A-16-036 (2016), A-19-028 (2020), A-21-013 (2021), A-21-014 (2021), and A-21-048 (2021).

[20] See NTSB Safety Recommendation A-21-048 (2021).

[21] See 2021-2022 NTSB Most Wanted List of Transportation Safety Improvements, https://www.ntsb.gov/advocacy/mwl/Pages/default.aspx.

3.0 Baseline for the Analysis

The baseline for the analysis of the incremental benefits and costs of the rule includes existing SMS regulations and standards, existing practices, affected entities, and current risks of aircraft accidents and incidents. This section describes these conditions.

3.1 Existing Regulations and Standards

ICAO Annex 19 requires that member states implement SMS requirements for operators, maintenance organizations, and organizations responsible for the type design or manufacture of aircraft, engines, or propellers. Within the United States, SMS requirements are defined in 14 CFR part 5 and are currently applicable only to part 119 certificate holders operating under part 121.

3.1.1 14 CFR Part 5, Safety Management Systems

On January 8, 2015, FAA published a final rule (80 FR 1308) requiring each air carrier operating under 14 CFR part 121 to develop and implement an SMS (14 CFR part 5) to improve the safety of its aviation-related activities. An SMS is a formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls.[22] It includes systemic procedures, practices, and policies for the management of safety risk. SMS enforces the concept that safety should be managed with as much emphasis, commitment, and focus as any other critical area of an organization.

3.1.2 International Standards

ICAO established a framework for member states to develop and implement SMS requirements.[23] ICAO requires SMS for international commercial air transportation, international general aviation, design and manufacturing, maintenance, air traffic services, training organizations, and certified aerodromes. The rule would further align U.S. SMS requirements with ICAO standards by requiring additional aviation organizations to develop and implement SMS, including certain design and production certificate holders under part 21, commercial operations under part 135, and commercial air tour operators under § 91.147.

3.2 Existing Practices

The FAA provides voluntary SMS programs for certificate and approval holders that are not currently required to implement 14 CFR part 5.[24] Table 3 shows the number of certificate and approval holders that are already in active conformance. The FAA's voluntary programs are based on the current requirements in part 5, and participants receive formal FAA acceptance (versus any other SMS that an organization may have implemented does not have formal FAA recognition). The FAA encourages participants to integrate existing programs into their SMS.

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[22] Currently defined at 14 CFR § 5.5.

[23] The first edition of ICAO Annex 19, Safety Management, was published in July 2013 and became applicable in November 2013.

[24] See FAA Order 8900, Volume 17, Safety Management System, Chapter 3, Safety Management System Voluntary Program, available at https://drs.faa.gov/browse.

Table 3. FAA Voluntary SMS Program Participants

Category	Number[1]
Part 21	5
Part 135	40
1. Accepted by the FAA.	

In addition, many aviation entities have implemented an SMS under other standards, such as the International Standard for Business Aircraft Operations (IS-BAO) and the industry-recognized set of standards for designers and manufacturers (AS9100 series). Some third-party organizations (e.g., trade associations) offer SMS products and services (which may be scaled by entity size or revenues) to their membership for a fee.

3.3 Affected Entities

This section describes the entities affected by the rule.

3.3.1 Design and Production (Part 21)

Regulations governing design and production are contained in 14 CFR part 21, including procedures for obtaining type certificates for aircraft, aircraft engines, and propellers, and production certificates to produce a product. The requirements for SMS apply to entities that hold both a type and production certificate for the same product. The rule also applies to holders of and applicants for a production certificate that are also the holder or licensee of the type certificate for the same product, and type certificate holders who allow other persons to use their type certificate to manufacture that same product.

The FAA used data from its Dynamic Regulatory System (DRS) to identify the potential number of companies that would be affected by the rule (Table 4). Holders of type and production certificates under EASA already have to implement SMS under EASA's requirements.[25] The FAA identified one affected entity that would be subject to EASA requirements.

Table 4. Potentially Affected Entities: Design and Production (Part 21)

Category	Number of Entities
TC and PC[1]	65
TC = type certificate PC = production certificate Source: FAA analysis of Dynamic Regulatory System data as of October 2021. 1. Includes holders of both a TC and PC for the same product, including TC holders who allow other persons to use their TC to manufacture that same product under a PC, and holders of and applicants for a PC that are also the holder or licensee of the TC for the same product.	

3.3.2 Commuter and On Demand Operations (Part 135) and Commercial Air Tours (§ 91.147)

Air operator entities conducting operations under 14 CFR part 135 can conduct non-scheduled on demand operations, with some limited scheduled operations. Part 135 also allows for

[25] See https://www.easa.europa.eu/community/topics/sms-part-21-and-part-145 for information on these rules for part 21 and part 145.

scheduled commuter operations. Each type of operation, on demand or commuter, has specific limitations, including, e.g., the number of passenger seats that can be installed on the aircraft, maximum payload limits, and whether turbo-jet aircraft can be used in that kind of operation.

Entities conducting operations under § 91.147, Passenger carrying flights for compensation or hire, must receive an LOA from the FAA. These operators conduct nonstop passenger-carrying flights in an airplane, rotorcraft, or powered-lift for compensation or hire that begin and end at the same airport within a 25-statute mile radius of that airport.

Table 5 shows the number of entities conducting operations under part 135 and § 91.147. The FAA does not collect data on the number of entities with a single pilot who is the sole individual performing all necessary functions in the conduct and execution related to, or in direct support of, the safe operation of the aircraft. Of part 135 operators, however, 522 are single pilot and 26 are single pilot-in-command. Of § 91.147 LOA holders, 327 have only 1 aircraft registration.

Table 5. Part 135 Operators and § 91.147 LOA Holders

Regulatory Authority	Description	Number of Entities
Part 135	Commuter and on demand operations	1,848[1]
§ 91.147	Air tour operators	715[2]
LOA = Letter of Authorization Source: FAA data as of June 2023 1. Includes 203 part 135 operators that are also 91.147 LOA holders. 2. LOA holders not associated with a part 135 certificate.		

3.3.4 Domestic, Flag, and Supplemental Operations (Part 121 Operators)

Part 121 operators are authorized to conduct domestic, flag, or supplemental operations. Domestic and flag part 121 operations are scheduled operations which involve turbo-jet powered airplanes, or powered-lift, or with an aircraft configured to carry more than 9 passengers or payload of more than 7500 pounds. Part 121 supplemental operations are unscheduled and involve carriage of more than 30 passengers or a payload of more than 7500 pounds.

Table 6 shows the number of part 121 operators that are already required to implement SMS under part 5. A number of these certificate holders authorized to conduct both part 121 and 135 operations already cover their part 135 operations under their SMS. Further, the FAA determined that the rule would make only minor changes to the SMS requirements under part 5 (e.g., adopt a code of ethics, and share hazard information with interfacing persons). As a result, the rule would require part 121 operators to make only minor changes to their existing SMS. Accordingly, the FAA estimated only minor incremental costs attributable to these changes.

Table 6. Part 121 Operators

Certificated Part	Description	Number of Entities
121	Domestic, flag, and supplemental operations	59
121/135	Domestic, flag, and supplemental operations, combined certificate	7
Source: FAA data as of September 2021		

3.4 Risks

This section describes the existing aviation accidents and consequences under the different operating parts (parts 121, 135, and 91, including § 91.147) that may be addressed through SMS implementation extended to design and manufacturing, 14 CFR part 135 operations, and operations pursuant to a § 91.147 LOA. Also discussed are aircraft incidents, the precursors of which are the same conditions that could lead to an accident.

3.4.1 Domestic, Flag, and Supplemental Operations (Part 121)

Table 7 shows the number of accidents, fatalities, serious injuries, flight hours, flight departures, and passenger enplanements under 14 CFR part 121 operations from 2015 to 2019.

Table 7. Accidents, Consequences, and Operations, Part 121: 2015 - 2019

Year	Accidents	Fatalities	Serious Injuries[1]	Flight Hours (millions)	Flight Departures (millions)	Passenger Enplanements (millions)
2015	28	0	8	17.9	9.1	801
2016	30	0	4	18.3	9.2	826
2017	33	0	1	18.6	9.2	851
2018	31	1	11	19.3	9.5	891
2019	40	4	3	19.8	9.7	928

Source: NTSB (2022).
1. Injuries exclude flight crew and cabin crew.

3.4.2 Commuter and On Demand (Part 135) and General Aviation (Part 91)

Table 8 shows the number of accidents, fatalities, and flight hours under part 135 operations from 2015 to 2019.

Table 8. Accidents, Consequences, and Operations, Part 135: 2015 - 2019

Year	Accidents	Fatalities	Flight Hours (millions)
Commuter			
2015	4	1	0.4
2016	9	8	0.4
2017	6	0	0.4
2018	2	0	0.4
2019	9	2	0.4
On Demand			
2015	39	27	3.6
2016	29	19	3.5
2017	44	16	3.5
2018	40	16	3.8
2019	33	32	3.8

Source: NTSB (2022).
1. On Demand operations encompass charters, air taxis, air tours, or medical services (when a patient is on board).

Table 9 shows the number of accidents, fatalities, and flight hours under 14 CFR part 91 operations from 2015 to 2019. The rule addresses Part 91 accidents in general (other than under

§ 91.147) to the extent that causation relates to design and manufacturing. Table 10 provides the accidents and consequences from the part 91 accidents that the NTSB identified as sightseeing flights (i.e., commercial flights under a § 91.147 LOA, and for which the rule would require an SMS).

Table 9. Accidents, Consequences, and Operations, Part 91: 2015 - 2019

Year	Accidents	Fatalities	Flight Hours (millions)
2015	1,211	378	20.6
2016	1,269	386	21.3
2017	1,233	331	21.7
2018	1,275	379	21.7
2019	1,220	414	21.8
Source: NTSB (2022). Flight hours are estimated by the FAA. Departure information for general aviation operations is not available.			

Table 10. Sightseeing Accidents and Consequences: 2015 – 2019

Year	Accidents	Fatalities	Serious Injuries
2015	3	0	0
2016	7	8	3
2017	8	0	6
2018	7	5	3
2019	8	3	3
Source: Data file of sightseeing accidents provided by the NTSB April 2020.			

3.4.2 Incidents

Some aviation incidents are indicative of unsafe conditions that could result in an accident in the future. Under 14 CFR part 39, the FAA issues an Airworthiness Directive (AD) when it finds that an unsafe condition exists in the product and the condition is likely to exist or develop in other products of the same design.[26] ADs are legally enforceable rules that apply to the following products: aircraft, aircraft engines, propellers, and appliances.[27] An AD mandates actions necessary to address the unsafe condition.[28] Typically, the FAA issues ADs as a result of aircraft operational incidents, findings during maintenance inspections, or when manufacturers issue service bulletins. In rarer cases, however, the FAA may issue ADs as a result of accident investigations. From 2015 to 2021, the FAA issued over 1,500 ADs, including 31 emergency ADs.[29]

3.5 Uncertainty

The key uncertainty in the baseline for the analysis is the extent to which future risks will resemble current risks. For example, there may be trends in the incident data that have yet to manifest in accidents but could in the future in the absence of the rule. Additionally, the

[26] See 14 CFR § 39.5.
[27] See 14 CFR § 39.3.
[28] See 14 CFR § 39.11.
[29] Based on data as of December 2021; excludes ADs superseding earlier ADs or superceded by later ADs.

voluntary adoption of SMS may continue in the absence of the rule, reducing the potential benefits and costs of extending part 5 requirements to the additional entities covered by this rule.

4.0 Benefits Analysis

The benefits of the rule include the value of the risk reductions that result from implementing an effective SMS. For reasons discussed in Section 4.2.3, the FAA cannot quantify the benefits of this rule, therefore, the following sections illustrate the potential scope of the benefits subject to the effectiveness of the rule.

4.1 Data

The data available for estimating the benefits of the rule, which are partly anecdotal in nature, and includes aviation accident investigation reports and information on the causes of aviation accidents, aviation accident rates and consequences, and values associated with accident consequences.

4.1.1 Accident Reports

The NTSB provides aviation accident investigation dockets and reports, which the FAA used to identify accidents that could have been mitigated through the implementation of an effective SMS. The FAA obtained an electronic file of completed NTSB investigations that included the following information: the date and time of the accident, carrier, type of flight, consequences from the accident, description, cause, and links to the electronic docket for the investigation and report, if applicable (NTSB, 2020). The NTSB data is also available online.[30] The NTSB also provided a file of sightseeing accidents for analysis of air tour flights conducted under § 91.147.

The FAA reviewed individual accidents for issues that could be mitigated by the rule, with a focus on accidents involving fatalities and serious injuries (1,954 of the 6,718 accidents across parts 91, 121, and 135 operations from 2015 to 2019). In addition, for part 21 operations, the FAA screened the file of completed NTSB investigations for evidence in the accident related to aircraft, engines, and propellers. For part 135 and § 91.147 operations, the FAA looked for information on organizational processes and management structure. However, there was not always sufficient information available on these factors at the time of the analysis to assess whether an SMS could have mitigated an adverse outcome.

Table 11 shows the accidents between 2015 and 2019 (Appendix A provides the rationale for including each accident). The FAA notes that 2019 is the most recent year for which final reports were available at the time of the analysis. As illustrated by the header rows, Table 11 organizes the accidents based on which entity could have mitigated the risk associated with the accident (i.e., certificate holders under parts 21, part 135 operators, or a § 91.147 LOA holder).[31]

Table 11. Accidents Potentially Mitigatable by SMS

NTSB Number	Year	CFR Operating Part	Number of Fatalities	Number of Serious Injuries
SMS for Part 21				
DCA19MA086	2019	121	3	0
ERA18LA199	2018	91	1	0

[30] The data is searchable online at: https://data.ntsb.gov/carol-main-public/basic-search. The NTSB also publishes statistics online at: https://www.ntsb.gov/investigations/data/Pages/aviation_stats.aspx.

[31] For one accident, the FAA identified that SMS for both parts 21 and part 145 could have mitigated the risk.

Table 11. Accidents Potentially Mitigatable by SMS

NTSB Number	Year	CFR Operating Part	Number of Fatalities	Number of Serious Injuries
DCA18MA142	2018	121	1	8
ERA18FA120	2018	91	2	0
DCA17FA021	2016	121	0	1
WPR16FA153	2016	135	4	0
DCA16FA199	2016	91	2	0
ERA16FA185	2016	91	4	0
WPR16FA055	2016	135	0	6
DCA16FA013	2015	121	0	1
ERA15FA254	2015	91	3	0
SMS for Part 135				
CEN19FA072	2019	135	3	0
ANC18LA027	2018	135	0	1
CEN18FA215	2018	135	1	0
ANC18FA045	2018	135	1	0
ANC18LA046	2018	135	0	1
CEN18FA259	2018	135	0	3
ANC18FA053	2018	135	0	6
ANC18FA055	2018	135	1	3
ANC18FA063	2018	135	5	0
CEN18FA386	2018	135	1	0
ERA18FA264	2018	135	2	2
ANC17TA015	2017	135	0	2
CEN17FA100	2017	135	1	0
CEN17FA168	2017	135	3	0
ANC17FA021	2017	135	1	0
DCA17FA109	2017	135	2	0
ERA17FA195	2017	135	1	2
ANC17FA039	2017	135	1	0
CEN18FA033	2017	135	3	0
ANC16LA012	2016	135	0	5
ANC16FA017	2016	135	3	1
ERA16FA215	2016	135	2	0
CEN16FA372	2016	135	0	3
CEN16LA386	2016	135	0	1
WPR16LA189	2016	135	0	2
ANC17MA001	2016	135	3	0
ERA17FA066	2016	135	1	0
CEN15FA171	2015	135	1	2
ANC15LA033	2015	135	0	1
WPR15LA198	2015	135	0	1
ANC15MA041	2015	135	9	0
CEN15LA288	2015	135	0	1
ANC15FA049	2015	135	1	4
CEN16MA036	2015	135	9	0
WPR16FA037	2015	135	4	0
SMS for § 91.147				

Table 11. Accidents Potentially Mitigatable by SMS

NTSB Number	Year	CFR Operating Part	Number of Fatalities	Number of Serious Injuries
ERA18MA099	2018	91	5	0
CEN16LA338	2016	91	2	0
WPR16FA072	2016	91	1	3
WPR14FA186	2014	91	1	1
CFR = Code of Federal Regulations				

4.1.2 Accident Rates

The NTSB compiles data on domestic accidents, fatalities, and injuries across part 121, 135, and 91 operations. Table 12 provides this data for the years 2015-2019. For part 91, the rule would require SMS only for LOA holders conducting flights under § 91.147. However, Table 12 includes statistics for all of part 91 operations because the aircraft used in general aviation could be affected by safety hazards that are attributable to design and production issues[32] (e.g. part 21 certificate holders).[33] Therefore, there could be reductions in part 91 accidents in general due to the effective implementation of SMS in part 21.

Table 12. U.S. Aviation Accident Statistics

Year	Part 121	Part 135	Part 91	§ 91.147[2]
Fatalities				
2015	0	28	378	0
2016	0	27	386	8
2017	0	16	331	0
2018	1	16	379	5
2019	4	34	414	3
Average 2015-2019	1	24	378	3
Injuries[1]				
2015	8	13	236	0
2016	4	23	182	3
2017	1	4	188	6
2018	11	17	210	3
2019	3	24	209	3
Average 2015-2019	5	16	205	3
Accidents				
2015	28	43	1,211	3
2016	30	38	1,269	7
2017	33	50	1,233	8
2018	31	42	1,275	7
2019	40	43	1,220	8
Average 2015-2019	32	43	1,242	7

[32] In NTSB accidents from 2012 to 2021, 28 percent relate to aircraft power plant, propeller, structures, and systems, of which the findings for half (about 15 percent of total) relate to design and manufacturing issues (https://www.ntsb.gov/safety/data/Pages/GeneralAviationDashboard.aspx).

[33] Part 125 operations could also be affected but the FAA determined that there were no part 125 accidents linked to design and production and repair and maintenance.

Table 12. U.S. Aviation Accident Statistics

Year	Part 121	Part 135	Part 91	§ 91.147[2]
Source: NTSB (2022). Part 135 and 91 injuries are from NTSB (2020). Data for sightseeing accidents (§ 91.147) from April 2020 file provided by the NTSB (excludes NTSB number ERA20MA001 which was conducted under a Living History of Flight Experience exemption). 1. Part 121 injuries are passenger serious injuries (excludes crew). 2. Subset of part 91.				

The NTSB also provides information on the number of aircraft damage, including destroyed and substantially damaged aircraft, in U.S. operations. Table 13 shows this data for the years 2015-2019.

Table 13. Aviation Accident Property Damage (Number of Aircraft)

Year	Destroyed[1]	Substantial Damage[2]
Part 121		
2015	0	7
2016	0	13
2017	0	15
2018	0	12
2019	1	24
Average 2015-2019	0	14
Part 135		
2015	5	38
2016	8	29
2017	7	43
2018	4	38
2019	11	31
Average 2015-2019	7	36
Part 91		
2015	136	962
2016	125	1,039
2017	121	1,007
2018	139	1,048
2019	143	971
Average 2015-2019	133	1,005
§ 91.147[3]		
2015	0	3
2016	1	6
2017	2	6
2018	0	7
2019	1	7
Average 2015-2019	1	6
Source: NTSB (2022). Data for sightseeing accidents (§ 91.147) from April 2020 file provided by the NTSB (excludes NTSB number ERA20MA001 which was conducted under a Living History of Flight Experience exemption). 1. Destroyed means all of the primary structure is damaged to the extent that it would be impracticable to return the aircraft to an airworthy condition by repair.		

Table 13. Aviation Accident Property Damage (Number of Aircraft)

Year	Destroyed[1]	Substantial Damage[2]
2. Substantial damage means damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component. 3. Subset of part 91.		

4.1.3 Value of Avoiding Accident Consequences

The FAA estimated the value of reducing the risk of fatalities using the value of statistical life (VSL) and injuries using fractions of the VSL based on the Maximum Abbreviated Injury Scale (MAIS). For example, reduction in the risk of one fatality generates benefits equal to the VSL (approximately $11.8 million). Reduction in the risk of serious injury generates benefits of equal to the fraction of the VSL associated with MAIS level 3 (.105), or approximately $1.2 million (.105 × $11.8 million; Table 14). Reductions in minor injuries generate benefits equal to approximately $35,400 per injury.

Table 14. Values Associated with Levels of Injury Severity Based on the VSL[1]

MAIS Level	Severity	Fraction of VSL	Value
MAIS 1	Minor	0.003	$35,400
MAIS 2	Moderate	0.047	$554,600
MAIS 3	Serious	0.105	$1,239,000
MAIS 4	Severe	0.266	$3,138,800
MAIS 5	Critical	0.593	$6,997,400
MAIS 6	Unsurvivable	1	$11,800,000
Source: Based on DOT (2022). VSL = value of statistical life 1. Fraction of VSL multiplied by VSL.			

The FAA estimated the value of reducing the risk of property damage (airplane damage or loss) using market values and estimates of average repair costs (FAA, 2018). The FAA used market values to estimate damages for aircraft destroyed in accidents and loss value for aircraft that incurred substantial damage in accidents. The FAA assigned no damage value to accidents involving minor aircraft damage.

Table 15 shows the estimated average values of replacement and restoration costs for passenger aircraft. The FAA used the average values for "All aircraft"[34] for part 121 accidents, and an average of the available values for aircraft that could be used under part 135 and § 91.147 for part 135 and part 91 accidents, respectively. Note that the values are fleet-weighted averages of replacement and restoration costs and therefore may over or understate costs for any individual accident.

Table 15. Property Damage Values for Passenger Aircraft

Type of Aircraft	Replacement Cost[1]	Weighted Average Loss[2]
All aircraft	$20,512,090	$4,195,660
Aircraft used in part 135 operations[3]	$1,748,190	$427,340

[34] "All aircraft" refers to "All aircraft" in Tables 5-2 and 5-4 of the source cited in Table 18 (FAA, 2018).

Table 15. Property Damage Values for Passenger Aircraft

Type of Aircraft	Replacement Cost[1]	Weighted Average Loss[2]
Aircraft used in § 91.147 operations[4]	$869,670	$177,280
Source: FAA (2018), Tables 5-2 and 5-4, updated from 2018 to 2022 dollars using the Consumer Price Index for All Urban Consumers. 1. Replacement cost estimated as weighted average current market value for passenger air carrier fleet. 2. Restoration cost estimated as average loss value for U.S. fleet. 3. Estimated as the average of three aircraft used in part 135 operations: regional jet 60 seats and below, turboprop 20-60 seats, and turboprop under 20 seats. 4. Estimated as the average of four aircraft used in § 91.147 operations: piston engine airplanes, one-engine turboprop airplanes, one-engine rotorcraft piston, and rotorcraft turbine, one-engine.		

The FAA estimated the value of avoided accident investigations based on data from the NTSB and internal FAA accounting (FAA, 2021). Table 16 shows the estimated costs. For this analysis, the FAA used the 'Major' category for part 121 accidents involving a major NTSB investigation, and the category associated with the NTSB investigation type (e.g., foreign) for nonmajor part 121 accidents. FAA used the 'Part 135' category estimate for all part 135 accidents, and the 'GA field' and 'GA limited' category estimates for part 91 accidents (depending on the NTSB investigation type).

Table 16. Aviation Accident Investigation Costs

Category (NTSB Code)	Accident Investigation Cost[1]
Major (MA)	$5,007,140
Foreign (RA)	$654,650
Part 135	$297,250
GA field (FA)	$284,720
GA limited (LA)	$12,970
GA data collection	$4,620
GA = general aviation (part 91) Source: FAA (2021). See Table 8.5. 1. Values updated from 2018 to 2022 dollars using the Consumer Price Index for All Urban Consumers.	

4.2 Method

The FAA analyzed the benefits that could result from the rule by estimating the value of the reduction in the risk of aviation accidents. To do this, the FAA identified the current rate of aviation accidents and associated consequences (risks), the share of those accidents and consequences (e.g., fatalities) represented by accidents that would be mitigatable by the rule, and the effectiveness of the rule. The general model is:

Benefits = Average Annual Damages × % Mitigatable × % Effectiveness

4.2.1 Accident Consequences

Based on the NTSB data shown above in Section 4.1, Table 17 shows the average annual rates of fatalities, serious injuries, property damage, and investigations. Combining these rates with the values shown in Section 4.1.3, Table 18 provides an estimate of average annual damages. Again, as described in Section 4.1.2, only a portion of the consequences of aviation accidents in all of part 91 are addressed by the rule because it would not require SMS in part 91 beyond § 91.147

LOA holders. Additionally, only a portion of part 91 accidents would be attributable to design and production issues (e.g. part 21 certificate holders).

Table 17. Average Annual Rates of Aviation Consequences[1]

Category	Part 121	Part 135	Part 91	§ 91.147[2]
Fatalities	1	24	378	3
Serious injuries	5	16	205	3
Property damage: destroyed	0	7	133	1
Property damage: substantial	14	36	1,005	6
Investigations	13	27	707	7
1. See Table 12. 2. Subset of part 91.				

Table 18. Value of Average Annual Aviation Consequences (Millions)[1]

Category	Part 121	Part 135	Part 91	§ 91.147[2]
Fatalities	$11.8	$285.6	$4,455.7	$37.8
Serious injuries	$6.7	$20.1	$254.0	$3.7
Property damage: destroyed	$0.0	$12.2	$115.7	$0.7
Property damage: substantial	$58.7	$15.4	$178.2	$1.0
Investigation costs	$21.6	$8.0	$36.0	$1.9
Total	$98.8	$341.2	$5,039.5	$45.1
1. Calculated as rate of consequences (Table 17) multiplied by value of consequences (Table 14, Table 15, and Table 16). 2. Subset of part 91.				

4.2.2 Mitigatable Consequences

The rule may reduce risks in aviation operations under parts 121, 135, and 91. While part 5 already requires Part 121 operators to implement an SMS, the rule may contribute to risk reductions in part 121 operations from accidents attributable to the design and manufacturing of airplanes used in those operations. The FAA estimated the share of total accident consequences that may be mitigatable by the rule based on the accidents identified in Table 11. Table 19 shows the number of fatalities, injuries, property damage, and investigations in the mitigatable accidents, and the share these represent of total relevant accident consequences. The relevant consequences depend on the part. For example, requiring SMS for certificate holders under parts 21 could affect certain accidents across all operating parts, whereas requiring SMS for certificate holders under part 135 and LOA holders under § 91.147 would only affect certain accidents in operations conducted under part 135 and § 91.147.

Table 19. Average Annual Consequences Mitigatable by SMS[1]

Category	SMS for Part 21	SMS for Part 135	SMS for § 91.147
Fatalities	4 (1.0%)	12 (49%)	2 (56%)
Serious injuries	3 (1.5%)	8 (51%)	1 (27%)
Property damage: destroyed	1 (0.9%)	3 (43%)	0 (0%)
Property damage: substantial	1 (0.1%)	4 (11%)	1 (14%)
Investigations	2 (0.3%)	7 (26%)	1 (12%)

Table 19. Average Annual Consequences Mitigatable by SMS[1]

Category	SMS for Part 21	SMS for Part 135	SMS for § 91.147

1. Average annual mitigatable consequences calculated from the accidents identified in Table 11. Percent of consequences mitigatable by SMS for certificate holders under part 21 calculated based on consequences from accidents across parts 121, 135, and 91 operations. For certificate holders under part 135 and LOA holders under § 91.147, percent calculated based on only consequences from accidents in part 135 and § 91.147, respectively.

4.2.3 Effectiveness in Mitigating Consequences

The FAA has not collected comprehensive data on SMS effectiveness from existing part 121 implementation or the SMS voluntary program.[35] An SMS, when effectively implemented by a certificate holder, works through managing accident precursors. This data would be collected and maintained by each certificate holder (with the FAA's responsibility to ensure compliance with the SMS).

Anecdotal evidence from some voluntary SMS program participants indicates that SMS improves the safety of organizations. For example, one participant noted that the compressed executive awareness time of new safety related issues resulted in formal management actions occurring in less than 90 days for low risk issues and within hours for high risk issues. Another participant noted that they have seen a substantial drop in the major risk categories that they track since implementing an SMS.

Research by Tinsley, Dillon, and Madsen (2011) suggests that the attention an SMS would bring to seemingly smaller events, or near accidents, could prevent catastrophes. Tinsley, Dillon, and Madsen (2011) studied near accidents in dozens of companies across industries and in laboratory simulations. They determined that multiple near accidents preceded and foreshadowed every disaster and business crisis they studied, and that most near accidents were ignored. The authors found that surfacing near accidents and correcting root causes is one the soundest investments that organizations can make. Similarly, in examining large U.S. commercial airlines that operated from 1990 to 2007, Madsen, Dillon, and Tinsley (2016) found that for airlines to continue to improve safety they must attend to the yet undiscovered or unrecognized risks in the system without waiting for an accident to bring attention to them.

There is uncertainty regarding the effectiveness of the rule given that FAA lacks data in assessing the extent to which an SMS assists aviation organizations in identifying and mitigating hazards. Therefore, the FAA did not quantify benefits.

4.4 Uncertainty

There are a number of limitations in the analysis of benefits. Table 20 provides the limitations and the likely impact they would have on the potential for benefits.

[35] Fatalities in part 121 accidents were at very low levels in 2018 when SMS was fully implemented in part 121 operations.

Table 20. Uncertainties in the Analysis of SMS Benefits

Assumption or Uncertainty	Direction of Impact	Comments
Effectiveness of SMS in identifying hazards and mitigating risk	?	SMS effectiveness may vary across organizations and over time.
Benefits based on past (domestic) accidents and causes as indicative of future risks	?	Future risks in the absence of the rule could look different from the past accidents. However, recent accident circumstances also suggest benefits from SMS. For example, the FAA identified 9 part 135 accidents and 1 § 91.147 accident from 2020-2021 (resulting in 27 fatalities and 8 serious injuries) in which SMS could potentially have prevented the accident.[36]
In identifying accidents that could be mitigatable by the rule, the FAA focused on accidents that caused fatalities or serious injuries	-	There is limited information available on some accidents and organizational factors could have played a role in additional accidents. In addition, accident circumstances that did not result in a fatality or serious injury in the past could result in fatalities/injuries in the future.
Two 737 MAX accidents (and other international accidents) not included in the analysis	-	The potential for benefits may be understated.
Timeframe for accruing benefits	?	It may take some time for SMS to mature and become well entrenched in the daily normal operations of the aviation entity employing SMS for the first time.
'-' = benefits may be understated '?' = benefits may be overstated or understated		

As noted in Table 20, the benefits do not include risks beyond domestic operations. This limitation is relevant to the benefits from requiring SMS in part 21 because aviation products designed and produced in the United States are used worldwide. Two accidents for which causation can be linked to decisions in the product design are the Lion Air and Ethiopian Air accidents in 2018 and 2019, respectively (Federal Democratic Republic of Ethiopia Ministry of Transport Aircraft Accident Investigation Bureau, 2019; Komite Nasional Keselamatan Transportasi, Republic of Indonesia. 2019). These two accidents involved The Boeing Company 737-8 airplanes (Boeing 737 MAX) and resulted in 346 fatalities. Based on fatalities alone, the damages from just these two accidents are $4 billion. However, it is important to note that in 2015, FAA required Boeing implement an SMS by 2020. FAA reviewed and approved Boeing's SMS in 2019. There may also be additional accidents in foreign operations that could have been mitigated by requiring SMS of part 21 certificate holders. Therefore, the potential for benefits may be underestimated.

[36] Among these accidents is the 2020 helicopter crash in Calabasas, CA resulting in 9 fatalities (DCA20MA059). The NTSB determined that a contributing factor to the accident was the lack of use and oversight of the company's SMS. These accidents also include single pilot operations (CEN20CA119, in 2020).

5.0 Costs

This section describes the estimation of the incremental costs of the rule, including the available data, method, results, and uncertainties.

5.1 Compliance Costs

The FAA used a variety of sources of data to estimate the costs of compliance with the rule. In addition to the estimates of affected entities described in Section 3, the FAA conducted outreach to certificate holders in the voluntary SMS programs to obtain information on the costs they incurred to develop and implement SMS.

5.1.1 Data

In its report, the SMS Aviation Rulemaking Committee (ARC) identified sources of additional incremental initial and recurring costs that could be incurred as a result of an SMS rule, noting that these costs are highly dependent on the existing safety programs and systems within the organization.[37] The FAA used the ARC's list of initial and recurring costs to develop cost categories, identified in Table 21. The FAA developed questions for participants in the voluntary SMS program based on these cost categories to obtain information on the costs of implementing an SMS. The FAA acknowledged, however, that participants may track costs differently and allowed the respondents to provide the information in the format available. Table 21 provides the categories of costs and the relationship to the regulatory requirements. Appendix C provides the questionnaires.

Table 21. Crosswalk of Estimated SMS Cost Categories and Implementation Requirements[1]

Cost Category	Implementation Requirements
Onetime	
Gap analysis	Development of system description and review of existing policies, processes, and procedures in comparison to the rule to identify whether any changes are required for compliance; implementation plan
SMS development	Development of any policies, processes, and procedures required for compliance (e.g., hazard information sharing)
Training	Development and delivery of initial training for employees
Software	Purchase or modification of software or the writing of macros for use in existing application software (e.g., Microsoft Excel or Access) needed for SMS processes, recordkeeping, or reporting (e.g., track identified hazards and mitigations; employee reports)
Documentation	Documentation of SMS policies (e.g., code of ethics), processes (e.g., employee reporting), procedures, and checklists; declaration of compliance
Other	Safety promotion activities
Recurring (e.g., Annual)	
Data collection and analysis	Collect and analyze data on risks and operational changes

[37] The SMS ARC report is accessible online at: https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/SMSARC-2122009.pdf.

Table 21. Crosswalk of Estimated SMS Cost Categories and Implementation Requirements[1]

Cost Category	Implementation Requirements
SMS review and evaluation (e.g., audits)	Conduct audits and evaluate the effectiveness of the policies, processes, and procedures
Software	Maintenance and ongoing costs for SMS software
Training	Recurring training of employees
Documentation	Maintenance of SMS documentation; recordkeeping and reporting
Other	Ongoing safety promotion activities

As previously discussed, the FAA's voluntary SMS programs are available for all non-part 121 operators, including those regulated under parts 21 and 135. The FAA contacted 9 participants in the voluntary SMS programs in each of these parts to obtain information on the costs and benefits associated with implementing an SMS. The FAA followed up with these participants, as needed, to clarify any responses. Additionally, because the FAA does not have a voluntary program for § 91.147 LOA holders, the FAA developed a separate questionnaire for these operators. The questionnaire for § 91.147 LOA holders was intended to obtain information from these operators concerning their § 91.147 operations and how SMS could enhance the safety of such operations. The FAA contacted 9 § 91.147 LOA holders to obtain this information. The information provided by the voluntary SMS participants and the § 91.147 LOA holders includes confidential business information. Therefore, this section provides only aggregated summary information.

FAA subject matter experts also compared the rule to the existing requirements in 14 CFR part 5, upon which the voluntary SMS programs are modeled, and determined that the experience in implementing a voluntary SMS is representative of the activities that would be required to implement an SMS under the rule. Therefore, the FAA used the confidential business information provided by the voluntary SMS program participants to develop costs of compliance with the rule.

Design and Manufacturing (Part 21)

The responses from design and production certificate holders in the voluntary SMS program indicated that organizations chose to implement an SMS as an industry best practice to improve safety as well as in anticipation of a regulatory requirement to do so. Some already had a functioning SMS. These entities differed in their implementation of SMS, which resulted in different types of implementation costs. Table 22 provides the aggregated response data.

Table 22. Industry Experience Developing and Implementing SMS: Part 21[1]

Category	Average Respondent Cost
Onetime Costs	
Gap analysis	$981,210
SMS development	$887,360
Training	$3,887,310
Software	$190,300
Documentation	$47,560
Other	$28,470

Table 22. Industry Experience Developing and Implementing SMS: Part 21[1]

Category	Average Respondent Cost
Total	$6,022,210
Recurring Costs (Annual)	
Data collection and analysis	$1,123,160
SMS review and evaluation (e.g., audits)	$1,036,280
Software	$227,040
Training	$171,250
Documentation	$32,540
Other	$240,850
Total	$2,831,120
1. Reflects the experience of 7 large aircraft design and manufacturers. Updated to 2022 dollars using the Consumer Price Index.	

Commuter and On Demand Operations (Part 135) and Air Tours (§ 91.147)

The responses from part 135 operators in the voluntary SMS program indicated that some operators had already implemented SMS or parts of SMS for other reasons (e.g., customer requirement to have an SMS). These respondents also differed in the types of costs they incurred based on existing practices and capabilities.[38] Table 23 provides the aggregated response data.

Table 23. Industry Experience Developing and Implementing SMS: Part 135[1]

Category	Average Respondent Cost
Onetime Costs	
Gap analysis	$128,430
SMS development	$186,990
Training	$15,160
Software	$110,930
Documentation	$4,320
Other	$9,180
Total	$455,010
Recurring Costs (Annual)	
Data collection and analysis	$127,710
SMS review and evaluation (e.g., audits)	$109,660
Software	$27,150
Training	$64,110
Documentation	$1,540
Other	$20,860
Total	$351,030
1. Reflects the experience of 8 part 135 operators ranging in fleet size from 9 to over 400 aircraft. Does not include an additional entity because one part 135 certificate holder did not incur costs under the voluntary program due to already having a formal SMS in place. Updated to 2022 dollars using the Consumer Price Index.	

[38] For example, Chapter 5, Integrating Existing Safety Programs into the Safety Management System, FAA Advisory Circular 120-92 in the docket for this rulemaking, describes existing programs that overlap and can be leveraged in an SMS.

Section 91.147 LOA holders provided information on the size of their operations and anticipated cost categories. However, because there is no voluntary SMS program available to § 91.147 LOA holders,[39] this analysis does not provide a table of average implementation costs for these operators.

5.1.2 Method

To estimate the compliance costs that could result from the rule, the FAA used average onetime SMS development costs and recurring SMS implementation costs based on the limited outreach data described in the section above. The FAA then extrapolated the estimates to the entities that would be required to develop and implement an SMS under the rule, but only those entities that are not already required to implement SMS[40] and are not implementing SMS voluntarily.[41]

Design and Manufacturing (Part 21)

The FAA used the data shown in Table 22 to estimate costs for part 21 certificate holders that would be required to implement an SMS under the rule. The FAA calculated the implied cost per employee for each respondent (based on either information from the outreach identifying number of employees, or publicly available company information) and then averaged across respondents.[42] Appendix B provides these estimated costs. Table 24 provides resulting example costs for different size companies. In the smallest size category, the FAA determined that there would be a minimum cost to address regulatory requirements (i.e., regardless of size or complexity of operations) and set the onetime and annual costs based on subject matter expert judgment.

Table 24. Example SMS Development and Implementation Costs: Part 21[1]

Company Size (Number of Employees)	Onetime	Annual
1[2]-99	$8,100 - $28,140	$540 - $10,940
100-499	$28,420 - $141,830	$11,050 - $55,130
500-10,000	$142,110 - $2,842-190	$55,240 - $1,104,870

1. Based on number of employees multiplied by the average onetime and recurring costs shown in Appendix B.
2. The FAA set the minimum onetime and annual cost based on FAA subject matter expert judgment. The minimum onetime cost is the midpoint of a range of $5,400 to $10,800, and the minimum annual cost is $540.

The FAA extrapolated the SMS development and implementation costs to part 21 certificate holders that would be required to implement an SMS under the rule (excluding those entities who are already required to implement an SMS or already implementing an SMS voluntarily) based on number of employees. The FAA estimated the applicable number of employees based

[39] The FAA recognizes that some § 91.147 LOA holders may also hold a part 119 certificate that authorizes part 135 operations and may therefore have experience implementing a voluntary SMS program under part 135. Implementation costs for part 135 operations are already accounted for in Table 38.
[40] As previously discussed, part 121 operators are already required to implement an SMS pursuant to 14 CFR part 5. Additionally, certain entities will be required to implement an SMS under EASA's final rule applicable to design and production organizations (part 21), March 7, 2023.
[41] As previously discussed, several entities have already developed and implemented an SMS under the FAA's voluntary SMS program, and these SMS are based on the existing part 5 requirements.
[42] There is uncertainty in this calculation because companies may include fewer or more employees in the SMS.

on publicly available online sources (e.g., annual reports, company websites) and FAA knowledge regarding the certificate holders.

For entities who will be required to implement an SMS under EASA or are already in conformance with the SMS voluntary program, the FAA determined that there would be only minimal costs associated with the rule (e.g., implementation plan, organizational system description, summary of confidential employee reports, code of ethics, and hazard information sharing). Table 25 provides these estimates.

Table 25. Compliance Costs: Part 21, Existing SMS[1] (Millions)

Onetime[2]	Annual[3]
$4,440	$1,480

1. Calculated as number of hours multiplied by an average wage including benefits of $92.53. Average wage based on the mean for aerospace engineers in scheduled air transportation in May 2022 ($61.10) divided by the percent of total employer costs of employee compensation represented by wages (66%) to account for benefits (34%). Wages and benefits information available at: https://www.bls.gov/oes/2022/may/oes172011.htm and https://www.bls.gov/news.release/ecec.t04.htm#ect_table4.f.1.
2. Based on an average of 48 hours.
3. Based on an average of 16 hours.

Commuter and On Demand Operations (Part 135) and Air Tours (§ 91.147)

The FAA used the data shown in Table 23 to estimate compliance costs for part 135 operators and § 91.147 LOA holders that would be required to implement an SMS under the rule. The FAA calculated the implied cost per aircraft for each respondent (based on internal FAA data on operator characteristics) and then averaged across respondents. Appendix B provides the estimated costs. Table 26 provides resulting example costs for different size operations. In the smallest size category, the FAA determined that there would be a minimum cost to address regulatory requirements (i.e., regardless of size or complexity of operations) and set the onetime cost based on subject matter expert judgment. As described in Section 1, the FAA has also excepted the smallest of these operations from SMS requirements that would not be applicable for one person.

Table 26. Example SMS Development and Implementation Costs: Part 135 and § 91.147[1]

Company Size (Number of Aircraft)	Onetime[2]	Annual
1-9	$8,100 - $41,180	$4,730 - $42,580
10-49	$45,750 - $224,180	$47,310 - $231,820
50-99	$228,750 - $452,930	$236,550 - $468,370
100-500	$457,500 - $2,287,510	$473,100 - $2,365,510

1. Based on number of aircraft multiplied by the costs shown in Appendix B.
2. The FAA set the minimum onetime cost based on FAA subject matter expert judgment. The minimum onetime cost is the midpoint of a range of $5,400 to $10,800.

The FAA extrapolated the SMS development and implementation costs to part 135 operators that are not already covered under a part 121 certificate and not in conformance with the SMS voluntary program, and § 91.147 LOA holders that are not associated with a part 135 certificate based on number of aircraft.

For those operators already in conformance under the voluntary SMS program, the FAA determined that there would be only minimal costs associated with the requirements for a declaration of compliance, code of ethics, and hazard information sharing based on labor cost (using U.S. labor rates). Table 27 provides these estimates.

Table 27. Compliance Costs: Part 135, Existing SMS[1]

Onetime[2]	Annual[3]
$930	$740

1. Calculated as number of hours multiplied by an average wage including benefits of $92.53. Average wage based on the mean for aerospace engineers in scheduled air transportation in May 2022 ($61.10) divided by the percent of total employer costs of employee compensation represented by wages (66%) to account for benefits (34%). Wages and benefits information available at: https://www.bls.gov/oes/2022/may/oes172011.htmand https://www.bls.gov/news.release/ecec.t04.htm#ect_table4.f.1.
2. Based on an average of 10 hours to meet onetime requirements of the rule.
3. Based on an average of 8 hours to meet annual requirements of the rule.

Part 121

Part 121 operators would need to make only minor changes to their existing SMS under the rule. The rule would add the requirement for a code of ethics to be added to the safety policy. The FAA determined that part 121 operators should be able to add a code of ethics with relative ease. Therefore, the FAA estimated only minimal incremental costs.

The rule would also add a requirement for hazard information sharing to the requirements in part 5. The FAA has observed that part 121 operations already voluntarily implement informal hazard information sharing between part 121 operators and interfaces (such as suppliers and airports); this requirement would simply extend that sharing to additional interfaces who could address the hazard or mitigate the risk. Therefore, the FAA also estimated only minimal incremental costs.

Table 28 provides these estimates.

Table 28. Compliance Costs: Part 121, Existing SMS[1]

Onetime[2]	Annual[3]
$740	$740

1. Calculated as number of hours multiplied by an average wage including benefits of $92.53. Average wage based on the mean for aerospace engineers in scheduled air transportation in May 2022 ($61.10) divided by the percent of total employer costs of employee compensation represented by wages (66%) to account for benefits (34%). Wages and benefits information available at: https://www.bls.gov/oes/2022/may/oes172011.htm and https://www.bls.gov/news.release/ecec.t04.htm#ect_table4.f.1.
2. Based on an average of 8 hours to meet onetime requirements of the rule.
3. Based on an average of 8 hours to meet onetime requirements of the rule.

5.1.3 Results

This section provides the estimated compliance costs by part and for distributional (size) breakdowns within those parts. The FAA calculated annualized and five-year present value costs using discount rates of three and seven percent.

Design and Manufacturing (Part 21)

Table 30 shows annualized and present value costs for part 21 assuming costs phase in over three years. Appendix B shows the detailed calculations.

Table 29. SMS Compliance Costs: Part 21 (Millions $2022)[1]

Discount Rate	Annualized	Present Value (5 Years)
3%	$4.9	$22.5
7%	$4.9	$20.1
1. Based on phasing in costs over 3 years.		

Commuter and On Demand Operations (Part 135) and Air Tours (§ 91.147)

Table 30 shows annualized and present value costs for part 135 under a 3-year phase-in schedule for full compliance. Appendix B shows the detailed calculations. Table 31 provides the distribution of costs by number of aircraft.

Table 30. SMS Compliance Costs: Part 135 and § 91.147 (Millions)[1]

Discount Rate	Annualized	Present Value (5 Years)
Part 135		
3%	$35.9	$164.5
7%	$35.3	$144.9
§ 91.147		
3%	$7.2	$33.2
7%	$7.1	$29.2
1. Based on phasing in costs over 3 years.		

Table 31. Distribution of SMS Compliance Costs: Part 135 and § 91.147[1]

Number of Aircraft	Number of Entities	Percent of Total Annualized Cost
Part 135		
<10	1594	44%
10-99	240	46%
100-463	14	10%
Total	1848	100%
§ 91.147[2]		
<10	690	78%
10-19	22	15%
20-80	3	7%
Total	715	100%
Note: Detail may not add to total due to independent rounding. 1. Reflects a 7% discount rate. 2. There are no aircraft registrations for 5 LOA holders.		

Domestic, Flag, and Supplemental Operations (Part 121)

Table 32 shows annualized and present value costs for part 121. Appendix B shows the detailed calculations.

Table 32. Compliance Costs: Part 121 (Millions $2022)

Discount Rate	Annualized	Present Value (5 Years)
3%	$0.05	$0.2
7%	$0.05	$0.2

5.2 Government Administrative Costs

The FAA evaluated the changes in internal resources that would be necessary to implement the rule, including the resources that would be required for SMS approval and oversight. The FAA estimated incremental impacts in terms of hours per activity and the labor categories associated with the labor hours. The FAA did not estimate potential changes in other program areas that may result from improved safety management across the aviation sector (e.g., reduced need for airworthiness directives, or other rulemaking, or enforcement).

Table 33 provides the FAA's estimates of incremental cost associated with administering the rule. The costs relate to effort needed to approve the SMS of certificate holders under part 21. These are onetime costs related to current approval holders. Table 34 provides the annualized and present values.

Table 33. Calculation of FAA Costs: Part 21

Number of Entities	Number of Hours	Total Hours	Total Undiscounted Cost[1] (Millions)
65	32	2,080	$0.2

Source: FAA internal estimates
1. Calculated as hours multiplied by $74 per hour, based on a 2023 mean J Band salary without locality pay (https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.faa.gov%2Fjobs%2Fworking_here%2Fbenefits%2Fpay%2Fcore_salary_with_conversion.xlsx&wdOrigin=BROWSELINK), escalated by a factor of 1.36 to account for benefits (https://georgewbush-whitehouse.archives.gov/omb/memoranda/fy2008/m08-13.pdf).

Table 34. Summary of FAA Costs: Part 21 (Millions)[1]

Discount Rate	Annualized	Present Value (5 Years)
3%	$0.03	$0.1
7%	$0.03	$0.1

1. Based on phasing in costs over 3 years.

The FAA determined that there would be only minimal costs associated with administering the rule for part 135 and § 91.147. The FAA will accept the declaration of compliance when submitted and validate compliance with part 5 using existing risk-based oversight processes. The FAA utilizes a Safety Assurance System to conduct oversight activities for these operators and allocate resources based on risk. The Safety Assurance System is a data driven automation system that enables flexibility in resource management. Therefore, the FAA expects only minimal impacts on resources.

5.3 Summary and Uncertainty

Table 35 provides a summary of annualized costs. The analysis contains a number of uncertainties. In particular, the estimated costs are based on a small sample, and on larger firms who are in the SMS voluntary program. As a result, costs could be lower or higher than estimated. The direction of bias is unclear for a number of reasons including that operator experience with the voluntary program may not be representative of implementation under the rule. The outreach results indicated a high level of variability in the costs and the categories of costs incurred depending on the individual circumstances of the entity (e.g., existing processes and capabilities). For this analysis, the intent is for the cost estimates to represent an average cost across entities.

Table 35. Summary of Annualized Costs[1]

Category	Cost (Millions)	Percent of Cost
Part 21[2]	$4.9	10%
Part 135	$35.3	75%
§ 91.147	$7.1	15%
Part 121	$0.05	0%
Total	$47.4	100%

Note: Detail may not add to total due to independent rounding.
1. Reflects a 7% discount rate. Excludes costs of mitigation.
2. Includes FAA administrative costs.

Another key uncertainty relates to mitigation costs, which are not quantified. While in some cases SMS procedures will result in different decisions that could avoid accidents with a relatively smaller cost impact (e.g., taking a different route or delaying a flight until weather clears; implementing specific training or enhanced checklists, etc.), or identifying mitigations sooner such that the incremental difference in cost is only one of timing,[43] in others more substantial mitigations may be needed to address the hazard (e.g., equipment purchase). For example, one company purchased Automatic Dependent Surveillance Broadcast (ADS-B) “In” and “Out” for its aircraft fleet and another chose to install crash resistant fuel systems in older helicopters. These costs of addressing hazards would be incremental to SMS development and implementation costs. Since they are unknown, they are not included in the estimates of compliance costs.

Table 36 provides a summary of key uncertainties and assumptions and the likely direction of impact on the compliance cost estimates.

[43] For example, in one 2018 accident evaluated, if an SMS had been in place at the time of a prior (2016) accident, Safety Risk Management likely would have determined that the risk of the engine inlet and cowling failing following an engine fan blade failure was unacceptable. Risk controls to strengthen the engine inlet and cowling could have been developed and implemented which would have prevented the 2018 accident. Instead, these mitigations are being developed and implemented now.

Table 36. Uncertainties in the Analysis of SMS Compliance Costs

Assumption or Uncertainty	Impact on Costs	Comments
Costs are based on a small number of participants' experience with the FAA's SMS voluntary program, and these are typically larger firms	?	Some participants indicated that there was little guidance on implementing SMS at the time. Industry associations are developing products and services for their members that may enable compliance at lower cost; the FAA's Web-Based Analytical Technology (WBAT) is also available at no cost and different pricing levels. For part 21, respondents are large entities. Costs for small firms may be particularly uncertain.
Estimated compliance costs do not reflect cost savings (e.g., reduced incident or insurance costs) or the costs of hazard mitigations[44]	?	Both cost savings and mitigation costs would be entity specific and thus cannot be quantified. The outreach responses identified examples of both types of impacts.
There may be costs savings associated with airworthiness directive development and compliance	+	SMS may reduce the number of airworthiness directives needed to maintain safe aircraft. These savings would accrue to both industry and government.
'+' = costs may be overstated '?' = costs may be over- or understated		

Given the uncertainties, costs may be under- or overstated (e.g., representative costs for larger entities may reflect economies of scale not experienced by smaller ones; industry association products and services may result in lowering the costs to entities implementing SMS under the rule). Cost impacts may also cross certificated parts. For example, to the extent that the requirement for an SMS in design and production reduces the volume of ADs, entities operating aircraft across certificated parts would experience cost savings. For example, the FAA estimated the cost of compliance with AD 2020-17-3 at $1.9 million for 1,203 affected airplanes of U.S. registry. In addition, the FAA identified a cost of $411,413 per product for any necessary modifications that would be required based on the results of any required actions. (The FAA did not have data to estimate the number of aircraft that would need such modifications.)

[44] Examples of cost savings include less mistakes and repeat work from refined policies and procedures. Examples of mitigations, or risk controls, include new processes and equipment, training, new supervisory controls, and changes to staffing arrangements.

6.0 Summary of Benefits and Costs

Table 37 provides a summary of the quantified annualized and present value compliance costs. Not included in the estimates are costs to mitigate hazards, which are yet unknown.

Table 37. Summary of Costs[1] (Millions $2022)

Category	Annualized	Present Value (5 years)
3% Discount rate		
Part 21[2]	$4.9	$22.5
Part 135	$35.9	$164.5
§ 91.147	$7.2	$33.2
Part 121	$0.05	$0.3
Total	$48.1	$220.4
7% Discount rate		
Part 21[2]	$4.9	$20.1
Part 135	$35.3	$144.9
§ 91.147	$7.1	$29.2
Part 121	$0.05	$0.3
Total	$47.4	$194.5
1. Based on quantified impacts. Excludes costs of mitigation. 2. Includes FAA administrative costs.		

Because the FAA did not estimate benefits quantitatively, it cannot estimate net benefits (benefits minus costs).

7.0 Alternatives

This section analyzes the regulatory alternatives to the rule that the FAA considered. The preamble to the rule provides the FAA's rationale for the selected options.

7.1 Alternative 1: Extend Applicability of Part 5 for Part 21 Entities

As described in the preamble to the rule, the FAA considered an alternative based on recommendations from the part 21 SMS Aviation Rulemaking Committee (ARC). The ARC recommended that SMS requirements apply to organizations that design or manufacture products (under a TC or a PC) and to those that design or manufacture articles (under a technical standard order authorization or parts manufacturer approval), or that make changes to products (under a supplemental type certificate) that could directly prevent continued safe flight and landing if they fail.[45]

Under this alternative, the SMS requirements would apply beyond holders of both a type and production certificate for the same product and would include most design and production approval holders. This alternative would exclude design and production approval holders of products, articles, or changes to existing type certificated products that are not typically used for carrying passengers or property for compensation or hire. Also, as part of this alternative, the FAA considered a process that would allow design and production approval holders to apply to be excluded from SMS requirements if the failure of the article or approved product alteration would have little or no effect on the continued safe flight or landing of the aircraft.

The FAA estimated that over 3,000 additional entities (e.g., holders of a type certificate, a production certificate, parts manufacturer approval, technical standards order authorization, or supplemental type certificate) would be required to implement an SMS under this alternative. The FAA also estimated that over 3,000 additional entities (not associated with the entities in the previous sentence) would likely apply for an exception from the SMS requirements.

The alternative would increase benefits through SMS implementation by the approximately 3,000 entities who design or produce certain safety-critical parts under any design or production approval. The alternative would also hold entities who design and produce interchangeable safety-critical parts to the same SMS standard that would be required of entities holding both a type certificate and a production certificate for the same product. There are examples of risks in products that would meet the exception criteria under the alternative (although the parts may be installed on airplanes used in air tour operations under § 91.147).[46] However, similar risks may exist among the safety-critical parts designed or manufactured by the additional entities that would be required to implement SMS.

The alternative would increase costs. The FAA does not have access to data on company size for the approximately 3,000 entities that would be required to implement SMS if it adopted the ARC's recommendation. However, using industry wide employment in aircraft manufacturing,

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[45] See Part 21/Safety Management Systems (SMS) Aviation Rulemaking Committee to the Federal Aviation Administration: Recommendations on Certification Procedures for Products and Parts, October 5, 2014, page 31.

[46] Eleven accidents from 2004 to 2019, resulting in a total of 3 fatalities and 5 serious injuries, involved an oil filter adapter developed under supplemental type certificate approval and parts manufacture approval.

and assumptions regarding entities that may be classified outside of this sector, the FAA estimated that costs could be in the order of $37 million for this alternative. The costs include SMS development and implementation costs, costs to apply for an exception from the SMS requirements, and FAA review and approval costs. Compared to the rule, the increase is approximately $32 million (annualized using a 7% discount rate).

7.2 Alternative 2: Limit Applicability of Part 5 for Part 135 Operators and § 91.147 LOA Holders

The FAA considered an alternative to the applicability for part 135 and § 91.147 that would limit the number of small operators affected. The FAA considered excluding the part 135 operators that use only one pilot-in-command in their operations and the § 91.147 LOA holders that conduct less than 100 flights per year.

The FAA has data to identify part 135 operators that use only one pilot-in-command. However, for § 91.147 LOA holders, the FAA does not have data on the number of flights. For this analysis, the FAA used LOA holders with one aircraft listed on the LOA as an estimate of those that would not be affected under the alternative. Table 39 provides the number of affected entities under the rule and this alternative.

Table 38. Number of Affected Entities: Part 135/§ 91.147 Alternatives

Category	Rule	Alternative[1]
Part 135	1,848	1,300
§ 91.147[2]	715	338

Source: FAA data as of June 2023
1. The alternative is to exclude from SMS requirements the part 135 operators that use only one pilot-in-command in their operations and the § 91.147 LOA holders that conduct less than 100 flights per year.
2. Reflects number of LOA holders not associated with a part 135 certificate.

The limited applicability under Alternative 2 would lower benefits by reducing the pool of accidents that could be mitigatable by the rule. The FAA identified one part 135 accident involving a single-pilot operator that would not be required to implement SMS.[47] Alternative 2 would also reduce costs. Table 40 shows the estimated costs of the alternative compared to the rule.

Table 39. Annualized Costs: Part 135/§ 91.147 Alternative (Millions $2022)[1]

Category	Rule	Alternative	Change in Costs from Rule
Part 135	$35.4	$32.4	-$3.0 (-10%)
§ 91.147	$7.1	$5.5	-$1.6 (-23%)

1. Based on phasing in costs over 3 years.

[47] The accident number is ANC18LA046. Based on further review, the FAA determined several accidents identified in the preliminary alternative analysis for the NPRM were not single pilot operations at the time of the accident and therefore would have been required to implement SMS. The FAA identified another single pilot accident during 2020 (CEN20CA119), which is not included as it is outside the period of this analysis.

7.4 Summary

Table 41 provides a summary of the analysis of alternatives. The uncertainty associated with the estimation of benefits and costs of the also applies to the estimates of the alternatives. The preamble to the rule (Section V. A., Applicability) discusses the factors the FAA considered in option selection.

Table 40. Summary of Alternatives Analysis

Scenario	Change from Rule	
	Benefits	**Costs (Millions)** [1]
Alternative 1: Extend applicability to additional design and production approval holders	Data not available to quantify change in risk	+$32.0
Alternative 2: Limit applicability for part 135 to exclude operators that use only one pilot-in-command, and under § 91.147 to exclude operators conducting fewer than 100 flights per year	Lower (would not mitigate risks identified in 1 part 135 accident)	Part 135: -$3.0 § 91.147[3]: -$1.6
1. Annualized costs using a 7% discount rate.		

8.0 References

Federal Aviation Administration (FAA). 2021. 2020 Aviation Accident Investigation Costs. Office of Aviation Policies and Plans. Prepared by GRA, Incorporated. https://www.faa.gov/regulations_policies/policy_guidance/benefit_cost/media/econ-value-section-8-accident-investigation-costs.pdf.

Federal Aviation Administration (FAA). 2018. Unit Replacement and Restoration Costs of Damaged Aircraft. Office of Aviation Policy and Plans. Prepared by GRA, Incorporated. https://www.faa.gov/regulations_policies/policy_guidance/benefit_cost/media/econ-value-section-5-resto.pdf.

Federal Democratic Republic of Ethiopia Ministry of Transport Aircraft Accident Investigation Bureau. 2019. Aircraft Accident Investigation Preliminary Report Ethiopian Airlines Group B737-8 (MAX) Registered ET-AVJ, Report No. AI-01/19, March 10. https://flightsafety.org/wp-content/uploads/2019/04/Preliminary-Report-B737-800MAX-ET-AVJ.pdf.

Komite Nasional Keselamatan Transportasi, Republic of Indonesia. 2019. Aircraft Accident Investigation Report PT. Lion Mentari Airlines Boeing 737-8 (MAX), KNKT.18.10.35.04 Final, http://knkt.dephub.go.id/knkt/ntsc_aviation/baru/2018%20-%20035%20-%20PK-LQP%20Final%20Report.pdf.

Madsen, Peter, Robin L. Dillon, and Catherine H. Tinsley. 2016. Airline Safety Improvement Through Experience with Near-Misses: A Cautionary Tale. *Risk Analysis*, Vol. 36, No. 5.

Tinsley, Catherine H., Robin L. Dillon, and Peter M. Madsen. 2011. How to Avoid Catastrophe. Harvard Business Review. https://hbr.org/2011/04/how-to-avoid-catastrophe.

National Transportation Safety Board (NTSB). 2020. Electronic data file of aviation accidents (completed investigations). Provided to FAA.

National Transportation Safety Board (NTSB). 2022. 2001-2020 U.S. Civil Aviation Accident Rates. Downloaded April 5, 2022. https://www.ntsb.gov/safety/Pages/research.aspx.

U.S. Department of Transportation (DOT). 2022. Treatment of the Value of Preventing Fatalities and Injuries in Preparing Economic Analyses. Office of the Secretary of Transportation. March. Departmental Guidance on Valuation of a Statistical Life in Economic Analysis | US Department of Transportation.

Appendix A. Mitigatable Accidents

This appendix provides the accidents the FAA's subject matter experts identified as potentially mitigatable through requiring SMS for parts 21 (Table 42), part 135 (Table 43), and § 91.147 (Table 44). The tables show the NTSB probable cause statement, and the FAA's evaluation of how SMS could have mitigated the accident. Not included is the probability of mitigating the accident (i.e., the effectiveness of SMS), which would vary across accidents, and is an uncertainty in the analysis. The FAA identified these accidents by screening information in the investigation dockets for the set of accidents that occurred between 2015 and 2019. (Table 10 shows the total number of accidents.) Since this screening did not entail in-depth review of each individual accident, there may be additional accidents that the rule could have mitigated that were not included in the analysis.

The accident investigation information represents examples where having SMS could have aided the aviation organizations in avoiding what occurred. Some of the examples involve noncompliance with existing FAA regulations. The existence of an applicable regulation may address a certain safety hazard, but it may not necessarily cover or lead to the identification and mitigation of all possible conditions that could result in regulatory noncompliance and an accident. In this way, SMS complements but operates independently from existing regulations to help prevent accidents.

Increased oversight and enforcement of existing regulations would be one method to help prevent re-occurrence of accidents involving the specific hazards addressed by the regulations. However, the FAA cannot be omnipresent to continually assure regulatory compliance of all certificate holders and operators on a real-time basis. An SMS is a framework of requirements to enable operators' processes to work together to identify safety risks, whether or not those risks are addressed by other FAA regulations, independent of regulatory oversight and enforcement. In essence, SMS acts as a force-multiplier by requiring aviation organizations to address areas in their operations where risks are identified without relying solely on the FAA to assure compliance and safety.

Moreover, SMS is designed to help an organization self-correct before an event by impacting decision-making within the organizations. In some of the accidents listed, an action by one person in the organization is noted as the probable cause. SMS is designed to improve safety culture within aviation organizations by providing a structure for proactive and preventative safety actions. It emphasizes the importance of safety at all levels of the organization and creates a safety-conscious work environment. This helps organizations comply with existing regulations as well as forecast future needs. The objective is to enhance the safety attitudes and outcomes of an organization by changing the safety culture of leadership, management, and employees. The desired end state is that employees are able to internalize the safety culture and, ultimately, make better decisions.

Table 41. Accident Analysis Results: Design and Manufacturing (Part 21)

Accident No.	NTSB Probable Cause Statement	SMS Mitigation
DCA19MA086	The inappropriate response by the first officer as the pilot flying to an inadvertent activation of the go around mode, which led to his spatial disorientation and nose-down control inputs that placed the airplane in a steep descent from which the crew did not recover.	This accident is an example of how faults in the design phase can impact operations. The performance of the pilots was a factor in the accident, but flight deck layout and human factors contributed significantly. Effective Safety Assurance at the aircraft design and manufacturer may have raised awareness of the hazard and highlighted the need for requiring improved cockpit imaging equipment to improve future cockpit designs and improve flight crew procedures/training to mitigate incidents in the existing design. Having awareness of the risk may have assisted the first officer or pilot-in-command in making appropriate corrections to the airplane. SMS may have highlighted the risk, and at a minimum, created awareness, specific training or enhanced checklists in the event that this situation occurs. All requirements under 14 CFR Part 5 could have assisted in preventing this accident, but primarily, § 5.53 System analysis and hazard identification, § 5.55 Safety risk assessment and control, § 5.71 Safety performance monitoring and measurement, § 5.73 Safety performance assessment, and § 5.75 Continuous improvement.
ERA18LA199	The undetected wear of the ignition switch and key, which allowed removal of the key from an intermediate position and subsequently led to an unintended engine start-up. Contributing to the undetected wear of the 42-year-old ignition switch was the lack of guidance by the switch manufacturer and airframe manufacturer for procedures to detect lack of integrity between the ignition key and switch.	The undetected wear of the ignition switch and key allowed removal of the key from an intermediate position and subsequently led to an unintended engine start-up. The specific test required by the manufacturer to test when new may be sufficient when new. However, the manufacturer could have identified this type of wear on an ignition switch through Safety Assurance processes had an SMS been in place. The manufacturer could have used previous incidents and Service Difficulty Reports as hazard identification methods, and taken action on ignition systems that did not operate as intended and not meeting design requirements. They also could have required additional test and maintenance be performed while in operation. This accident highlights the benefit of flowing SMS requirements through the supply chain. The airplane original equipment manufacturer, in contracting with the switch manufacturer, retains the responsibility for the safety of the delivered airplane. However, no reference was identified in the final report of an inspection program for the ignition switch. All SMS requirements would have supported the prevention of this accident, but primarily, § 5.23 Safety accountability and authority; § 5.51 Applicability; § 5.53 System analysis and hazard identification; § 5.71 Safety

Table 41. Accident Analysis Results: Design and Manufacturing (Part 21)

Accident No.	NTSB Probable Cause Statement	SMS Mitigation
		performance monitoring and measurement; § 5.75 Continuous improvement; § 5.91 Competencies and training; and § 5.93 Safety communication
DCA18MA142	A low-cycle fatigue crack in the dovetail of fan blade No. 13, which resulted in the fan blade separating in flight and impacting the engine fan case at a location that was critical to the structural integrity and performance of the fan cowl structure. This impact led to the in-flight separation of fan cowl components, including the inboard fan cowl aft latch keeper, which struck the fuselage near a cabin window and caused the window to depart from the airplane, the cabin to rapidly depressurize, and the passenger fatality.	This event highlights the need for type certificate and production certificate holders to effectively implement all major elements of an SMS. The investigation highlighted opportunities for SMS policy, risk management, assurance, and promotion activities, not only at the aircraft type certificate/production certificate holder, but also at the engine type certificate/production certificate holder and further through the supply chain. This event was the third time in two years that this sequence of events resulted in damage to the aircraft fuselage ((2) 737 events; (1) 777 event). Effective Safety Assurance processes at the engine manufacturer could have exposed the ineffective inspection procedures and identified the need for establishing more robust methods, which would increase the likelihood of fan blade crack detection. Also, if an SMS had been in place at the time of the accident, the aircraft manufacturer may have conducted Safety Risk Management following prior similar incidents and may have identified the risk of the engine inlet and cowling failing following an engine fan blade failure as unacceptable. Risk controls to strengthen the engine inlet and cowling could have been developed and implemented to prevent the 2018 accident. Unfortunately, this event highlights the need for effective Safety Assurance processes with the aircraft manufacturer. An effective SMS at the manufacturers of the fan blades, engine, engine cowling, and airplane would have required activities in each of the following sections of 14 CFR § 5 – § 5.23 Safety accountability and authority; § 5.51 Applicability; § 5.53 System analysis and hazard identification; § 5.71 Safety performance monitoring and measurement; § 5.75 Continuous improvement; § 5.91 Competencies and training; and § 5.93 Safety communication. These activities were conducted after this fatal accident and contributed to the mitigation actions. Effective regulatory requirements for SMS would help drive additional systemic improvements to engine cowling design and manufacturing and help mitigate additional similar events.
ERA18FA120	Extensive fatigue cracking in the left-wing main spar lower cap and doublers, which resulted in the in-flight separation of the left wing. The fatigue cracks initiated and grew	An effective design and manufacturing SMS would have been beneficial in this case and likely would have prevented this accident. The design considerations through an SMS mindset would have considered: (1) use of airplane for training (i.e. high cycle times, inexperienced pilots, likelihood of

Table 41. Accident Analysis Results: Design and Manufacturing (Part 21)

Accident No.	NTSB Probable Cause Statement	SMS Mitigation
	to a critical size due to flight and ground loads associated with flight-training involving flight-training maneuvers, significant operation at low altitudes and frequent landing cycles. Previously established inspection criteria were insufficient to detect the fatigue crack before it grew to a critical size.	hard landings, and etc.), (2) lessons learned from previous PA-28 accident with similar causes, (3) better instructions with respect to maintenance program; the current program only states to inspect and no other specific instructions, and (4) a Service Bulletin that invokes a dye penetrant inspection for the wing mounts, but the initial flight hours requirement for the inspection may be too high or doesn't consider the operational conditions for the aircraft. The accident and subsequent investigation highlight the series of risk management decisions that continued to result in catastrophic outcomes. A more complete assessment of the structural integrity of the main spar / cap design appears to now have been accomplished reactively, after multiple accidents spanning decades. All four major elements of SMS are aimed at approaching these type of design issues through added considerations of the margin associated with risk decisions.
DCA17FA021	The failure of the high-pressure turbine (HPT) stage 2 disk, which severed the main engine fuel feed line and breached the right main wing fuel tank, releasing fuel that resulted in a fire on the right side of the airplane during the takeoff roll. The HPT stage 2 disk failed because of low-cycle fatigue cracks that initiated from an internal subsurface manufacturing anomaly that was most likely not detectable during production inspections and subsequent in-service inspections using the procedures in place.	Supply chain is a critically important part of a certificate holder's design and manufacturing system. Thus, § 5.53, System analysis and hazard identification, requires the activities provided by the supply chain to also be assessed and managed through Safety Risk Management, as well as assessed and managed through Safety Assurance, § 5.71 Safety performance monitoring and measurement. A certificate holder's Safety Policy, § 5.23 Safety accountability and authority, should codify the requirements for extending their SMS to the supply chain, to ensure accountability and responsibility are aligned. The investigation found that fatigue cracks probably initiated from an internal subsurface manufacturing anomaly that was most likely not detectable during production inspections and subsequent in-service inspections using the procedures in place. However, the supplier would have understood the hazard of "dirty white spots" and that they could be missed with surface based inspection procedures. An effective part 21 and 121 SMS would have highlighted a need for better inspection methods as well as the need to understand uncontained engine failures more accurately. This event highlighted how a failure to adequately manage a known hazard that can be created during nickel disk manufacture; how a lack of information on manufacturing hazards resulted in lack of applying adequate risk controls (inspections) needed during manufacture and during service (overhaul); the

Table 41. Accident Analysis Results: Design and Manufacturing (Part 21)

Accident No.	NTSB Probable Cause Statement	SMS Mitigation
		need for Safety Policy and Safety Promotion to formally flow to supply chain to augment quality control programs.
WPR16FA153	An inflight fire in the floor area near the main bus tie circuit breaker panel that resulted from chafing between an electrical wire and a hydraulic line or airplane structure.	An effective SMS would require the assessment and action related to safety hazards with wires/fluid lines in contact, as has been advised in aircraft design for decades. Further, an effective SMS at the airplane original equipment manufacturer would have required the assessment of product safety performance from in-service hardware, which most likely would have identified the unsafe condition found in six exemplar aircraft. An effective SMS would have likely found this safety hazard before this accident flight occurred and driven risk management actions. The lack of an effective product safety performance monitoring and response program at the original equipment manufacturer allowed this specific hazard to exist until this catastrophic consequence forced more focused attention to the safety concern. Waiting for the fatal accident to guide actions is contrary to the fundamental tenets of SMS. This accident emphasizes the benefits of a part 21 original equipment manufacturer having an established and effective system safety processes/policies (§ 5.23 Safety accountability and authority), of using effective in-service safety performance monitoring and response processes (§ 5.71 Safety performance monitoring and measurement and § 5.75 Continuous improvement), and explicitly promoting (§ 5.93 Safety communication) lessons learned system.
DCA16FA199	A severe vibration of the helicopter that led to the crew's inability to maintain sufficient rotor rotation speed (Nr), leading to excessive main rotor blade flapping, subsequent main rotor blade contact with the tail boom, and the resultant in-flight breakup.	This accident highlights the need for an effective SMS in the design and development functions to maintain an equal and independent voice on product-safety hazards and risks during the earliest phases of an aerospace program. The investigation of this accident identified numerous gaps in protection that could have been implemented into the rotorcraft control system. These protections were needed to minimize risks associated with known rotorcraft flight dynamics, which were subsequently highlighted through the investigation to exist. Subsequent to the investigation, the rotorcraft manufacturer "incorporated a safety officer for the accident helicopter model test program who will have dedicated safety-related responsibilities." This finding does not clearly identify whether the manufacturer has instituted this organizational change as part of an overall policy change or rather only changed the organization for this one helicopter model. An effective SMS

Table 41. Accident Analysis Results: Design and Manufacturing (Part 21)

Accident No.	NTSB Probable Cause Statement	SMS Mitigation
		would have required identification of personnel with dedicated, safety-focused responsibilities and a safety program to support their responsibilities, that would have extended to all flight test programs and equally important to the prior system safety evaluations occurring prior to flight test. Through these system safety evaluations, the opportunities to highlight the hazards and risks related to the lack of flight control system protections could be highlighted and addressed. All SMS requirements could have assisted in preventing this accident, but primarily, § 5.51 Applicability, § 5.53 System analysis and hazard identification, § 5.55 Safety risk assessment and control, § 5.71 Safety performance monitoring and measurement, § 5.73 Safety performance assessment, and § 5.75 Continuous improvement.
ERA16FA185	A preexisting stress rupture that initiated at a spot weld in the turbocharger v-band exhaust clamp, which resulted in the failure of the clamp and separation of the exhaust tailpipe, an in-flight fire, and subsequent impact with terrain.	The concerns related to V-band couplers used for exhaust systems were well known (multiple Airworthiness Directives, other accidents, Special Airworthiness Information Bulletin, etc.). An Airworthiness Directive for this aircraft model did not come out until after the accident. An effective SMS may have included a look at this particular model earlier and/or considered a different design to mitigate the hazard. This accident is another in a long trend of general aviation accidents and incidents related to engine exhaust system integrity. An effective SMS applied to designers, manufacturers, and maintenance providers of general aviation aircraft exhaust systems would require learnings from maintenance findings to be aggregated by designers, manufacturers, and maintenance providers that would provide a clearer view of the risk resulting from these exhaust system hazards, rather than the silo evaluations that continue without an effective SMS across these stakeholders. All SMS requirements could have assisted in preventing this accident.
WPR16FA055	The fatigue failure of the engine fuel pipe as a result of vibration caused by a worn starter-generator front bearing support, which excited the fuel pipe and caused it to oscillate at a resonant frequency, and a subsequent loss of engine power due to fuel starvation. Contributing to the severity of passenger injuries was the improper positioning of the passengers' seat belts.	In this case, the starter generator showed early wear and fretting of the front bearing causing a vibration. Early failure of the bearing may have been associated with a design and manufacturing flaw. The starter-generator was the subject of maintenance planning at the original equipment manufacturer, the operator, and approved by regulator. Through these maintenance programs, event data existed that could have been useful in raising attention to the frequency and possible consequences of starter-generator vibrations. Following this accident, the type certificate holder implemented a quality inspection (safety risk control) after learning from the field event. The goal of

Table 41. Accident Analysis Results: Design and Manufacturing (Part 21)

Accident No.	NTSB Probable Cause Statement	SMS Mitigation
		SMS is to implement these risk controls before the first significant field event occurs, by identifying through system safety analysis and precursor analysis, where to apply these risk controls. This accident highlights not having an effective monitoring system (risk control) to identify vibration that can lead to catastrophic consequences, and not having an effective procedure to monitor and address repeated events (while not fatal), at minimum, precursor events. This accident emphasizes the benefits of an original equipment manufacturer having an established and effective system safety processes/policies (§ 5.23 Safety accountability and authority), of using effective in-service safety performance monitoring and response processes (§ 5.71 Safety performance monitoring and measurement and § 5.75 Continuous improvement), and explicitly promoting (§ 5.93 Safety communication) lessons learned system.
DCA16FA013	The separation of the flexible fuel line coupling and subsequent fuel leak due to the failure of maintenance personnel to install the required safety lockwire. Contributing to the severity of the accident was the initiation of the evacuation before the right engine was shut down which led to the passenger's injury.	This accident highlights the critical need to effectively account for human factor hazards in the equipment system safety assessments (§ 5.53 System analysis and hazard identification) and incorporate effective monitoring and improvements (§ 5.71 Safety performance monitoring and measurement; § 5.75 Continuous improvement). Connection to part 21 comes from the principle of flowing field events (safety assurance) back into design process, in order to ensure equipment is performing as intended. This accident highlights 1) not having an effective monitoring system (risk control) to identify vibration that can lead to catastrophic consequences, and 2) not having an effective procedure to monitor and address repeated events (while not fatal), at minimum, precursor events.
ERA15FA254	The total loss of engine power due to the failure of the alternator drive coupling. Contributing to the accident was the pilot's inability to locate and navigate to a suitable forced landing site.	This accident had inconsistent procedures and inspection requirements from multiple sources. There were unidentified hazards (abnormal wear), no method to differentiate source of failures, no reporting of prior out of tolerance parts manufacturer approval couplings, and lack of follow through. There were potential maintenance errors caused by either incomplete or unclear instructions. Comparison of instructions provided by original equipment manufacturer and parts manufacturer approval (PMA) holders showed differences in content and clarity. Existence of an effective SMS by the engine manufacturer would have required a hazard-focused evaluation of the maintenance instructions and tooling requirements for safety alternator

Table 41. Accident Analysis Results: Design and Manufacturing (Part 21)

Accident No.	NTSB Probable Cause Statement	SMS Mitigation
		coupling use. The results of this evaluation would have influenced the maintenance manual content. This evaluation would have been required through safety policy requirements. The field performance of the hardware would have also been required to be monitored according to safety assurance activities, in order to validate the initial hazard/risk evaluation.

Table 42. Accident Analysis Results: Commuter and On Demand Operations (Part 135)

NTSB No.	Probable Cause Statement	SMS Mitigation
CEN19FA072	Survival Flight's inadequate management of safety, which normalized pilots' and operations control specialists' noncompliance with risk analysis procedures and resulted in the initiation of the flight without a comprehensive preflight weather evaluation, leading to the pilot's inadvertent encounter with instrument meteorological conditions, failure to maintain altitude, and subsequent collision with terrain.	SMEs noted management’s practice of accepting high risk (§ 5.55(b)). SMEs noted the management’s failure to address issues raised by employees leading to a ‘blaming’ culture that discouraged employees from reporting safety hazards or issues (§ 5.21(a)(4) and § 5.71(a)(7)). SMEs noted the lack of Safety Assurance audits or evaluations to ensure processes were effective to maintain safety such as pre-flight risk assessment tools (§ 5.71). SMEs noted that risk controls were either not implemented or assessed for their effectiveness (§ 5.73).
ANC18LA027	The flight crew's improper decision to deliberately operate the airplane at low altitude and along a flightpath that resulted in a collision with a pedestrian after takeoff. Contributing to the accident was the pedestrian's proximity to the runway.	SMEs noted that effective management’s support and involvement in SMS may have prevented the accident, (§ 5.23(a)). Also, SMS may have played a role in preventing this accident via the enforcement of unacceptable behavior and conditions for disciplinary action, (§ 5.21(a)(5)). Also, Safety Assurance, monitoring and measurement supporting such items as a confidential employee reporting system may have helped prevent the accident (§ 5.71).
CEN18FA215	The pilot's decision to fly over the river at a low altitude and his failure to maintain clearance with wires during low-level flight.	SMEs noted hazards along waterways were identified and controls discussed. The development of a safety risk control, describing a minimum altitude above known or presumed obstructions for enroute phase of flight would have precluded the accident (5.55(c)). Safety performance monitoring (5.71) could verify that risk controls were appropriately applied. Safety

Table 42. Accident Analysis Results: Commuter and On Demand Operations (Part 135)

NTSB No.	Probable Cause Statement	SMS Mitigation
		Promotion (Subpart E) provides for internal publication of obstruction avoidance techniques, the organization would benefit from communicating hazard information (5.93(b)).
ANC18FA045	The failure of both pilots to see and avoid the other airplane while in level cruise flight, which resulted in a midair collision.	SMEs noted § 5.73 (b) would identify that existing mitigations (see and avoid or the use of the common traffic advisory frequency) to avoid midair collisions would trigger Safety Risk Management, leading to the development of improved controls s (§ 5.55). Additional controls could be implemented to avoid mid-air collision hotspots. SMEs also noted that hazards identified through § 5.73 (b) can be shared among operators (§ 5.57) which would also trigger their SRM process. Monitoring (§ 5.71) could verify that controls are appropriately implemented.
ANC18LA046	The pilot's selection of an unsuitable takeoff area with unfavorable wind conditions, which resulted in the airplane's inability to maintain a climb.	SMEs noted varying degrees of pilot capability signify needed operational policies and/or standard procedures. Having a Safety Risk Management process (§ 5.51 – § 5.55), additional development of risk controls to ensure safer operations such as: tools for a go/no-go decision, selection of aircraft and standardized procedures.
CEN18FA259	The pilot's inadvertent disabling of the No. 1 and No. 2 engines' electronic engine control systems, which resulted in engine and rotor overspeed conditions, a subsequent autorotation, and a hard landing. Contributing to the accident were the pilot's inexperience with the helicopter variant and the operator's lack of a more robust helicopter differences training program.	SMEs noted Safety Risk Management was not performed as required by (§ 5.51 – § 5.55) on the differences between series of aircraft in their fleet. Safety promotion (§ 5.91 SMS training) was also absent, which would have indicated when Safety Risk Management was needed. Application of these sections of part 5 may have prevented this accident.
ANC18FA053	The pilot's decision to continue the visual flight rules flight into instrument meteorological conditions, which resulted in controlled flight into terrain.	SMEs noted prior to this accident, the air carrier discontinued some Safety Risk Management/SMS processes previously implemented. Pre-flight risk assessment tools were incorrectly used by operations center employees, and operational control decision making was not present. Section 5.23(a)(2) and (3) would hold management and employees accountable. Safety performance assessment (§ 5.73) would identify these deficiencies and (§ 5.75 continuous improvement) would correct

Table 42. Accident Analysis Results: Commuter and On Demand Operations (Part 135)

NTSB No.	Probable Cause Statement	SMS Mitigation
		these deficiencies. Development of appropriate safety policies and the development of safety promotion (§ 5.91, § 5.93) combined with the above should make significant reductions in probability of this kind of accident recurring.
ANC18FA055	The pilot's exceedance of the airplane's critical angle of attack during departure climb, which resulted in an aerodynamic stall. Contributing to the accident was the pilot's improper decision to load the airplane beyond its allowable gross weight and center of gravity limits, coupled with his lack of operational experience in the airplane make, model, and configuration.	SMEs noted the application of Safety Risk Management (§ 5.51–§ 5.55) would have identified hazards within the company’s weight and balance process and establish additional requirements (risk controls) for weight and balance checks to prevent the overloading of the aircraft. Safety policies related to the loading and performance of aircraft (§ 5.21) communicated to all company personnel (§ 5.93) may have resulted in the pilot aborting takeoff after failed attempts.
– NC18FA063	Impact with terrain for reasons that could not be determined because the airplane was not recovered due to the inaccessible nature of the accident site.	SMEs noted the lack of operational control and management oversight. Under § 5.23, the operator would have been required to hold all members of management accountable for identification of hazards and risk assessment, assuring safety risk controls are followed and promoting safety. In this case the pilot would not have been allowed to make his own decision with respect to modifying the route if an operational control system was more robust. SMEs also noted that a Safety Risk Management process (§ 5.53, § 5.55) such as a formal preflight risk assessment, would have required consideration of hazards and risks associated with poor weather information and development of controls. Also, a documented Safety Assurance process (§ 5.71 – § 5.75) may have revealed whether or not the above items were effective.
CEN18FA386	The pilot's improper decision to continue the flight in deteriorating weather conditions, which resulted in an inadvertent entry into a box canyon and subsequent controlled flight into mountainous terrain.	SMEs noted limited operational control which would be corrected by § 5.23(a). It would hold all members of management, including the accountable executive, responsible for hazard identification, risk assessment and effectiveness of controls plus promoting safety. Under § 5.53, § 5.55 a process for identifying hazards and developing risk controls, such as weather minimums and required consultation of available weather information, would be established and a preflight risk

Table 42. Accident Analysis Results: Commuter and On Demand Operations (Part 135)

NTSB No.	Probable Cause Statement	SMS Mitigation
		assessment tool would have been used. In this case, the weather cam information would not have been disregarded as all employees would be responsible for safety (§ 5.23(a)(3)) and the pilot would not have initiated the flight.
ERA18FA264	The operator's decision to allow a flight in an airplane with known, unresolved maintenance discrepancies, and the flight crew's failure to properly configure the airplane in a way that would have allowed the emergency or parking brake systems to stop the airplane during landing.	SMEs noted multiple SMS interventions may have prevented accident. Management oversight (§ 5.23) and improved safety culture and communication with the workforce (§ 5.21, § 5.93) could have prevented the conditions that led to the accident.
ANC17TA015	The pilot's continued flight into known icing conditions, which resulted in structural icing and a forced landing on icy, snow-covered terrain.	SMEs noted there was an apparent lack of any Safety Risk Management resources/tools to aid in preflight risk assessment and decision making (§ 5.51 – § 5.55).
CEN17FA100	The pilot's failure to recognize the flight had encountered instrument meteorological conditions at night, which resulted in an unrecognized descent and collision with water.	SMEs noted a hazard exists concerning the preflight weather collecting and distribution procedures [(§ 5.51(d) – § 5.55] and § 5.71(a)(1)). Also, § 5.23(a)(2)) management action would be required to assure the Safety Risk Management process was completed which may have prevented the accident.
CEN17FA168	The pilot's loss of airplane control due to spatial disorientation during the initial climb after takeoff in night instrument meteorological conditions and moderate turbulence.	SMEs noted management's involvement related to pilot competency and skills (§ 5.23(a)). SMS may have precluded the accident by auditing (§ 5.71(a)(3)) contract training to identify hazards (§ 5.73(a)(5)) to correct performance deficiencies (§ 5.75). Also, the organization would have benefitted by implementing a confidential employee reporting system (§ 5.71(a)(7)) providing the flight operations department with information to correct safety performance deficiencies of the maintenance department related to the continual auto pilot malfunctions (§ 5.75).
ANC17FA021	The pilot's continued visual flight rules flight into an area of mountainous terrain and instrument meteorological conditions, which resulted in controlled flight into terrain (CFIT). Contributing to the accident was the company's failure to provide the pilot with CFIT-avoidance recurrent simulator training as	SMEs noted that absence of SRM (§ 5.51 – § 5.55), Safety Monitoring, and Safety Assurance (§ 5.71 – § 7.75) would likely have remedied the situation. Also, management's inability to develop, implement, and maintain SMS processes within their area of responsibility (§ 5.23(a)(2)). It appears that the

Table 42. Accident Analysis Results: Commuter and On Demand Operations (Part 135)

NTSB No.	Probable Cause Statement	SMS Mitigation
	required by their CFIT avoidance program and the company's inadequate flight risk assessment processes, which did not account for the known weather hazards relevant to the accident route of flight.	organization had a documented SMS in place, however, not functioning due to inadequate training (§ 5.91).
DCA17FA109	the flight crew's improper decision to conduct a circling approach contrary to the operator's standard operating procedures (SOP) and the captain's excessive descent rate and maneuvering during the approach, which led to inadvertent, uncontrolled contact with the ground. Contributing to the accident was the operator's lack of a formal safety and oversight program to assess hazards and compliance with SOPs and to monitor pilots with previous performance issues.	SME identified the SMS requirements that may have precluded the accident include an employee safety reporting system]§ 5.21(a)(4)(5)][§ 5.71(a)(7)] that supports a culture of open communication, and developing safety policies and procedures resulting from an SRM process (§ 5.51 – § 5.55), and a monitoring process to ensure effectiveness of those policies and procedures (§ 5.71(a)(1)).
ERA17FA195	The pilot's failure to maintain adequate airspeed, properly correct for left yaw, and his exceedance of the airplane's critical angle of attack during initial climb, which resulted in an aerodynamic stall and subsequent uncontrolled descent into water.	SME noted management's inactive involvement by way of not assuring the effectiveness of safety risk controls, (§ 5.23(a)(2)(ii)) and the absence of the accountable executive regularly reviewing the safety performance and directing actions necessary to address substandard safety performance (§ 5.25(b)(5)) contributed to the accident. Also, having strong safety objectives (§ 5.21(a)(1)(2)) with respect to personnel hiring and qualification requirements would have helped prevent the accident.
ANC17FA039	(See report)	SMEs noted that a functioning SMS in the organization may have prevented the accident to include, evidence of SMS activity (§ 5.97), actions of the accountable executive, [§ 5.25(b)]. Additionally, applying the SRM process to identify hazards involved with preflight operations (§ 5.51(d) – § 5.55) may have prevented the accident. Also, having strong safety objectives [§ 5.21(a)(1)(2)] with respect to personnel hiring and qualification requirements would have helped prevent the accident.
CEN18FA033	An in-flight loss of control due to bird strikes.	SMEs noted that the organization would have benefitted by having an operational policy (risk control) regarding low-level operations where birds are found. A known hazard (migrating

Table 42. Accident Analysis Results: Commuter and On Demand Operations (Part 135)

NTSB No.	Probable Cause Statement	SMS Mitigation
		birds) could have triggered the Safety Risk Management process [§ 5.51(d)] which may have identified the risk (§ 5.53) and a control would be developed and implemented (§ 5.55). The new policy would then be communicated through the company (§ 5.93).
ANC16LA012	The pilot’s continued flight into deteriorating, flat light weather conditions, which resulted in impact with mountainous, snow-covered terrain.	Some SMEs noted that the pilot elected to operate contrary to existing company policy, and implementing an enhanced safety policy could have altered the outcome [§ 5.21(a)(5)]. Also, an evaluation of company-controlled flight into terrain procedures and pilot decision-making (§ 5.71 – § 5.75) which may lead to possible application of Safety Risk Management (§ 5.51 – § 5.55) may have prevented this accident.
ANC16FA017	The pilot's inadvertent turn toward terrain that was higher-than-expected while trying to avoid poor visibility conditions and his subsequent attempt to clear terrain, which reduced the airspeed and led to the exceedance of the airplane's critical angle of attack and an aerodynamic stall and spin.	Some SME noted that having a procedure (Flight Risk Assessment Tool) regarding route suitability by conducting an Safety Risk Management process (§ 5.51 – § 5.55), and a process to monitor this procedure to determine its effectiveness [§ 5.71(a)(1) – § .73] may have precluded the accident.
ERA16FA215	The pilot's decision to continue an unstabilized instrument approach in instrument meteorological conditions, which resulted in controlled flight into terrain.	Some SMEs noted that company processes and procedures were not complied with, and the company did not have any safety assurance processes to monitor pilot performance, (§ 5.71 – § 5.75).
CEN16FA372	The pilot's excessive cyclic input during a missed approach maneuver in night instrument meteorological conditions, which resulted in a loss of control and spiraling descent into terrain.	SMEs noted that an evaluation of pilot training through safety assurance (§ 5.71 – § 5.75) which may lead to an SRM process if deficiencies were identified (§ 5.51 – § 5.55).
CEN16LA386	The pilot's loss of helicopter control during landing, which resulted in a hard landing and collision with a wall.	SMEs noted that the selection of unique landing areas at night would have identified the need to apply Safety Risk Management (§ 5.51 – § 5.55). Safety monitoring and measurement (§ 5.71 – § 5.73) would assure that training and checking was being performed thus may have prevented the accident.
WPR16LA189	The pilot's decision to land in an area of low visibility and ground fog, which resulted in collision with water.	SMEs noted the application of safety assurance (§ 5.71 – § 5.75) focused on aircraft operations and seaplane pilot decision making

Table 42. Accident Analysis Results: Commuter and On Demand Operations (Part 135)

NTSB No.	Probable Cause Statement	SMS Mitigation
		may have identified deficiencies related to pilot judgment that could be mitigated through appropriate avoidance and inadvertent instrument meteorological conditions escape training (§ 5.51 – § 5.55).
ANC17MA001	The flight crew's decision to continue the visual flight rules flight into deteriorating visibility and their failure to perform an immediate escape maneuver after entry into instrument meteorological conditions, which resulted in controlled flight into terrain (CFIT). Contributing to the accident were (1) Hageland's allowance of routine use of the terrain inhibit switch for inhibiting the terrain awareness and warning system alerts and inadequate guidance for uninhibiting the alerts, which reduced the margin of safety, particularly in deteriorating visibility; (2) Hageland's inadequate crew resource management (CRM) training; (3) the FAA's failure to ensure that Hageland's approved CRM training contained all the required elements of Title 14 Code of Federal Regulations 135.330; and (4) Hageland's CFIT avoidance ground training, which was not tailored to the company's operations and did not address current CFIT-avoidance technologies.	SMEs noted having a robust company policy (risk control) regarding the Terrain Warning Avoidance System) developed through a Safety Risk Management process (§ 5.51 – § 5.55) and a monitoring process that ensures the effectiveness of that policy [§ 5.71(a)(1) – § 5.73)]. Also, some SME noted there may have been weak oversight by management to ensure policy was adhered to [§ 5.21(a)(5) and § 5.23(a)(2)].
ERA17FA066	The pilot's decision to initiate and continue the flight into known adverse weather conditions, which resulted spatial disorientation, a loss of airplane control, and a subsequent in-flight breakup.	SMEs noted management's lack of operational control [§ 5.23(a)(1)(2)] and their inability to ensure company policies, processes and procedures were being followed may have contributed to this accident (§ 5.71 – § 5.75).
CEN15FA171	The flight's inadvertent encounter with night instrument meteorological conditions, which resulted in the pilot turning the helicopter and subsequently descending into trees and terrain due to spatial disorientation.	Some SMEs noted the pilot did not execute an appropriate escape maneuver when inadvertently entering instrument meteorological conditions [§ 5.23(a)(3)].
ANC15LA033	The pilot's failure to maintain an adequate visual lookout, which resulted in a midair collision.	SMEs noted that management's actions for promoting safety related to arrival procedures may have precluded the accident

Table 42. Accident Analysis Results: Commuter and On Demand Operations (Part 135)

NTSB No.	Probable Cause Statement	SMS Mitigation
	Contributing to the accident was the pilot's failure to follow FAA-recommended traffic pattern procedures.	[§ 5.23(a)(2)(iii)]. Also, robust safety promotional activity that communicates safety information to pilots may have prevented the accident (§ 5.93).
WPR15LA198	The pilot's failure to maintain directional control of the airplane during the landing roll in variable and gusting wind conditions.	SMEs noted pilot's failure to abort the landing due to current weather conditions may have prevented this accident. Employees should understand their actions affect the organization's safety performance [§ 5.23(a)(3)].
ANC15MA041	(1) the pilot's decision to continue visual flight into an area of instrument meteorological conditions, which resulted in his geographic disorientation and controlled flight into terrain; and (2) Promech's company culture, which tacitly endorsed flying in hazardous weather and failed to manage the risks associated with the competitive pressures affecting Ketchikan-area air tour operators; its lack of a formal safety program; and its inadequate operational control of flight releases.	SMEs noted that the establishment of appropriate roles and accountability for an accountable executive, [§ 5.23(a)(1)(2)], as well as the establishment and adherence to a code of ethics [§ 5.21(a)(7)]. Through safety performance monitoring and measurement [§ 5.71 through § 5.75] the repeated lack of adherence to company operational control policies and training for installed equipment and controlled flight into terrain could have been identified, which would trigger Safety Risk Management (§ 5.51 through § 5.55) to address deficiencies identified. SMS training required by § 5.91 could also have helped to prevent the accident.
CEN15LA288	The pilot's lack of awareness of the severity of the gusting winds, which led to the helicopter being pushed off of the oil platform by a wind gust during engine start. Contributing to the accident was the unavailability of a nearby weather monitoring system.	SMEs noted that utilizing an SRM process to develop more robust policies and procedures, related to oil platform preflight risk assessment tools (§ 5.51 – § 5.55). Additionally, the Operational Control Center should have prevented the helicopter from departing [§ 5.23(a)(3)].
ANC15FA049	The pilot's decision to initiate and continue visual flight into instrument meteorological conditions, which resulted in a loss of situational awareness and controlled flight into terrain. Contributing to the accident were the company's failure to follow its operational control and flight release procedures and its inadequate training and oversight of operational control personnel. Also contributing to the accident was the FAA's failure to hold the company accountable for correcting known regulatory deficiencies and	SMEs noted a lack of management oversight, operational control procedures inadequate and not followed (§ 5.23(a), § 5.25(b)(5) and § 5.75). The pre-flight risk assessment tool was not used. Safety promotion under § 5.91 and § 5.93(b) would have conveyed why those risk assessment tools were important. Under § 5.21 the company would have a policy in place for unacceptable behavior and disciplinary action.

Table 42. Accident Analysis Results: Commuter and On Demand Operations (Part 135)

NTSB No.	Probable Cause Statement	SMS Mitigation
	ensuring that it complied with its operational control procedures.	
CEN16MA036	The flight crew's mismanagement of the approach and multiple deviations from company SOPs, which placed the airplane in an unsafe situation and led to an unstabilized approach, a descent below minimum descent altitude without visual contact with the runway environment, and an aerodynamic stall. Contributing to the accident were Execuflight's casual attitude toward compliance with standards; its inadequate hiring, training, and operational oversight of the flight crew; the company's lack of a formal safety program; and the FAA's insufficient oversight of the company's training program and flight operations.	SMEs noted the application of Safety Policy to require adherence to standard operating procedures [§ 5.21(a)(5)]. Also, a lack of management exercising appropriate oversight or operational control contributed to this accident [§ 5.23(a)(1)(2)]. Safety performance monitoring and assessment to verify the organization is adhering to policies and standard operating procedures could have prevented the accident (§ 5.71 – § 5.73).
WPR16FA037	The pilot's loss of control and collision with terrain while attempting a course reversal after inadvertently entering an area of reduced visibility weather conditions. Contributing to the accident was the pilot's lack of recent experience with night time operations.	SMEs noted there was a lack of management responsibility for oversight of risk management processes [§ 5.23)(a)(2)] and the organizations lack of safety monitoring under safety assurance [§ 5.71(a)(1)]; specifically training for aircraft variances. Differences between aircraft avionics should have triggered a Safety Risk Management process, which would result in appropriate changes to their training program, i.e., creation of risk controls (§ 5.51 – § 5.55).
1. Represents the average of the individual probability distributions weighting all experts equally.		

Table 43. Accident Analysis Results: Air Tours (§ 91.147)

NTSB No.	Probable Cause Statement	SMS Mitigation
WPR14FA186	The pilot's inability to maintain aircraft control due to a partial loss of engine power and an encounter with downdrafts and gusting crosswinds while on final approach to the runway. The reason for the partial loss of engine power could not be determined because post-accident examination revealed no mechanical malfunction or failure that would have precluded normal operation.	SMEs noted that a lack of policies and tools addressing common hazards related to local metrological condition would have been discovered during the monitoring of operational environment (§ 5.71(a)(2)), which could have resulted in additional risk controls related to preflight planning mandated restrictions to flight operations during these weather conditions (§ 5.51 – § 5.55). Also,

Table 43. Accident Analysis Results: Air Tours (§ 91.147)

NTSB No.	Probable Cause Statement	SMS Mitigation
		accountability for safety under § 5.23(a)(2(iii) by conveying hazard information relevant to the employees' responsibilities (§ 5.93) may have prevented the accident.
WPR16FA072	The in-flight failure of the engine-to-transmission drive shaft due to improper maintenance, which resulted in low main rotor revolutions per minute and a subsequent hard landing to water.	SMEs noted systemic failures of: managerial oversight related to maintenance procedures and practices [§ 5.23(a)(1)(2)]. Additionally, safety performance monitoring and measurement as applied to maintenance methods and procedures would have prevented the accident [§ 5.71(a)].
CEN16LA338	The pilot's improper decision to continue a descent during a night visual approach for landing which resulted in controlled flight into terrain. Contributing to the accident was the reduced visibility and pilot's disregard of the PAPI indications that the airplane's approach path was excessively low.	An SRM may have led to development of weather minimums policy, robust pre-flight risk analysis, and weather avoidance decision making that could have prevented the accident (§ 5.51 – § 5.55).
ERA18MA099	Liberty Helicopters Inc.'s use of a NYONair-provided passenger harness/tether system, which caught on and activated the floor-mounted engine fuel shutoff lever and resulted in the in-flight loss of engine power and the subsequent ditching. Contributing to this accident were (1) Liberty's and NYONair's deficient safety management, which did not adequately mitigate foreseeable risks associated with the harness/tether system interfering with the floor-mounted controls and hindering passenger egress; (2) Liberty allowing NYONair to influence the operational control of Liberty's FlyNYON flights; and (3) the Federal Aviation Administration's inadequate oversight of Title 14 Code of Federal Regulations Part 91 revenue passenger-carrying operations. Contributing to the severity of the accident were (1) the rapid capsizing of the helicopter due to partial inflation of the emergency flotation system and (2) Liberty and NYONair's use of the harness/tether system that hindered passenger egress.	SMEs noted a lack of management accountability for safety [§ 5.23(a)(1)(2)) contributed to the accident. Any one of the following hazards related to the tethering device relating to the aircraft controls, and passenger egress, would have been identified, associated risk analyzed, and risk controls developed and implemented using an SRM process, (§ 5.51 – § 5.55). Implemented risk controls would then be monitored regularly through Safety Assurance for its effectiveness (§ 5.71 – § 5.73).
1. Represents the average of the individual probability distributions weighting all experts equally.		

Appendix B. Detailed Calculations

This appendix provides the detailed calculations of costs.

Table 45 provides the estimated average SMS costs for onetime development and annual or ongoing implementation.

Table 44. Estimated Average SMS Costs[1]

Category	Part 21 ($/Employee)	Part 135 ($/Aircraft)
Onetime	$284	$4,575
Annual	$110	$4,731
1. Based on limited industry outreach (see Section 5, Costs). Actual costs will vary depending on, among other factors, existing processes in place. Updated to 2022 dollars using the Consumer Price Index.		

Table 46 provides the calculation of present value compliance costs for part 21; Table 47 provides the calculations for part 135; and Table 48 provides the calculations for § 91.147.

Table 45. Calculation of 5-Year Present Value Costs: Part 21

Year	SMS Onetime	SMS Annual	Existing SMS Onetime	Existing SMS Annual	FAA Onetime	Total	Discounted 7%	Discounted 3%
1	$3,754,823	$0	$19,500	$0	$51,421	$3,825,744	$3,575,462	$3,714,315
2	$3,754,823	$1,443,987	$19,500	$12,350	$51,421	$5,282,082	$4,613,575	$4,978,869
3	$3,754,823	$2,887,975	$0	$24,700	$51,421	$6,718,919	$5,484,639	$6,148,763
4	$0	$4,331,962	$0	$24,700	$0	$4,356,662	$3,323,676	$3,870,838
5	$0	$4,331,962	$0	$24,700	$0	$4,356,662	$3,106,240	$3,758,095
Total	NA	NA	NA	NA	NA	NA	$20,103,592	$22,470,878

NA = not applicable

1. FAA assumes that costs are not incurred until the year following promulgation of a final rule, and thus discounts the first-year values.

Table 46. Calculation of 5-Year Present Value Costs: Part 135

Year	Onetime	Annual	Total	Discounted 7%	Discounted 3%
1	$15,438,319	$0	$15,438,319	$14,428,335	$14,988,659
2	$15,438,319	$15,071,645	$30,509,964	$26,648,584	$28,758,567
3	$15,438,319	$30,143,290	$45,581,609	$37,208,170	$41,713,629
4	$0	$45,214,935	$45,214,935	$34,494,257	$40,172,884
5	$0	$45,214,935	$45,214,935	$32,237,623	$39,002,800
Total	NA	NA	NA	$145,016,970	$164,636,540

NA = not applicable
1. FAA assumes that costs are not incurred until the year following promulgation of a final rule, and thus discounts the first-year values.

Table 47. Calculation of 5-Year Present Value Costs: Part 91.147

Year	U.S. Onetime	Annual	Total	Discounted 7%	Discounted 3%
1	$3,305,656	$0	$3,305,656	$3,089,398	$3,209,375
2	$3,305,656	$2,966,356	$6,272,012	$5,478,218	$5,911,973
3	$3,305,656	$5,932,711	$9,238,368	$7,541,260	$8,454,415
4	$0	$8,899,067	$8,899,067	$6,789,056	$7,906,706
5	$0	$8,899,067	$8,899,067	$6,344,912	$7,676,413
Total	NA	NA	NA	$29,242,840	$33,158,880

NA = not applicable
1. FAA assumes that costs are not incurred until the year following promulgation of a final rule, and thus discounts the first-year values.

Appendix C. Outreach

Part 21 Design and Manufacturing Safety Management Systems (SMS) Questionnaire

Note: FAA will not share any Confidential Business Information and will aggregate data such that it will not identify the provider of the information.

1. Why did you implement SMS voluntarily?

2. What incremental costs, if any, did you incur to implement SMS? (If you did not incur new costs, but did things differently, please explain.) Please provide a breakdown using any existing format or the table below, as appropriate. Please explain the SMS processes these costs pertain to any categories (e.g., other) as needed.

Example Table - Incremental Costs to Develop and Implement SMS

Category	Amount
Initial (Onetime)	
Gap analysis	
SMS development	
Training	
Software	
Documentation	
Other (specify)	
Recurring (Annual or other frequency)	
Data collection and analysis	
SMS review and evaluation (e.g., audits)	
Software	
Training	
Documentation	
Other (specify)	

3. What incremental costs, if any, have you incurred to address risks and process gaps identified by SMS (i.e., mitigations, such as adding engineers)? Please explain.

4. What cost savings, if any, did you experience as a result of or anticipate with implementing SMS (e.g., reduced costs associated with correcting an unsafe condition in a product)? Please provide a breakdown by year and component, as available.

5. What impacts on safety risks, if any, did you experience from implementing SMS? Please provide any available supporting (qualitative or quantitative) information.

6. What changes in these costs, cost savings, or impacts on safety risks (e.g., increases or decreases) do you foresee in the future as a result of continued implementation of SMS? Please provide any available supporting (qualitative or quantitative) information.

Part 135 Operations Safety Management Systems (SMS) Questionnaire

The FAA is researching the costs and benefits associated with implementing SMS in part 135 operations. The following questions relate to your experience implementing SMS voluntarily.

Note: FAA will not share any Confidential Business Information and will aggregate data such that it will not identify the provider of the information.

1. Why did you implement SMS voluntarily?

2. What incremental costs, if any, did you incur during voluntary SMS implementation? (If you did not incur new costs, but did things differently, please explain.) Please provide a breakdown of the actual costs incurred using any existing format or the table below, as appropriate. Please explain the SMS implementation processes these costs pertain to (e.g., gap analysis, other) as needed.

Example Table - Incremental Costs to Develop, Implement, and apply SMS

Category	Amount
Initial (Onetime)	
Gap analysis	
SMS development	
Training	
Software	
Documentation	
Other (specify)	
Recurring (Annual or other frequency)	
Data collection and analysis	
SMS review and evaluation (e.g., audits)	
Software	
Training	
Documentation	
Other (specify)	

3. What incremental costs, if any, have you incurred to address risks and process gaps identified by SMS (i.e., mitigations, such as adding staff, or adding tasks and activities such as performing pre-flight safety risk analysis procedures, or safety promotion, etc.)? Please explain.

4. Did you experience any cost savings as a result of the voluntary implementation of SMS? Please provide a breakdown by year, SMS element, and cost center component, as available.

5. Has the data collected under the voluntary SMS program evidenced or suggested an actual reduction in operational risks? If so, how? Please provide any available (qualitative or quantitative) supporting information.

6. As you continue to implement SMS, do you foresee changes (e.g., increases or decreases, improvements or degradations, etc.) in the costs, cost savings, or impacts on safety risks? If so, which changes and why? Please provide any available (qualitative or quantitative) supporting information.

Part 91.147 Operations Safety Management Systems (SMS) Questionnaire

The FAA is researching the benefits and costs associated with requiring part 91.147 operators to develop and implement SMS. The last page of this document briefly describes the four components of SMS and the activities involved. The following questions seek information on your current operations and how SMS could enhance the safety of such operations.

Note: FAA will not share any Confidential Business Information and will aggregate data such that it will not identify the provider of the information.

1. How many (total) tour flights do you perform each year and over what months of the year?

2. Do you hold a part 135 certificate in addition to your 91.147 LOA? If yes, do you conduct part 135 air tours?

3. How many people do you employ and in what role?

4. How many airports or off airport landing sites do you conduct air tours from annually?

5. Yes or no: Do you currently adhere to any safety management procedures? If yes, what do these entail?

6. The table below has general categories of costs that may be incurred to implement SMS. Please indicate which categories you believe would apply to your organization if it voluntarily implements SMS, and why.

Potential Incremental Costs to Develop and Implement SMS

Category	Explanation of Potential Need
Initial (Onetime)	
Gap analysis	
SMS development	
Training	
Software	
Documentation	
Other (specify)	
Recurring (Annual or other frequency)	
Data collection and analysis	
SMS review and evaluation (e.g., audits)	
Software	
Training	
Documentation	
Other (specify)	

7. Do you have any data or information that indicates there could be cost savings from implementing SMS?

8. Do you have any data or information that indicates implementing SMS could reduce safety risks?

The four components of a SMS are[48]:

1. **Safety Policy** — Establishes senior management's commitment to continually improve safety; defines the methods, processes, and organizational structure needed to meet safety goals
    - Establishes management commitment to safety performance through SMS
    - Establishes clear safety objectives and commitment to manage to those objectives
    - Defines methods, processes, and organizational structure needed to meet safety goals
    - Establishes transparency in management of safety
        - Fully documented policy and processes
        - Employee reporting and resolution system
        - Accountability of management and employees
    - Builds upon the processes and procedures that already exist
    - Facilitates cross-organizational communication and cooperation
2. **Safety Risk Management (SRM)** — Determines the need for, and adequacy of, new or revised risk controls based on the assessment of acceptable risk
    - A formal process within the SMS composed of:
        - Describing the system
        - Identifying the hazards
        - Assessing the risk
        - Analyzing the risk
        - Controlling the risk
    - The SRM process may be embedded in the processes used to provide the product/service
3. **Safety Assurance (SA)** — Evaluates the continued effectiveness of implemented risk control strategies; supports the identification of new hazards
    - SMS process management functions that systematically provide confidence that organizational outputs meet or exceed safety requirements
    - AVS SMS has a dual safety assurance focus:
        - AVS organizations
        - Product/service providers
    - Ensures compliance with SMS requirements and FAA orders, standards, policies, and directives
        - Information Acquisition
            - Audits and evaluations
            - Employee reporting
        - Data Analysis
        - System Assessment
    - Provides insight and analysis regarding methods/opportunities for improving safety and minimizing risk
    - Existing assurance functions will continue to evaluate and improve service
4. **Safety Promotion** — Includes training, communication, and other actions to create a positive safety culture within all levels of the workforce
    - Safety promotion activities within the SMS framework include:
        - Providing SMS training
        - Advocating/strengthening a positive safety culture
        - System and safety communication and awareness
        - Matching competency requirements to system requirements
        - Disseminating safety lessons learned
    - Everyone has a role in promoting safety

[48] See also: https://www.faa.gov/about/initiatives/sms/explained/components/