# Comparative Analysis of Aviation and Ground Transportation Safety Standards Applicable to the Integration of Unmanned Aircraft Operations

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This study examines the differences in the safety management systems (SMS) across the aviation and ground transportation industries to identify gaps that might impact the ground transportation industry's adoption of unmanned aircraft systems (UAS). Currently, the Federal Aviation Administration (FAA) does not require UAS operators to utilize an SMS; however, this study is conducted in anticipation of the eventual SMS requirement for UAS operators.

## Background

As unmanned aircraft systems (UAS) increase in use and become further integrated into the national airspace system (NAS), many non-aviation organizations will seek to incorporate them into their operations. Packaging shipping organizations are an early example of those wanting to utilize UAS. Other organizations in the ground transportation industry will likely follow as UAS capabilities increase and autonomous human transport becomes practical. This widespread adoption of UAS across industries will require those industries to adjust their operating practices to conform with FAA regulations and aviation industry standard practices. Conforming with FAA regulations will include adopting aviation safety frameworks such as SMS.

Currently, the adoption of SMS among organizations utilizing small UAS (sUAS) is limited (Phillips & Herr, 2020). The organizations seeking to utilize UAS come from various industries with different implementations of safety standards. Of these industries seeking adoption of UAS operations, this study will focus on the ground transportation industry. Therefore, this study will examine the safety standards required by the Federal Motor Carrier Safety Administration (FMCSA) and the Occupational Safety and Health Administration (OSHA) to identify differences with aviation SMS standards. The differences will then be analyzed to determine their impact on aviation safety.

This study is timely because of the rapid advancement in UAS technology and capability, resulting in the increasing use of UAS over time. That increase will likely come with leaps and bounds when the FAA fully integrates UAS into the NAS. Therefore, this study can assist the ground transportation industry in seeking the adoption of UAS in their operations by helping them align their safety policies with those of the aviation industry. In addition, the aviation industry may utilize this study to identify and adopt beneficial practices from other industries and assist those industries in merging their current safety standards with those of the aviation industry.

## Statement of the Problem

The problem is that a sudden, rapid increase in the number of UAS operators in traditionally non-aviation industries may jeopardize the safety of the NAS if those operators are slow to adapt to aviation SMS standards. Therefore, safety standards across industries must be examined to determine the differences compared to aviation SMS. An understanding of these differences will allow the

FAA and the aviation industry to provide support to organizations transitioning to the use of UAS.

Current literature provides insight into the differences between the various SMS standards and the benefits of implementing an SMS. However, there is a gap in the literature regarding the differences in SMS standards between industries. Furthermore, the impact of these differences will be exacerbated if many organizations from non-aviation industries suddenly begin to operate UAS.

**Research Question**

This study proposes the following research questions:

RQ1: Is the safety management system in use with the ground transportation industry adequate for incorporating UAS operations?

HN1: Differences in safety standards would not impact safety.

HA1: Differences in safety standards would impact safety.

## Literature Review

This review of the relevant literature focuses on the benefits of SMS for UAS organizations, risks associated with UAS operations, SMS standards, and their differences. The literature review has been conducted in a deductive manner, seeking facts and practical analytical methods related to the research subject. As the literature findings have accumulated, they have been categorized as shown by the headings.

### Safety Management Systems

A paper by Phillips and Herr (2020) investigated the costs and benefits of SMS for organizations using sUAS and outlined steps that can be taken for implementation. In addition, Phillips and Herr described some of the challenges facing smaller organizations in implementing SMS, including the ability to handle the additional workload needed to manage and monitor the system.

Code of Federal Regulation 14 C.F.R. § 5 (2015) is the relevant FAA regulation defining SMS as a requirement for 14 C.F.R. § 121 air carriers. The regulation defines an SMS policy's required components, personnel roles and responsibilities, and requirements for risk management, safety assurance, safety promotion, and record keeping.

Advisory Circular (AC) 120-92B, published by the FAA (2015), guides the development and implementation of SMS. The AC is written explicitly for the benefit of 14 C.F.R. § 121 air carriers to help comply with 14 C.F.R. § 5 but is also intended to be useful for other aviation organizations.

### UAS Risks

Stastny and Stoica (2021) identified risks associated with UAS operations and outlined existing global safety management regulations. Stastny and Stoica lay out a series of shortcomings and suggest mitigations with the ability of the current implementation of SMS to incorporate UAS. Additionally, the paper outlined the differences that will need to be addressed by SMS in the current air traffic

management (ATM) system and the anticipated unmanned traffic management (UTM) system.

### Differences in SMS Standards

A comparative analysis by Shekari (2020) highlighted the differences between the primary SMS standards, including ISO 45001, ANSI/ASSP Z10, ILO-OSH 2001, and 14 C.F.R. § 5. Shekari concluded that no standard was better, but some highlight certain aspects of SMS that others do not. Therefore, the identified differences between 14 C.F.R. § 5 and the other standards will be considered in this study.

Elsebaei et al. (2020) examined SMS in the construction industry. It outlined the main elements of SMS, including versions developed by international organizations and by OSHA. In addition, Elsebaei et al. described various metrics that can be used to evaluate the performance of SMS implementation.

### Impact on Safety

A study by Nævestad (2022) estimated the impact of implementing safety management measures in the trucking industry. The method outlined in this study may be particularly useful in further defining the effect of differences between aviation and ground transportation SMS.

### Gaps in the Literature

Current literature offers little discussion of safety management systems related to the ground transpiration industry. There is also a gap in the current literature regarding defining an adequate means to compare two safety policies quantitatively. Much of the safety literature related to the ground transportation industry revolves around the direct analysis of accident data rather than policy evaluation. In particular, very little literature is available regarding the impact on aviation safety of incorporating UAS operations in the ground transpiration industry.

## Methodology

This study used a comparative analysis to identify the differences between the FAA SMS standards used by the aviation industry and the FMCSA Safety Management Cycle (SMC) standard used by the ground transportation industry. The two systems are broken down into primary components and reviewed to determine where each is lacking. The FAA SMS is the reference or baseline when comparing the two systems (Walk, 1998). The method used by Nævestad (2022) to quantify the impact of implementing aspects of an SMS in the trucking industry was considered; however, it was determined to be overly reliant on incident data for use in this policy comparison study.

## Results

### Occupational Health and Safety Standards

A provision of U.S. law (Applicability to existing standards, 2022) states that OSHA regulations are superseded in areas where another Federal agency has

jurisdiction. The FAA and OSHA have established a memorandum of understanding (MOU) between the two federal agencies. They have agreed that during flight operations, the FAA will have the authority over the health and safety of personnel onboard an aircraft. However, the agencies have agreed that regarding non-inflight operations, OSHA will have authority over the health and safety of personnel (U.S. Department of Labor, 2000). The FMCSA has also entered an MOU with OSHA (U.S. Department of Labor, 2017) outlining their cooperation, primarily focused on whistleblower-type employee protections. These MOUs determine that OSHA regulations govern the ground-based operations of the aviation and ground transportation industry. Therefore, as UAS operators are ground-based, it is further determined that the ground transportation industry will not incur new OSHA regulations, unlike those they must adhere to already. Thus, no impact is anticipated by the ground transportation industry related to OSHA regulation resulting from the ground transportation industry's incorporation of UAS operations.

**Safety Management Standards**

The FAA's governing standard for SMS is 14 C.F.R § 5 (Safety Management Systems, 2015), and further guidance is provided by advisory circular No. 120-92B (U.S. Federal Aviation Administration, 2015). The FMCSA requires new industry entrants to have safety management controls in place. This requirement is established by 49 C.F.R. § 385 (Safety Fitness Procedures, 2022), and FMCSA has provided the SMC with guidance on how to comply with the regulation. The primary components of the FAA SMS and the FMCSA SMC are compared in Tables 1 through 6, and a determination regarding their relative equivalence is provided.

**Policy Components**

The policy components of SMS and SMC are compared in Table 1. Both management systems address this component and have similar features in establishing policy, procedure, and roles and responsibilities. The FAA SMS has an additional focus on management involvement, and FMCSA SMC has an additional focus on hiring practices. However, FMCSA SMC addresses management commitment to safety and accountability for safety as part of the safety promotion (Table 3) and meaningful actions (Table 5) components. Despite subtle differences, both systems adequately address this component.

**Table 1**
*Policy Components*

| FAA Safety Management System | FMCSA Safety Management Cycle |
|---|---|
| • Top management involvement<br>• Roles, responsibilities, and relationships<br>• Procedures and controls | • Policies and procedures<br>• Roles and responsibilities<br>• Qualification and hiring |
| Comparative analysis: Both SMS and SMC satisfy this component. | |

**Safety Risk Management Components**

The safety risk management (SRM) components of SMS and SMC are compared in Table 2. The FAA SMS addresses this component adequately; however, the FMCSA SMC does not. Although SMC alludes to risk management in some areas, such as using risk-based disciplinary processes (Table 5), SRM is a critical component of SMS, and a complete process description should be provided. As such, it is determined that SMC is substantially lacking in this area.

**Table 2**
*Safety Risk Management Components*

| FAA Safety Management System | FMCSA Safety Management Cycle |
|---|---|
| • Safety Risk Management<br>• System description and task analysis<br>• Hazard identification<br>• Risk analysis and assessment<br>• Controlling risk<br>• Residual and substitute risk<br>• System operation | • Not specified |
| Comparative analysis: SMS satisfies this component; however, SMC does not adequately address SRM. | |

**Safety Promotion Components**

The safety promotion components of SMS and SMC are compared in Table 3. Both management systems address this component and have similar features in establishing a safety culture, training, and communication. The FAA SMS focuses more on establishing a safety culture, while FMCSA SMC has an additional focus on hiring practices. However, SMC addresses various communication practices that further a safety culture, such as management communicating their commitment to safety. Despite subtle differences, both systems adequately address this component.

**Table 3**

*Safety Promotion Components*

| FAA Safety Management System | FMCSA Safety Management Cycle |
|---|---|
| • Safety Promotion<br>• Safety cultures<br>• Reporting culture<br>• Just culture<br>• Own safety<br>• Competencies and training<br>• Communication and awareness | • Training and Communication<br>• Convey expectations to all staff<br>• Company policies and procedures<br>• New-hire and refresher training<br>• Establish communication channels such as newsletters<br>• Provide safety seminars<br>• Communicate safety metrics to staff<br>• Managers communicate a commitment to safety<br>• Inform drivers that their driving history is a factor in the roadside inspection rate<br>• Ensure staff receives all necessary training<br>• Screen for qualified safety-minded candidates<br>• Reinforce training and encourage feedback |

| FAA Safety Management System | FMCSA Safety Management Cycle |
|---|---|
| Comparative analysis: Both SMS and SMC satisfy this component. | |

**Safety Assurance Components**

The safety assurance components of SMS and SMC are compared in Table 4. Both management systems address this component and have relatively similar features related to the establishment of data acquisition, assessment, and record management. The FAA SMS prescribes audits, and FMCSA SMC more loosely defines a similar process of evaluating safety monitors. Despite subtle differences, both systems adequately address this component.

**Table 4**

*Safety Assurance Components*

| FAA Safety Management System | FMCSA Safety Management Cycle |
|---|---|
| • Safety Assurance<br>• System operation – performance monitoring and measurement<br>• Data acquisition<br>• External audits<br>• Investigations<br>• Employee reporting systems<br>• Analysis and assessment<br>• Management of change<br>• Continuous improvement | • Monitoring and Tracking<br>• Ensure routes can be completed within speed limits<br>• Maintain roadside inspection reports, moving violation records, and complaints<br>• Review and retain each driver's MVR at least annually<br>• Monitor drivers' speed and movements via driver reports, global positioning systems, and travel receipts<br>• Evaluate safety monitors<br>• Assess safety feedback from the public<br>• Regularly evaluate the company's SMS data for process breakdowns and how to remedy them<br>• Implement a system for keeping accurate records |

| FAA Safety Management System | FMCSA Safety Management Cycle |
|---|---|
| | • Assess incidents for systemic policy breakdown |
| Comparative analysis: Both SMS and SMC satisfy this component. | |

**Meaningful Action Components**

The meaningful action components of SMS and SMC are compared in Table 5. Both management systems address this component, though SMS does not do so as an independent component, as does SMC. Actions and continuous improvement are both adequately addressed by SMS in both the SRM (Table 2) and SA (Table 4) components. There is additional focus by SMC on reward and compensation strategies focused on safety rather than performance; however, both systems are determined to address this component adequately.

**Table 5**

*Meaningful Action Components*

| FAA Safety Management System | FMCSA Safety Management Cycle |
|---|---|
| • Not specified | • Meaningful Action<br>• Design and implement incentives<br>• Reward for safety over performance<br>• Compensation method to promote safety<br>• Timely feedback and corrective action<br>• Provide training<br>• Implement a risk-based disciplinary policy<br>• Management is held accountable for safety<br>• Address systemic problems with the policy |

| FAA Safety Management System | FMCSA Safety Management Cycle |
|---|---|
| Comparative analysis: Both SMS and SMC satisfy this component; although SMS does not separately address this it does address it as part of its SRM and SA components. | |

**Emergency Response Components**

The emergency response components of SMS and SMC are compared in Table 6. The FAA SMS addresses this component adequately; however, the FMCSA SMC does not. SMC does not address emergency response at all and, as such, is found to be substantially lacking in this area. While SMC does not address emergency response, OSHA requires organizations with more than ten employees to have a written Emergency Action Plan (EAP) in place (Emergency Action Plans, 2022). The emergency action plan would suffice to satisfy the emergency response component, but it is recommended to be integrated directly as a component of the SMC.

**Table 6**

*Emergency Response Components*

| FAA Safety Management System | FMCSA Safety Management Cycle |
|---|---|
| • Emergency Response<br>• Delegation of emergency authority<br>• Assignment of emergency responsibilities<br>• Documentation of emergency procedures and processes<br>• Coordination of emergency efforts internally and with external parties | • Not specified |
| Comparative analysis: SMS satisfies this component; however, SMC does not adequately address emergency response. | |

## Discussion

This study performed a comparative analysis of SMS in both the aviation and ground transportation industries to identify any gaps that may impact aviation

safety by incorporating UAS operations within the ground transportation industry. This study is critical because of the rapid transformation expected in many industries, particularly the ground transportation industry, as UAS technology advancement and regulatory changes allow for the widespread application of UAS. The study reviewed relevant literature and compared the FAA SMS and FMCSA SMC policy components. The study also compared the implementation of OSHA requirements within the aviation and ground transportation industries. However, the study is limited to a comparative analysis of policies and, as such, cannot make a quantitative assessment of the impact on safety outcomes that result from the identified policy differences.

## Conclusion

After reviewing the relevant policy components, the study's findings support the alternative hypothesis that differences in the safety standards between the FAA SMA and FMCSA SMC would impact safety. Therefore, the study determines that the ground transportation industry SMS, known as the FMCSA SMC, is inadequate for incorporating UAS operations. The study recommends that the SMC incorporate process descriptions for SRM and emergency response to bring the system to the same level of competency as the FAA SMS. Making these improvements to SMC will allow the ground transportation industry to integrate UAS operations more quickly and seamlessly into their industry. It will improve aviation safety outcomes as many more organizations join the UAS technology revolution. The study determines that the ground transportation industry will not need to incur new OSHA regulations due to adopting UAS operations, as the aviation and ground transportation industries already adhere to similar OSHA regulations for their ground-based operations.

### Recommended Future Research

It is recommended that future research be conducted to establish a method to quantify the impact each component of an SMS has on safety outcomes. Quantifying the impact of each SMS component will allow for the prediction of improved safety outcomes as an organization matures its implementation of SMS. Also, by quantifying the impact of each SMS component, other systems, such as SMC, can be evaluated to predict how much improvement they would see by adopting components of SMS.

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