IMPACT OF SAFETY MANAGEMENT SYSTEMS ON 14 CFR, PART 135 SAFETY PERFORMANCE

By

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Dedicated to my family and friends whom have encouraged me in my walk with Jesus Christ. Thank you for the peace, grace, hope, love, and joy that you all have brought to my life.

"We have peace with God through our Lord Jesus Christ, through whom we have gained access by faith into this grace in which we now stand. And we boast in the hope of the glory of God. And hope does not put us to shame, because God's love has been poured out into our hearts through the Holy Spirit." Romans 5:1-2, and Romans 5:5 (NIV)

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ABSTRACT

Safety Management Systems (SMS) are currently required at all U.S. scheduled air carriers operating under Title 14 of the Code of Federal Regulations (CFR), Part 121, but are not currently required for air carriers operating under 14 CFR, Part 135. Therefore, some Part 135 operators adopted SMS, and some did not. This study determined the impact of SMS on 14 CFR, Part 135 operator's safety performance.

A simple random sample (SRS) of Part 135 operators was chosen, and then divided into two different categories including operators with, and without, an SMS. The safety performance of each group was measured by the aircraft accident and incident rate of the two groups. SMS databases from International Standard for Business Aircraft Operations (IS-BAO), Wyvern Consulting LLC (WYVERN), and ARGUS International, Inc (ARGUS) were used to determine which Part 135 operators had an SMS. Federal Aviation Administration (FAA) and National Transportation Safety Board (NTSB) databases were used to determine the accident and incident rate of each group.

A plus four confidence interval analysis was performed, and it was determined that the operators with an SMS did not have better safety performance than the operators without an SMS. The safety performance of the group with an SMS was then compared before and after SMS implementation. A significance test for comparing two proportions and a plus four confidence interval analysis were performed, and it was determined that the implementation of SMS did improve an operator's safety performance.

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LIST OF ABBREVIATIONS

AC – Advisory Circular

AFS - FAA Flight Standards

AIDS - FAA Accident and Incident Data System

ARGUS – ARGUS International, Inc.

ARP – FAA Airport line of business

ATC – Air Traffic Control

ATO – FAA Air Traffic Control line of business

AVS – FAA Aviation Safety line of business

AVSSMS - Aviation Safety (AVS) Safety Management System (SMS)

CFA - Confirmatory Factor Analysis

CFR – Code of Federal Regulations

CY - Calendar Year (January 1 through December 31)

FAA – Federal Aviation Administration

GASP - Global Aviation Safety Plan

Group N – Operators with no SMS

Group S – Operators with an SMS

Group SP05 - Group S prior to 2005

ICAO – International Civil Aviation Organization

IS-BAO – International Standard for Business Aircraft Operations

NTSB – National Transportation Safety Board

QMS - Quality Management System

SARP – Standards and Recommended Practices

SAS - Safety Assurance System

SEM - Structural Equation Model

SMM – ICAO Safety Management Manual

SMS – Safety Management System

SRS - Simple Random Sample

SSP – State Safety Programs

U.S. – United States of America

WBAT - Web Based Application Tool

WYVERN – Wyvern Consulting LLC.

CHAPTER I: INTRODUCTION

Air carriers operating under the rules of 14 CFR, Part 135 includes a wide range of aircraft with many different operational missions. Part 135 operators vary from a single-engine Cessna 206 hauling cargo to a Bell-407 helicopter air ambulance to a large cabin Gulfstream G550 flying internationally. The two main categories of Part 135 operations include on-demand and commuter operations. Part 135 operators with commuter authority can operate scheduled flights but are limited to turboprop aircraft with less than nine seats and less than four flights per week between two specific destinations. Part 135 on-demand operators do not have the passenger seat or flight frequency restrictions that commuters have. Also, Part 135 on-demand operators may not operate scheduled service.

Scheduled 14 CFR, Part 121 operators have the authority to operate larger more complex jet aircraft without a flight frequency restriction. Part 121 operators must also meet higher regulatory standards than Part 135 operators. Safety Management Systems (SMS) are now required at all U.S. scheduled air carriers operating under Part 121, but are not required for air carriers operating under Part 135. Therefore, some Part 135 operators have adopted this voluntary program, and some have not.

Part 121 operators also have better safety performance than 135 operators. For example, in 2014, the scheduled Part 121 accident rate was 0.157 accidents per 100,000 flight hours, while the Part 135 on-demand and commuter was 1.145 and 1.02 accidents per 100,000 flight hours, respectively. Part 135 operators had 6.9 times as many accidents as 121 operators over an equal number of flight hours in 2014 (National Transportation Safety Board, 2015).

A comprehensive study of the impact of safety management systems on Part 135 operators has not been conducted to date despite the disparity in safety performance between Part 135 and Part 121 operators. This study will analyze the safety performance of a sample of Part 135 operators. Safety performance will be measured by the accident and incident rate as defined by NTSB Part 830. The safety performance of Part 135 operators with an SMS will be compared to the safety performance of Part 135 operator without an SMS. Then, the Part 135 operators with an SMS will be analyzed over two different time periods to determine if the implementation of SMS increased the safety performance of these Part 135 operators. This study will determine the impact of SMS on a Part 135 operator's safety performance.

Literature Review

The Federal Aviation Administration (FAA) Advisory Circular (AC) 120-92B explains what a safety management system (SMS) is and how to implement an SMS in accordance with the requirements of 14 CFR, Part 5. 14 CFR, Part 5 requires a U.S. air carrier operating in accordance with 14 CFR, Part 121 to have an SMS. Compliance with Part 5 is currently voluntary for Part 135 operators, but may become mandatory in the future. Therefore, a Part 135 operator should strive to develop an SMS that meets the requirements of Part 5 (Federal Aviation Administration, 2015b).

A safety management system (SMS) has four pillars including Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion (Federal Aviation Administration, 2015b). These four pillars are all supported by the Safety Culture of the organization, which exists as the sum total of the safety behavior of each individual within the organization. The four pillars of an SMS provide the structure of the SMS for

Part 135 operators. These pillars each contain specific processes and procedures that must be developed and implemented. Once developed, these pillars work together to form the entire SMS for the Part 135 operator. These processes and procedures can be simple, but must be adhered to once they are developed. To meet the requirements of Part 5, a Part 135 operator's SMS must include specific elements regarding Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion. The following paragraphs will detail the required elements for these four pillars of an SMS in accordance with Part 5 (Federal Aviation Administration, 2015b).

Safety Policy is the high level standards set by upper management in an organization concerning safety within the organization. The required Safety Policy elements include establishment of safety objectives, a commitment to those safety objectives, a provision of organizational resources for the SMS, a requirement of employees to report safety hazards or issues, unacceptable behavior and discipline related to that behavior, and an emergency response plan. This safety policy must be signed by the accountable executive, documented and communicated to the entire company, and be periodically reviewed and revised as necessary (Federal Aviation Administration, 2015b).

A Part 135 operator's Safety Policy should include one specific person that is the accountable executive at the company. This accountable executive should normally be the highest-ranking executive at the company, such as the Owner, President, or CEO. This accountable executive must be the person with ultimate control over the Part 135 operator in regards to operations, financial resources, and human resources. The accountable executive also has the final responsibility for the safety performance of the organization (Federal Aviation Administration, 2015b).

The Safety Policy also requires that the accountable executive designates managers with the responsibility for the overall SMS, hazard identification and analysis, monitoring safety controls, ensuring safety promotion, and reporting safety information back to the accountable executive. The designation of these persons may vary by operator. For example, a large operator may have a separate person designated for each one of these responsibilities, while a smaller operator may assign these as ancillary duties to persons already holding Director of Operations or Chief Pilot positions (Federal Aviation Administration, 2015b).

Finally, the Safety Policy pillar of the SMS must include an emergency response plan in the event of an accident, emergency, or crisis situation. This emergency response plan allows a Part 135 operator to transition from normal operations, to emergency operations, back to normal operations while maintaining the same level of safety in the operation. In regard to an emergency situation, the emergency response plan must delegate authorities, assign specific employee responsibilities, and coordinate with other organizations involved in the emergency (Federal Aviation Administration, 2015b).

Safety Risk Management is the process used within the organization to identify hazards and manage the associated risks. Risk has traditionally been managed by pilots using one of four different techniques including transfer, eliminate, accept or mitigate. This risk management technique is called the TEAM concept. The Safety Risk Management pillar of SMS requires organizations to apply these same principles to safety risks within the organization as a whole (Federal Aviation Administration, 2015b).

The processes necessary within the Safety Risk Management pillar include system description and analysis, hazard identification, safety risk analysis, safety assessment, and safety control. The Part 135 operator must apply these safety risk management processes when implementing new systems, revising existing systems, developing operational procedures, or identifying new hazards. The safety risk analysis process must consider the system's function and purpose, operating environment, an outline of the process, and the personnel, equipment, and facilities required. This analysis must also have a method to identify new hazards introduced from this analysis. If any new hazards are identified from this process then they must also be analyzed. The Safety Risk Management process to analyze hazards must determine whether the risk that the hazard poses is acceptable. If the risk is unacceptable, then it should be controlled. Once this unacceptable risk is controlled, then it should be re-analyzed to determine if the risk has been reduced to an acceptable level (Federal Aviation Administration, 2015b).

Safety Assurance is the continual process of identifying safety hazards through audits and self-reporting, and then addressing those hazards by revisions to established procedures. Part 135 operators must develop procedures to acquire safety data and to monitor safety performance. The process and systems used to acquire safety data and monitor safety performance must be monitored. These processes and systems must also be able to detect changes in the operating environment, and be periodically audited and evaluated. Additionally, the Safety Assurance process and systems must include the investigation of accidents, incidents, and potential non-compliance with standards or established procedures. Finally, the Safety Assurance process and systems must include a confidential employee-reporting program. All data that is identified through the Safety Assurance process and systems must be analyzed (Federal Aviation Administration, 2015b).

The Safety Assurance pillar of the SMS must also include a review of the safety performance of the Part 135 operator against the safety objectives established by the Safety Policy. The accountable executive should conduct this review of safety performance. Any new hazards identified by the review of safety performance should be analyzed in accordance with the Part 135 operators Safety Risk Management processes. A process must also be developed to increase the safety performance identified during the review if the safety performance does not meet the stated safety objectives (Federal Aviation Administration, 2015b).

Safety Promotion is the final pillar of SMS, which comprises both the communication and the training aspects of the Part 135 operator. The Safety Promotion pillar requires the Part 135 operator to provide training to each person within the organization that has SMS responsibilities or authorities. The Part 135 operator must also have a medium to communicate safety information. The medium to communicate safety information must convey certain items to the company employees. The items that must be conveyed to employees include the applicable portions of the SMS, relevant safety information, safety actions taken by the operator, and any new or revised safety procedures (Federal Aviation Administration, 2015b).

The final SMS requirement for the Part 135 operator is to document and record the SMS. The Part 135 operator must document Safety policy and the required SMS processes and procedures. The Part 135 operator must keep various records related to SMS. Any process performed in the Safety Risk Management pillar or Safety Assurance pillar of the SMS must be recorded, and those records must be kept until they are no longer relevant to the operator. The Part 135 operator must also maintain a record of all

SMS training for each employee until that person's employment is terminated. Finally, a record of all SMS communication must be maintained for 24 calendar months (Federal Aviation Administration, 2015b).

The FAA alone did not initially conceive the requirement to have a SMS, nor did the FAA create the required structure of a SMS. The organization that has led this effort to improve safety through SMS is the International Civil Aviation Organization (ICAO). ICAO creates Standards and Recommended Practices (SARP) for adoption by the Federal Aviation Administration (FAA) and the civil aviation organizations of other countries that are ICAO members. ICAO SMS guidance is provided in Doc 9859, Safety Management Manual, and the SMS requirements are provided in Annex 19 – Safety Management. The ICAO working paper from April 9, 2013, of the 38^{th} session provides evidence of ICAO future intentions for SMS. The working paper recommends, "The Assembly is invited to task ICAO with initiating a review of the principles of safety culture and integrating these principles in successive stages of SARP development and implementation of SMS" (International Civil Aviation Organization, 2013a, p. 4). This statement summarizes the direction of ICAO in regards to SMS requirements for member countries.

The mid term objective of the ICAO 2013 Global Aviation Safety Plan (GASP) states that countries with over 60% SMS implementation should have State Safety Programs (SSP), which are the equivalent of a country's SMS requirements, fully implemented by 2017. The ICAO 2013 GASP also calls for all ICAO member states to have fully implemented SSP by 2022 (International Civil Aviation Organization, 2013a).

The FAA is complying with these requirements for a SSP by implementing SMS within the different lines of businesses, such as Aviation Safety (AVS) and Air Traffic Control (ATO). The AVS safety management system includes a new form of SMS-based surveillance called the Safety Assurance System (SAS), which will be detailed later.

ICAO Annex 19 requires that SMS be implemented by the following aviation service providers: approved training organizations, operators of airplanes or helicopters authorized to conduct international commercial air transport, approved maintenance organizations providing services to operators, international general aviation conducting operations of large or turbojet airplanes, organizations responsible for the type design or manufacture of aircraft, air traffic service providers, and operators of certified aerodromes (International Civil Aviation Organization, 2013b). Once ICAO creates the safety culture requirements for SMS as a SARP, the FAA will likely adopt these changes into the federal regulations pertaining to SMS. Therefore, SMS may be required in the future for additional operators such as 14 CFR, part 141 flight schools, Part 142 training centers, or Part 145 repair stations.

Currently, 14 CFR, Part 5 SMS regulations are only applicable to Part 121 operators. However, this regulation could easily be revised to become applicable to other operators, such as Part 135 on-demand air carriers and Part 145 repair stations. Although the rules for airports and air operators are different, they represent the requirements of the respective ICAO Annexes. Therefore, 14 CFR, Part 5 was modeled after ICAO Annex 6 and was enacted by the United States to align the regulations with ICAO Standards and Recommended Practices. The preamble to 14 CFR, Part 5 also states that this part may be changed in the future so that Part 5 applies to Part 135 operators, but any change to the applicability of Part 5 will be completed through the normal rule making process. This normal rule making process allows a period of time for the public to comment, which allows the public to voice questions, concerns, or support for regulatory changes (Federal Register, 2015).

The FAA started SMS Pilot Projects prior to the implementation of Part 5. The purpose of these pilot projects was for the FAA and the aviation industry to collaborate and learn about SMS together, which would smooth the transition to SMS for each sector of the aviation industry. This project, which is still active, includes provisions for Part 135 operators to voluntarily implement an SMS. This process follows a four-phase approach that slowly and methodically builds the SMS. This process is modeled after the ICAO documents that guide an operator's implementation of SMS. Many resources are available to 135 operators from this website including a voluntary program guide (Federal Aviation Administration, 2015c).

The FAA Safety Assurance System (SAS) and Compliance Philosophy

The FAA has established a Safety Management Systems (SMS) in the various lines of businesses such as AVS, ATO, and ARP, in response to International Civil Aviation Organization (ICAO) requirements. The FAA Aviation Safety (AVS) Safety Management System (SMS), or AVSSMS, was established as part of this initiative.

ICAO began incorporating the requirements for SMS into the various ICAO annexes in 2001. ICAO Annex 19 consolidated these requirements into one annex and made the State Safety Program (SSP) an ICAO requirement when it was published on November 14, 2013. ICAO Document 9859, the Safety Management Manual (SMM), was also updated to the third edition in the same year. The SMM third edition provided the framework for each ICAO member state to implement a SSP (International Civil Aviation Organization, 2016). FAA Aviation Safety (AVS) is complying with the requirement to implement a SSP with the AVSSMS.

FAA Order VS 8000.367 was initially published on May 14, 2008. FAA Order VS 8000.367 established The Aviation Safety – Safety Management System (AVSSMS). This order states that it is not practical for all aviation stakeholders to develop an SMS, but each aviation stakeholder still has the responsibility of managing safety. This order further states that AVS must conduct oversight on entities with and without an SMS, and that rapid changes within the industry will lead to new forms of oversight in the future (Federal Aviation Administration, 2008).

FAA Order 8000.368A was published on December 12, 2012. This order provided guidance to AFS staff and offices to meet the requirements of the Aviation Safety (AVS) Safety management System (SMS). This order discusses the incorporation of system safety and is inclusive of SMS concepts into the future AFS oversight approach. This concept was the birth of the compliance philosophy. It made high-level executives within the FAA aware of the need for a compliance and enforcement policy change within the entire agency (Federal Aviation Administration, 2012).

The four pillars of SMS include Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion. The FAA Compliance Philosophy itself falls under the Safety Policy pillar of the AVSSMS. The FAA application of the Compliance Philosophy falls under the Safety Risk Management pillar and Safety Assurance pillar. The FAA mission is to provide the safest, most efficient aerospace system in the world (Federal Aviation Administration, 2010). FAA Flight Standards (AFS) supports this

FAA mission by setting the standards for certification and oversight of airmen, air operators, air agencies, and designees. The AVSSMS is intended to assist the FAA in these missions (Federal Aviation Administration, 2014).

A critical aspect of the AVSSMS is the FAA Safety Assurance System (SAS). A principle motivation for Part 135 operators to implement a safety management system (SMS) is that the FAA is now using a safety assurance system (SAS) for the oversight and surveillance of Part 135 operators. A Part 135 operator SMS could work in conjunction with SAS to improve aviation safety. SAS is a recent development that ties into the FAA's AVSSMS. SAS utilizes a risk-based, system safety principles approach for oversight of certificated entities. Today, SAS is being used for the oversight of all Part 121, 135, and 145 operators. This system will be incorporated into the oversight of Part 141 and 147 air agencies in the near future, and will eventually be used for the oversight, certification, and investigation activities of all operators, including Part 91 (Federal Aviation Administration, 2015d).

Another important aspect of the AVSSMS is the FAA Compliance Philosophy. The Compliance Philosophy is an agency wide, FAA National Policy that was published in FAA Order 8000.373 on June 26, 2015, by Administrator Michael Huerta. The FAA Compliance Philosophy was created because of many different factors that all focus on improvements to aviation safety. The first reason the FAA Compliance Philosophy was created was to establish a just safety culture. Another reason the Compliance Philosophy was created was to foster an open and transparent exchange of safety information between the FAA and aviation industry. Finally, the FAA Compliance Philosophy was created to help the aviation industry obtain a higher level of safety and compliance with regulatory standards (Federal Aviation Administration, 2015a).

The Compliance Philosophy is vital to FAA and aviation industry relations because the Compliance Philosophy supports the FAA mission to improve aviation safety and efficiency through the AVSSMS. The implementation of SMS will benefit a Part 135 operator because it could ease relations between with the primary government regulatory agency, the FAA. A Part 135 operator's SMS works separately, but in conjunction with, the AVSSMS, FAA Compliance Philosophy, and FAA Safety Assurance System.

Part 135 SMS Implementation

Part 5 contains the processes necessary for a safety management system, but does not provide a specific way to implement an SMS. Each Part 135 operator must design an SMS that is specific to the organization. Also, a Part 135 operator should incorporate any current safety programs into the design of an SMS during implementation (Federal Aviation Administration, 2015b).

The task of SMS implementation may be more difficult at a Part 135 operation when compared to a Part 121 operation because of the fragmented and ever changing nature of this section of the industry. Another hurdle will be the many wide range of operations that exist in Part 135 from the small one-airplane, one-pilot company, to the large multi-jet fleets. Some of these operators have already voluntarily adopted an SMS. Additionally, the operators that fly internationally are required by some foreign countries to have an SMS. The current International Civil Aviation Organization (ICAO) requirements call for member states to have an SMS regulatory requirement for on-demand air carriers, but the United States has not yet adopted this mandate for on-demand air carriers (Bergin, 2013).

Two of the important reasons why all Part 135 operators should implement SMS are that it can prevent loss of human life and resources, and the safety risk management principles can be applied to the achievement of other business goals. Although many training programs and commercially developed SMS programs exists, the most difficult part of SMS implementation is changing the company's safety culture (Van Dyke, 2009).

A safety culture is only effective if it is intertwined with an organization's culture. Organizational culture is the sum total of each persons' characteristics and perceptions, which affects the interactions of the members of the group. Organizational culture affects the prioritization and balancing of policies and processes, such as safety versus efficiency, and enforcement versus corrective action (International Civil Aviation Organization, 2013c).

A just culture is equally as important to SMS as a safety culture. This non-punitive approach to safety will lead an organization from a reactive safety strategy to a proactive or predictive safety strategy. Although safety culture and a just culture are both important to an effective SMS, they are two different concepts. Even though a non-punitive policy is vital to the prevention of accidents, it is also becoming commonplace in some countries for management to be held accountable after an accident if reasonable measures to prevent it were not taken. These reasonable measures to prevent accidents can include the implementation of an SMS at a Part 135 company. The basic principles of an SMS can also be applied to business aspects other than safety. An increase in business efficiency can be achieved at an organization by applying SMS concepts such as error recognition and continual improvement (Van Dyke, 2009).

Even with the many recognized safety benefits, concerns about SMS requirements and implementation exist within the Part 135 industry segment. The two biggest concerns with SMS requirements by Part 135 operators are redundancy and documentation. Many Part 135 operators believe that SMS requirements will duplicate existing regulatory requirements and increase clerical workloads within their organizations. The Part 135 industry also believes that the documentation requirements, such as written procedures and additional safety documentation, will be overly burdensome on Part 135 operators and their employees (Steckel, Lercel, Rieser, Kostal, & Patankar, 2013).

Smaller companies tend to be more concerned about SMS requirements, while larger companies tend to be less concerned. One possible reason for this is that the larger companies already have the infrastructure in place for SMS, such as safety programs and training departments. Some concerns about SMS by Part 135 operators may also stem from a lack of understanding of SMS (Steckel, et al., 2013).

The documentation requirements of an SMS may be completed in the FAA sponsored web based application tool (WBAT), which is free to all Part 135 operators. The WBAT is a software program that is proprietary to the Part 135 operator, but can be shared with the FAA if desired. The WBAT contains the tools necessary to implement an SMS such as a gap analysis template and employee safety reporting system. The WBAT also contains a record storage function, internal audits, and safety analysis features for use once the SMS has been implemented (Steckel, et al., 2013).

Universal Technical Resource Services, Inc. created the WBAT software program through funds provided by the FAA. This software program could be very beneficial for every Part 135 operator, but especially for the smaller 135 operators that may find it cost prohibitive to purchase a third party software program to implement the SMS. Utilizing a software program for the implementation is advantageous when compared to paper documentation because the software program will increase efficiency. For example, many operators have cited the WBAT as helping save time with developing, administering, and documenting the SMS (Steckel, et al., 2013). Universal Technical Resource Services, Inc. will also provide free training to Part 135 operators utilizing WBAT at their principle base of operations. Additionally, the company will provide technical support for no charge to Part 135 operators utilizing WBAT (Federal Aviation Administration, 2015a).

As previously mentioned, the primary document that should be used by a Part 135 operator to model an SMS is FAA Advisory Circular (AC) 120-92B. The two industry SMS programs available to all Part 135 operators that meet or exceed the requirements of FAA AC 120-92B are The International Standards for Business Aircraft Operations (IS-BAO), and the Air Charter Safety Foundation Operator Standards Manual. While Safety Management Systems (SMS) have evolved from the principles of a Quality Management System (QMS), they are two separate and distinct systems. By definition, SMS involves the safety of an operation, while QMS refers to the quality of the product or service provided by that operation. The most widely recognized QMS system is ISO 9000, but implementation of this standard alone does not meet the requirements for an SMS as stated in FAA AC 120-92B (Steckel, et al., 2013).

The Impact of SMS Implementation

A detailed study was conducted in 2008 regarding the effects of SMS on various safety aspects of an organization between companies that have, and have not, implemented SMS. The data for this study was obtained through the survey method. The sample for the survey included over 500 randomly selected companies, in which 116 companies provided a survey response. Approximately half of the 116 companies that responded had implemented an SMS (Bottani, Monica, & Vignali, 2009).

The companies that responded to the survey represented many different industries such as manufacturing, construction, and agriculture. The results of the survey indicate that companies that have implemented SMS had an average of 7.03 accidents per year, while companies that had not implemented SMS had an average of 15.05 accidents per year. The results also indicated that a majority of the accidents were attributed to human error. The survey results indicated that the mean responses between companies that have, or have not, implemented SMS were all statistically different. The results indicate that companies with an SMS have significantly better performance concerning communication of safety goals, updating risk data, assessing risk data, and implementation of training programs (Bottani, Monica, & Vignali, 2009).

Another SMS related study was conducted that focused on companies in the airline industry specifically, instead of companies from various different industries. This study examined the effects of SMS on airline safety performance. The emphasis of this research was the effects of a pilot's safety motivation on that pilot's safety behavior. Chen and Chen (2014) studied pilot's safety motivation and safety behavior as an important component of airline safety, since a majority of the major airline accidents are attributed to pilot error. Additionally, the three safety predictors of a pilot's safety behavior analyzed included individual factors, group factors, and organizational factors (Chen, & Chen, 2014).

The data for this research project was collected via the survey method. The sample surveyed included pilots employed at one of five Taiwan international airlines. A total of 420 surveys were disseminated to a random sample of pilots at the selected airlines. The total response rate to the survey was 57%, or 239 surveys. The topics of the survey questions included perceived SMS practices, morality leadership, self-efficacy, safety motivation, and safety behavior. The results of the survey were initially analyzed for variance, and then a structural equation model (SEM) was performed to analyze the measurement and structural models (Chen, & Chen, 2014).

Once the data was collected, the surveys were divided into two separate groups. A t-test of significance was performed to determine if a significant difference existed between the survey results of the two groups. This t-test revealed no significant difference between the two groups, which signifies the sample accurately represents the population studied. Finally, a confirmatory factor analysis (CFA) was performed to confirm the results of the survey. The CFA indicated that all t-values of this test were statistically significant with each p-value less than 0.01 (Chen, & Chen, 2014).

The structural model from this research indicates that the more safety motivation a pilot has, the more likely that pilot is to exhibit safety behavior. The structural model also found that a pilot's perception of SMS has a direct effect on a pilot's safety behavior. Finally, the structural model found that individual, group, and organizational safety motivation affect a pilot's safety behavior (Chen, & Chen, 2014).

This study concludes that a pilot's perception of the airline's SMS has a direct effect on his/her safety behavior. Additionally, a stronger self-efficacy level of a pilot directly correlates to stronger safety behavior by that pilot. The researchers of this study admit the data obtained from the survey may be biased since the survey was self-administered. This survey was self-administered because the survey was mailed to each pilot, the pilot filled out the survey, and then the pilot mailed the survey back to the researcher. A more accurate method of administering the survey would have been for the researcher to directly question each selected pilot (Chen, & Chen, 2014).

Statement of the Problem

SMS appears to be vital to safe operations for Part 135 operators. A major hurdle in the implementation of Safety Management Systems is the safety culture of the operator. The safety culture starts at the executive level of the company, as the attitude towards safety of these individuals will cascade to the frontlines of the company. Experts agree that SMS is vital for Part 135 operators, but no research has been conducted to validate that an SMS improves the safety performance of Part 135 operators (Bergin, 2013).

Further research is needed to determine how SMS can improve non-safety related aspects of a Part 135 company (Van Dyke, 2009). Further research is also needed on the safety benefits of SMS for Part 135 operators. It is a widely held belief that 135 operators who have voluntarily implemented SMS have better safety cultures then 135 operators who have not, but no hard evidence currently exists to confirm this belief (Bergin, 2013).

Taking into account the FAA measures safety performance by the accident/incident rate, this study will examine how a safety management system (SMS) affects the safety performance of a 14 CFR, Part 135 air carrier. The FAA requirement for an air carrier to monitor safety performance is that the air carrier must collect data regarding incidents and accidents. The FAA requirement for measuring safety performance is that the air carrier must investigate incidents and accidents (Federal Aviation Administration, 2015b).

The FAA definition of an aircraft incident is found in 49 CFR, Part 830, which defines an aircraft incident as an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations. The FAA definition of an aircraft accident is found in 49 CFR, Part 830, which defines an aircraft accident as an occurrence associated with the operation of an aircraft, which takes place between the time any person boards the aircraft with intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage (NTSB, 2010).

Research Questions

This study will address the following research questions:

1. Is the safety performance of Part 135 operators with a safety management system better than Part 135 operators without a safety management system, as measured by the aircraft incident and accident rate?
2. How does the implementation of SMS affect the safety performance of a Part 135 operator, as measured by the aircraft incident and accident rate?

This study will test the following null hypothesis and alternative hypothesis:

- Null hypothesis: The percentages of operators in Group S and Group SP05 that had an accident or incident were equal.
- Alternative hypothesis: The percentages of operators in Group S and Group SP05 that had an accident or incident were not equal.

CHAPTER II: METHODOLOGY

The goal of this study was to determine how the implementation of SMS affected a Part 135 operator's safety performance. Separate groups of Part 135 operators were compared, and the operators in each group were divided into two different categories. These categories included operators that had an incident or accident during the time period analyzed, and operators that did not have an incident or accident. This categorical data was then analyzed with a t-test of significance, and a plus four confidence interval for comparing two proportions. This method of statistical analysis was chosen instead of a comparison of operators through mean accident and incident rates because the data contained outliers that would have made a comparison of means unreliable.

To gather the necessary data to answer the research questions of this study, a simple random sample (SRS) of Part 135 operators was chosen, and then this sample was divided into two different categories. The two different categories included Part 135 operators with an SMS and Part 135 operators without an SMS. The safety performance of each group was measured by the aircraft accident and incident rate of these two categories in accordance with the definition of an aircraft accident or incident in 49 CFR, Part 830. SMS databases from International Standard for Business Aircraft Operations (IS-BAO), Wyvern Consulting LLC (WYVERN), and ARGUS International, Inc (ARGUS) were used to determine which Part 135 operators had an SMS, and which did not. The FAA Accident and Incident Data System and NTSB Aviation Accident Database and Synopses were used to determine the accident and incident rate of the simple random sample (SRS) of Part 135 operators in each category over a three-year period. A three-year period was chosen so that enough data would be available for a reliable statistical analysis. A plus four confidence interval for comparing two proportions was performed to make an inference about the two categories of Part 135 operators.

Finally, the Part 135 operator's safety performance was examined before SMS implementation and after SMS implementation. A plus four confidence interval for comparing two proportions, and t-test for significance were performed to make an inference about the two time periods, which determined how safety performance was affected by the implementation of SMS by a Part 135 operator.

Participants

This study measured the safety performance of a sample of the total population of Part 135 air carriers. The research participants were limited to Federal Aviation Administration (FAA) certificated United States air carriers operating under 14 CFR, Part 135. The study participants included both on-demand and commuter operations under Part 135. The Federal Aviation Administration –Airline Certificate Information database was maintained by the FAA and was available to the general public. This database also contained information about each air carrier, including the air carrier's length of existence, location, aircraft, and type of operation, such as on-demand or commuter (Federal Aviation Administration, 2016a).

Instruments

Research question number one required an analysis of the safety performance of Part 135 operators with an SMS compared to Part 135 operators without an SMS. To answer research question number one, a simple random sample (SRS) of all Part 135 operators was chosen. A sample size of approximately 5% of the total Part 135 operators, or 103 of the total population of 2052 Part 135 operators, was chosen for this study. A Random Number Generator was utilized to select the SRS. The Random Number Generator produced random numbers utilizing a statistical algorithm. No computerized Random Number Generator is truly random, but this Random Number Generator produced numbers that were nearly random. This Random Number Generator was ideal for randomly selecting sample numbers from a numbered list of a population (Stat Trek, 2016).

Once the sample of Part 135 operators was chosen from the population of U.S. air carriers operating under Part 135, the sample was divided into two separate groups. Group S consisted of the Part 135 operators from the sample that had an SMS and group N consisted of Part operators from the sample that did not have an SMS. This was accomplished by a review of multiple databases from International Standard for Business Aircraft Operations (IS-BAO), Wyvern Consulting LLC (WYVERN), and ARGUS International, Inc. (ARGUS), to determine which United States air carriers operating under Part 135 have a documented SMS.

An operator must have successfully completed an audit within the previous 2 years to be IS-BAO registered. To successfully complete an IS-BAO audit, the operator must have established an SMS. Three different levels of IS-BAO registration were available for a particular operator. Level 1 confirmed that the SMS infrastructure is established; level 2 confirmed that the safety risks were being effectively managed within the SMS; and level 3 confirmed that safety management was fully integrated and the operator had a positive safety culture (International Standard for Business Aircraft Operations, 2015).

Wyvern also maintained a list of operators with an established SMS. To be named a Wingman Certified Operator, each operator must have passed a Wingman audit. The Wingman Audit was based on the ICAO Doc 9859, which included the requirement to have an operating SMS in place. The Wingman Audit also included a review of the operator's safety record, operational control, manuals, administrative items, training records, and aircraft maintenance. An operator must have exceeded the regulatory standards for pilot training and maintenance training to pass a Wingman Audit (Wyvern Consulting LLC, 2016).

The ARGUS Operator Registry contained a list of all operators that had obtained a rating from ARGUS International, Inc. The ARGUS ratings available included Gold, Gold Plus, and Platinum. To obtain an ARGUS Gold rating, an operator must have maintained current data in the ARGUS database that allowed others to check the operator's credentials prior to a planned charter flight. The ARGUS Gold rating had no requirement for an operator to have an established SMS. To obtain the ARGUS Gold Plus rating, an operator must have passed the Gold Plus Audit in the previous 24 months or be IS-BAO stage 1 registered. To obtain the ARGUS Platinum rating, an operator must have passed an ARGUS Platinum audit within the previous 24 months. An operator with a Gold-Plus or Platinum ARGUS rating must have passed an audit within the previous 24 months that incorporates a verification of the operator's SMS (ARGUS International, Inc., 2016).

This method of determining whether an operator had an SMS made the assumption that the operators without an SMS would not have been registered with IS-BAO, ARGUS, or WYVERN. This assumption could have been flawed since an operator may have still had an SMS in place, but not be registered with one of these companies. However, it is unlikely that a Part 135 operator would have gone through the trouble to implement an SMS without also registering with one of the third party auditing companies IS-BAO, ARGUS, or WYVERN. If a company did have an SMS, but was not registered with one of the third party auditing companies, then it was likely that the SMS was not adequate since it had not been independently audited. It was not possible to positively identify 100% of 135 operators with an SMS due to the FAA regulatory structure and fragmented nature of the Part 135 industry.

After the establishment of the specific operators in Group S and Group N, the safety performance of each group was measured by the aircraft accident and incident rate of these two categories in accordance with the definition of an aircraft accident or incident in 49 CFR, Part 830. Two databases were utilized for this step because complete records of aircraft incidents were only maintained in the FAA Accident and Incident Data System, while complete records of aircraft accidents were only maintained in the NTSB Aviation Accident Database. Access to each database was open to the public with no special permission required.

The NTSB Aviation Accident Database and Synopses contained information about all civil aviation accidents. This database contained information about each civil aviation accident that occurred in the United States, U.S. territories, U.S. possessions, and in international water from 1962 to present. Basic information about each accident was available in this database within a few days after an incident, while detailed information was usually available within a year. It was possible to filter the accident search in this database by operation type, such as Part 135. It is important to note that Part 91 flights, such as repositioning and training flights, which are operated by a Part 135 operator, were recorded as Part 91 flights in this database. Part 91 flights by Part 135 operators were not included in this study (National Transportation Safety Board, 2016).

The FAA Accident and Incident Data System (AIDS) was used to obtain aircraft incident data. FAA AIDS contained incident data for each category of civil aviation, including Part 135 operators. The incidents contained in this database included all occurrences of aircraft damage or injury that were not considered accidents by the NTSB. The occurrences of aircraft damage or injury that were considered aircraft accidents are all contained in the previously mentioned NTSB Aviation Accident Database and Synopses. The FAA Accident and Incident Data System (AIDS) contained incident data from 1978 to present and was updated monthly. The FAA Accident and Incident Data System had a reporting delay of approximately four months from the date of the incident. Flights operated under Part 91 by Part 135 certificated operators, such as training or maintenance, were excluded from this study (Federal Aviation Administration, 2016b).

This study individually analyzed the accident reports and incident reports during a three year time period from January 1, 2013 to December 31, 2015. The accident reports were collected from the previously mentioned NTSB database and the incident reports were collected from the previously mentioned FAA database. Then, each accident and incident was categorized as operated by a Part 135 operator in Group S, Group N, or neither group.

A portion of the incidents and accidents in each database were events that could likely not have been prevented by an air carrier's SMS, such as an aircraft accident caused by a bird strike. These incidents and accidents had an equal probability of occurring in both Group S and Group N. Therefore, the influence of the incidents and accidents that could not have been prevented by an air carrier's SMS were considered to negate each other from a statistical perspective.

Research question number two required an analysis of the safety performance before SMS implementation and after SMS implementation. To answer research question number two, the Part 135 operators from Group S were analyzed. The safety performance of the Part 135 operators with an SMS was compared over two separate time periods to determine the safety performance before and after SMS implementation. The data already gathered for Group S from the beginning of Calendar Year (CY) 2013 to the end of CY 2015 was used as the time period after SMS implementation. Since it took at least one year to fully implement an SMS, then it can be assumed that each operator in Group S had either implemented or was implementing SMS during this time period.

SMS was not adopted by the aviation industry until the original release of FAA Advisory Circular (AC) 120-92, which was issued on June 22, 2006. Therefore, it can be assumed that all Part 135 operators did not have an SMS prior to CY 2005. The FAA database of all Part 135 operators was consulted for each operator in Group S to determine which Part 135 operators were in existence prior to CY 2005. The accident and incident data from January 1, 2003 to December 31, 2005 was utilized to represent the time period that Part 135 operators in Group S did not have an SMS. The operators in Group S that were initially certificated after CY 2005 were excluded from this portion of the study. The data for the time period prior to SMS implementation by Group S was obtained and recorded in the same manner as the data that was gathered for the time period from January 1, 2013 to December 31, 2015.

Procedures

The Federal Aviation Administration –Airline Certificate Information database was utilized to create an excel spreadsheet of every active Part 135 operator. In the search for an airline page, location was selected as the search function, 135 was selected in the FAR menu, United States was selected in the country option, Alabama was selected in the state option, then search was selected. Each operator identified was added to a spreadsheet. These steps were then repeated for every U.S. State, U.S. Territory, and U.S. possession available in the state option of the search page, and the Part 135 operators in each U.S. State, U.S. Territory, and U.S. possession were added to the spreadsheet. This spreadsheet contained a numbered list from 1 to 2052, including all of the active Part 135 operators as of July 2016.

In the Random Number Generator, 103 was entered into the “How many random numbers” box. Next, the minimum number value was set equal to 1 and the maximum number value was set equal to 2052. Finally, the allow duplicate entries box was set equal to false, and the list of random numbers was generated. Each random number that was generated was used to select the corresponding Part 135 operator from the spreadsheet of the population.

The IS-BAO Operators Online Listing contained the name of every operator that was registered with IS-BAO (International Standard for Business Aircraft Operations, 2015). The name of each Part 135 operator in the SRS was compared to The IS-BAO Operators Online Listing. Each Part 135 operator in the SRS that was on The IS-BAO Operators Online Listing was added to the S group. Ten of the 103 Part 135 operators in the SRS were found on The IS-BAO Operators Online Listing.

The certificate number of each Part 135 operator in the SRS was compared to the list of Wingman Certified Operators. Each Part 135 operator in the SRS that was on the list of Wingman Certified Operators was added to the S group. Four of the 103 Part 135 operators in the SRS were found to be Wingman Certified Operators, none of which were found on The IS-BAO Operators Online Listing.

The certificate number of each Part 135 operator in the SRS was compared to the ARGUS Operator Registry. Seven of the 103 Part 135 operators in the SRS were found in the ARGUS Operator Registry with a rating of Gold Plus or Platinum, six of which were already identified to have an established SMS from either the IS-BAO Operators Online Listing or list of Wingman Certified Operators. The one Part 135 operator with the ARGUS Platinum rating that was not found on the IS-BAO or WYVERN lists was added to Group S. Group S had fifteen Part 135 operators while Group N had 88 Part 135 operators. That means that 15 of the 103, or 14.6%, Part 135 operators in the SRS had an established SMS.

In the accident search page of the NTSB Aviation Accident Database and Synopses, January 1, 2013 was entered as the event start date, December 31, 2015 was entered as the event end date, Part 135 was selected as the operation, and submit query was selected. The accidents from the NTSB Aviation Accident Database and Synopses contained a total of 144 accidents from January 1, 2013 to December 31, 2015. Next, each accident was copied into a spreadsheet to organize the accident data. Then, each accident was analyzed to determine if the operator was in Group S, Group N, or neither group. If the Part 135 operator was in Group S or Group N, then the accident was labeled accordingly. If the Part 135 operator was in neither group, then the accident was labeled

O. This search revealed that Group N had four accidents during this time period, two of which were operated by Flight Alaska Inc., and two of which were operated by Metro Aviation Inc. Group S had zero accidents during this time period.

On the AIDS search form, January 1, 2013 was entered as the event start date, December 31, 2015 as the event end date, air taxi/commuter was selected as flight conduct, and search AIDS was then selected. This search resulted in 249 Part 135 incidents during this time period. CSV download was then selected and the downloaded data was saved to a spreadsheet. Next, the spreadsheet of aircraft incidents were analyzed for each operator in Group N and Group S, and then the number of incidents for each operator were recorded. Group S had one incident, which was operated by Flight Options, LLC. Group N had 13 incidents during this time period by 10 different operators. One of the Part 135 operators with an incident was, Flight Alaska Inc., which was involved in four separate incidents. Additionally, Metro Aviation LLC was one of the Part 135 operators with an incident during this time period. Metro Aviation LLC and Flight Options LLC were previously identified as each having two separate accidents during the same time period.

Finally, the data to answer research question number two was gathered. First, the Part 135 Operators in Group S that were originally certified before CY 2005 were identified and added to Group S prior to 2005 (SP05). Any Part 135 operator in Group S with more than 10 years in business was added to Group SP05. The state of the first Part 135 operator in Group S was entered into the Federal Aviation Administration –Airline Certificate Information database and a search was performed. Then, the name of the first Part 135 operator in Group S was selected. This operator’s years is business was identified as 22, so the operator was added to Group SP05. This process was repeated for the remaining Part 135 operators in Group S. Twelve of the 15 total Part 135 operators from Group S were added to Group SP05. That means that 80% of the Part 135 operators with an SMS were initially certified before SMS had been adopted by the aviation industry.

In the accident search page of the NTSB Aviation Accident Database and Synopses, January 1, 2003 was entered as the event start date, December 31, 2005 was entered as the event end date, Part 135 was selected as the operation, and submit query was selected. The accidents from the NTSB Aviation Accident Database and Synopses contained a total of 239 accidents. Next, each accident was copied into a spreadsheet to organize the accident data. Then, a search for each operator in Group SP05 was performed using this spreadsheet. If one of the operators in Group SP05 was identified, then was labeled accordingly. This search revealed that Group SP05 had two accidents during this time period.

On the AIDS search form January 1, 2003 was entered as the event start date, December 31, 2005 as the event end date, air taxi/commuter was selected as flight conduct, and then search AIDS was selected. This search resulted in 365 Part 135 incidents during this time period. CSV download was selected and the downloaded data was saved to a spreadsheet. Then, a search for each operator in Group SP05 was performed using this spreadsheet. If one of the operators in Group SP05 was identified, then was labeled accordingly. Group SP05 had five separate incidents during this time period that involved four separate Part 135 operators. These were the steps utilized in this study.

CHAPTER III: DATA ANALYSIS

Quantitative data for this study includes the number of accidents and the number of incidents for three separate groups of Part 135 operators. Group S includes the Part 135 operators that have an SMS from the sample of the population. Group N includes Part 135 operators that do not have an SMS from the sample of the population. Group SP05 includes the Part 135 operators from Group S that were initially certificated prior to CY 2005, which was the time period prior to the aviation industry's adoption of SMS. Therefore, the Part 135 operators in Group SP05 do not have an SMS. The Part 135 operators in each group are displayed in Appendix A.

Most Part 135 operators in the sample groups selected had zero accidents or incidents, a few had one accident or incident, and one had two accidents and four incidents. Therefore, this data was analyzed as proportions instead of means, and the operators were categorized by whether they had experienced an accident or incident, or had not experienced an accident or incident. This data is presented in Table 1.

Table 1

Number of Operators with an Accident or Incident in Each Group

Group	Operator with an Accident or Incident		Total Number of
	Yes	No	Operators (n)
S	1	14	15
N	10	78	88
SP05	5	7	12

Additionally, a visual representation of operators in each group that had an accident or incident is shown in the following pie charts. Figure 1 depicts operators in Group S with an accident or incident, Figure 2 depicts operators in Group N with an accident or incident, and Figure 3 depicts operators in Group SP05 with an accident or incident.

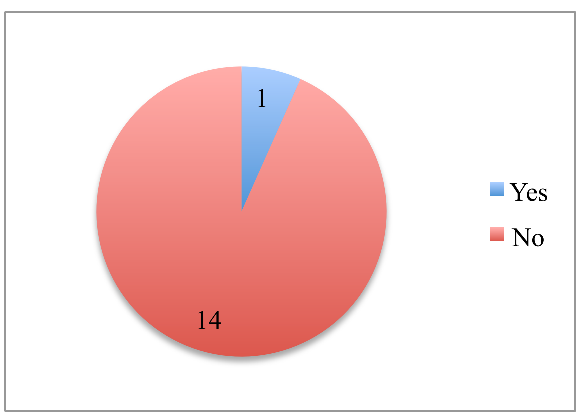

Figure 1

Part 135 Operators in Group S with an Accident or Incident

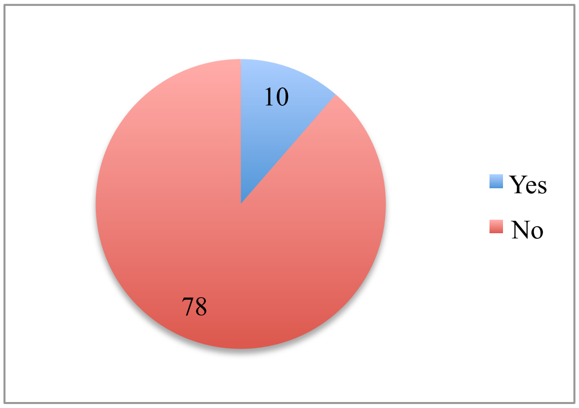

Figure 2

Part 135 Operators in Group N with an Accident or Incident

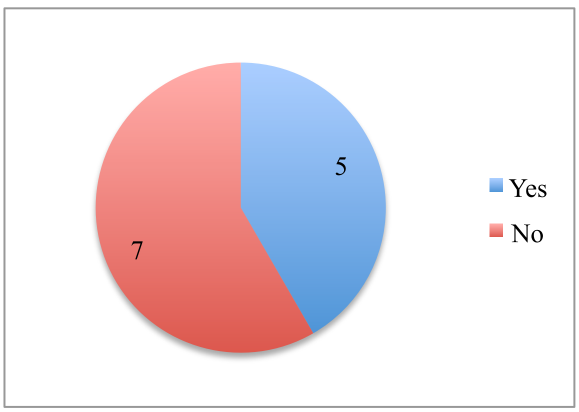

Figure 3

Part 135 Operators in Group SP05 with an Accident or Incident

A Chi-Square test would have been beneficial with the categorical data from Group S, Group N, and Group SP05. This Chi-Square test could have shown if a relationship existed between not having an SMS, and having an accident or incident. However, a Chi-Square test could not be safely performed with the data collected because

33% of our expected cell counts were less than 5. To safely perform a Chi-Square test, no more than 20% of the expected counts may be less than 5 and all individual cell counts must be 1 or greater (Moore, Notz, & Fligner, 2013). The expected cell counts, as calculated from Table 1, are displayed in Table 2.

Table 2

Expected Cell Counts for Chi-Square Test

Group	Operator with an Accident or Incident		Total Number of
	Yes	No	Operators (n)
S	2.087	12.913	15
N	12.243	75.757	88
SP05	1.670	10.330	12
Total	16	99	115

Comparing Group S and Group N

This study used a statistical calculation to analyze the safety performance of Group S and Group N to answer research question number one. Research question number one was, " Is the safety performance of Part 135 operators with a safety management system better than Part 135 operators without a safety management system?" The statistical analysis performed included a plus four confidence interval for comparing two proportions.

The proportion of operators in Group S with an accident or incident was 0.067, or 6.7%. The proportion of operators in Group N with an accident or incident was 0.114, or

11.4%. The difference in these proportions was 0.047 or 4.7%. This indicates that 4.7% more operators in Group N had an accident or incident compared to the operators in Group S.

A large sample confidence interval could not be used to compare these two proportions because the number of operators with or without an accident or incident in each group was not 10 or more. Therefore, a plus 4 confidence interval method was used. The plus 4 confidence interval method could be used for this comparison because the sample size was at least 5 operators in each group (Moore, Notz, & Fligner, 2013). The plus four confidence interval calculations yielded (-.1359, .1451) with $P_N = 0.1222$ and $P_S = 0.1176$. This means that there is a 90% confidence level that the operators in Group N had between 13.59% less operators to 14.51% more operators that had an accidents or incidents when compared to the operators in Group S.

A significance test for comparing two proportions could not be performed to test the null hypothesis that the percentage of operators in Group S and Group N that had an accident or incident are equal. A significance test for comparing two proportions could not be accurately performed because the number of operators with or without an accident or incident in both groups did not include at least 5 or more operators (Moore, Notz, & Fligner, 2013).

Comparing Group S and Group SP05

This study used two statistical calculations to analyze the safety performance of Group S and Group SP05 to answer research question number two. Research question number two was, “Does the implementation of SMS improve the safety performance of a Part 135 operator?” The statistical analysis performed included a significance test for comparing two proportions, and a plus four confidence interval for comparing two proportions. The significance test for comparing two proportions tested a null and alternative hypothesis. The null hypothesis tested was that the percentages of operators in Group S and Group SP05 that had accident or incident were equal. The alternative hypothesis tested was that the percentages of operators in Group S and Group SP05 that had an accident or incident were not equal.

The proportion of Operators in Group S with an accident or incident was 0.067, or 6.7% as previously mentioned. The proportion of operators in Group SP05 with an accident or incident was 0.417, or 41.7%. The difference in these proportions was 0.350, or 35.0%. This indicates that 35.0% more operators in Group SP05 had an accident or incident compared to Group S.

A large sample confidence interval could not be used to compare these two proportions either, because the number of operators with or without an accident or incident in each group was not 10 or more. Therefore, a plus 4 confidence interval method was used to compare Group S and Group SP05 as well. The plus 4 confidence interval method worked for this comparison because the sample size contained at least 5 operators in each group (Moore, Notz, & Fligner, 2013). The plus four confidence interval calculations yielded (0.2011, 0.70646) with $P_{SP05} = 0.5714$ and $P_S = 0.1176$. This means that there was a 90% confidence level that Group SP05 had between 20.11% to 70.65% more operators that had an accidents or incidents when compared to the operators in Group S.

Next, a significance test for comparing two proportions was performed to test the null hypothesis that the percentage of operators in Group S and Group SP05 that had an accident or incident were equal. A significance test for comparing two proportions was appropriate for Group S and Group SP05 because each group had 5 or more operators that either had or did not have an incident or accident (Moore, Notz, & Fligner, 2013). The pooled proportion of operators with an accident or incident in Group S and Group SP05 is 0.32258, or 32.258%. The z-statistic of $z = 2.68971631$ with a p-value of $p = 0.0071513741$. This small p-value, which is less than 0.05, gave strong evidence that the data collected was statistically significant.

CHAPTER IV: DISCUSSION

This study first examined two separate groups of Part 135 operators to determine whether a Part 135 operator with an SMS had better safety performance than a Part 135 operator without an SMS. The operators in Group S consisted of Part 135 operators with an SMS while Group N consisted of Part 135 operators without an SMS. Incident and accident data was collected for both groups over the same three year time period. The incident and accident data collected confirmed that Part 135 operators without an SMS did in fact have a higher percentage of operators with an accident or incident. However, a statistical analysis of the data indicated that the results from this sample do not necessarily represent the population of Part 135 operators. In fact, the statistical analysis revealed that there is a 90% confidence level that the percentage of operators with an accident or incident that had no SMS could have been about 14% more to about 14% less when compared to operators that did have an SMS.

This analysis reveals that there is no evidence that the safety performance of a Part 135 operator with an SMS is equal to the safety performance of a Part 135 operator without an SMS. Therefore, the results of this study suggest that the safety performance of Part 135 operators with a safety management system is equal to Part 135 operators without a safety management system.

Next, this study examined the group of operators previously identified in Group S over two separate time periods to determine whether the implementation of SMS improved the safety performance of a Part 135 operator. The operators in Group S were added to a new group called SP05 if they were initially certificated prior to CY 2005. Three of the operators from Group S were excluded from the newly formed Group SP05 in this study because they were initially certificated after CY 2005. This analysis allowed a comparison of safety performance to be made between the same operators prior to SMS implementation and after SMS implementation. The incident and accident data for operators in Group S and Group SP05 were each analyzed over two separate three year time periods. The incident and accident data collected did confirm that 35.0% more operators had an incident or accident prior to implementing SMS.

Next, a significance test was performed between the operators in Group S and Group SP05. This significance test revealed strong evidence ($p = 0.007$) that the difference in operators in each group was statistically significant. This means that safety performance of a Part 135 operator did in fact increase when an operator implemented SMS.

A plus four confidence level analysis was then performed to determine if the percentage of operators with an accident or incident was greater, prior to the implementation of SMS. This statistical analysis revealed there was a 90% confidence level that the percentage of operators with an incident or accident was 20.11% to 70.65% higher before implementing an SMS. This also indicates that the safety performance of a Part 135 operator increased after the implementation of an SMS. Therefore, the results of this study suggest that the implementation of SMS does improve the safety performance of a Part 135 operator.

Limitations

Two different time periods for the same operators had to be studied to analyze the effect on safety performance of implementing an SMS, which were represented by Group S and Group SP05. This was required because the specific date that a Part 135 operator implemented SMS was not publically or readily available. This could have exaggerated the improvement of safety performance by implementing an SMS. The effect on safety performance could have been exaggerated because this increased safety performance after implementing SMS could have been due to the operators being in business longer, which could simply indicate that an operator's safety performance improves as the experience of that operator increases. The operators in Group S likely had more flights during the time period studied then the operators in Group SP05, because they had been in business longer. This could have negated the effect of the operators increased experience. The operators in Group S likely had more flights overall, which could have increased the likelihood of operators in Group S having an incident or accident.

The operators in Group S had more experience compared to the time period studied ten years prior, which was Group SP05. This could indicate that the safety performance improved because of increased experience of the operator instead of the implementation of SMS. Identifying the exact date that each Part 135 operator implemented SMS, and then comparing the safety performance prior to and after SMS implementation, could reduce the effect of this limitation. Additionally, this limitation could be eliminated if two separate groups were studied over two separate time period that are ten years apart. These operators safety performance could then be compared to determine if the implementation of SMS, or the increased experience, led to a better safety performance.

An additional limitation of the study was the fact that a majority of Part 135 operators with an SMS had only confirmed the existence of the SMS through the third party companies including IS-BAO, WYVERN, and ARGUS. The vast majority of Part

135 operators do not have FAA approved SMS in accordance with 14 CFR, Part 5 SMS regulations. This limits the ability to efficiently and accurately track the specific operators that have an SMS.

Another limitation of this study was that the sample size of Part 135 operators was too small to make all of the desired statistical calculations. Although the relatively small sample size of Part 135 operators in this study limited the statistical analysis that could be performed with the data collected, the study has still made a valuable contribution to the knowledge of SMS in Part 135 aviation industry sector.

Future Research

A valuable contribution that this study made to the knowledge of SMS is the recognition of further research that can be conducted on this topic. It would be valuable to replicate this study utilizing a minimum sample size of 30% of the population of Part 135 operators, or ideally the entire population of Part 135 Operators, over the same time periods. This would yield a larger number of operators in each category of each group. This larger amount of categorical data would provide more accurate results for the significance test for comparing two proportions. Additionally, a larger amount of categorical data would have allowed the use of a large sample confidence interval for comparing two proportions instead of the plus four confidence interval method that was utilized. Finally, a larger amount of categorical data would have made the Chi-Square test a viable statistical analysis. A larger number of operators in each category would have allowed additional statistical analysis to be performed, which would have given more evidence to definitively answer the research questions posed (Moore, Notz, & Fligner, 2013).

A new potential research topic identified by this study is the effects of SMS on the prevention of multiple incidents and accidents. This study revealed that multiple operators without an SMS had multiple incidents and accidents, while operators with an SMS did not have any multiple incidents or accidents. It is fascinating to note that Group S, with an SMS, had zero accidents and only one single incident. This data is displayed in Table 3.

It is also interesting to note that the only two operators in Group N with an accident each had two separate accidents during the time period from CY 2013 to CY 2015. It is also remarkable to note that one of the operators with an accident also had one incident during this same time period, while the other operator with an accident had four separate incidents during this same time period. These findings are displayed in Table 4.

Finally, one of the two operators with an accident in Group SP05 also had two separate incidents during the three-year time period analyzed. This data is displayed in Table 5.

Table 3

Group S Incidents and Accidents from CY 2013 to CY 2015

Operator Name	Operator Certificate Number	Total Number of Incidents	Total Number of Accidents
FLIGHT OPTIONS LLC	DJFA	1	0

Note: *Operators in Group S not displayed in this chart did not have an incident or accident during this time period.*

Table 4

Group N Incidents and Accidents from CY 2013 to CY 2015

Operator Name	Operator Certificate Number	Total Number of Incidents	Total Number of Accidents
BASIN AVIATION INC	GYWA	1	0
FLIGHT ALASKA INC	YAAA	4	2
HUGHES FLYING SERVICE INC	EYAA	1	0
JET AIR INC	JAFA	1	0
KINGFISHER AIR INC	K0EC	1	0
KOLOB CANYONS AIR SERVICES L L C	K51A	1	0
MEMORIAL HERMANN HOSPITAL SYSTEM	GVNA	1	0
METRO AVIATION INC	HDNA	1	2
MOYER AVIATION INC	CDHA	1	0
RSB INVESTMENTS INCORPORATED	S2KA	1	0

Note: *Operators in Group N not displayed in this chart did not have an incident or accident during this time period.*

Table 5

Group SP05 Incidents and Accidents from CY 2003 to CY 2005

Operator Name	Operator Certificate Number	Total Number of Incidents	Total Number of Accidents
AMERICAN JET INTERNATIONAL CORPORATION	A8JA	1	0
CORPORATE AIR LLC	XCGA	2	1
FLIGHT OPTIONS LLC	DJFA	0	1
M C AVIATION CORP	M2GA	1	0
TAVAERO JET CHARTER CORPORATION	BN5A	1	0

Note: *Operators in Group SP05 not displayed in this chart did not have an incident or accident during this time period.*

The finding that operators without an SMS had multiple incidents or accidents is especially interesting because SMS is useful in eliminating a hazard once it is identified. This feature of an SMS will theoretically prevent an operator from creating similar errors that lead to multiple incidents or accidents. Further research on the topic of multiple incidents and accidents by Part 135 operators without an SMS would provide valuable insight into the affects that SMS has on reducing repetitive accidents and incidents by the same operator.

REFERENCES

ARGUS International, Inc. (2016). CHEQPoint. Retrieved from http://argus.aero/ProductsServices/CHEQPoint.aspx

Bergin, B. L. (2013). Safety Management Systems: Management's role at Part 135 carriers (Unpublished master's thesis). Purdue University, West Lafayette, IN.

Bottani, E., Monica, L., & Vignali, G. (2009). Safety management systems: Performance differences between adopters and non-adopters. Safety Science. doi:10.1016/j.ssci.2008.05.001

Chen, C. F., & Chen, S. C. (2014). Measuring the effects of Safety Management System practices, morality leadership and self-efficacy on pilots' safety behaviors: Safety motivation as a mediator. *Safety science*, *62*.

Federal Aviation Administration. (2008). *Aviation Safety (AVS) safety management system requirements* (VS 8000.367). Retrieved from http://www.faa.gov/documentLibrary/media/Order/VS%208000.367.pdf

Federal Aviation Administration. (2010). Mission. Retrieved from http://www.faa.gov/about/mission/

Federal Aviation Administration. (2012). *Flight Standards Service oversight* (Order 8000.368A). Retrieved from http://www.faa.gov/documentLibrary/media/Order/8000.368.pdf

Federal Aviation Administration. (2014). Flight Standards Service (AFS). Retrieved from http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/

Federal Aviation Administration. (2015a). *Federal Aviation Administration compliance philosophy* (Order 8000.373). Retrieved from http://www.faa.gov/documentlibrary/media/order/faa_order_8000.373.pdf

Federal Aviation Administration. (2015b). *Safety management systems for Aviation Service Providers* (AC 120-92B). Retrieved from http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-92B.pdf

Federal Aviation Administration. (2015c). Safety Management System – Voluntary Implementation of SMS for Non-Part 121 Operators, MROs, and Training Organizations. Retrieved from https://www.faa.gov/about/initiatives/sms/specifics_by_aviation_industry_type/air_operators/

Federal Aviation Administration. (2015d). System Approach for Safety Oversight Program (SASO). Retrieved from https://www.faa.gov/about/initiatives/saso/

Federal Aviation Administration. (2016a). Airline Certificate Information. Retrieved June 18, 2016, from http://av-info.faa.gov/OpCert.asp?SrchBy=Location

Federal Aviation Administration. (2016b). FAA accident and incident data system (AIDS). Retrieved from http://www.asias.faa.gov/pls/apex/f?p=100:12:0::NO

Federal Register. (2015). *Safety management systems for domestic, flag and supplemental operations certificate holders; final rule* (Docket No. FAA–2009–0671). Retrieved from Federal Aviation Administration website: https://www.gpo.gov/fdsys/pkg/FR-2015-01-08/pdf/2015-00143.pdf

International Civil Aviation Organization. (2013a). Global aviation safety plan. Retrieved from http://www.icao.int/Meetings/a38/Documents/GASP_en.pdf

International Civil Aviation Organization. (2013b). *Safety culture and the future enhancement of ICAO provisions related to SMS implementation* (A38-WP/206).

International Civil Aviation Organization. (2013c). *Safety Management Manual (SMM)* (Doc 9859). Retrieved from http://www.icao.int/safety/SafetyManagement/Documents/Doc.9859.3rd%20Edition.alltext.en.pdf

International Civil Aviation Organization. (2016). Safety Management. Retrieved from http://www.icao.int/safety/SafetyManagement/Pages/default.aspx

International Standard for Business Aircraft Operations. (2015). IS-BAO operators on-line listing. Retrieved from http://www.ibac.org/wp-content/uploads/2013/10/IS-BAO-Operators-On-Line-Listing1.pdf

Moore, D. S., Notz, W., & Fligner, M. A. (2013). *The basic practice of statistics* (6th ed.). New York: W.H. Freeman and Co.

National Transportation Safety Board. (2010). eCFR, — Code of Federal Regulations. Retrieved from http://www.eCFR,.gov/cgi-bin/text-idx?SID=0f6ddc4b0bafb3db995d770486c14f18&mc=true&node=se49.7.830_12&rgn=div8

National Transportation Safety Board. (2015). Aviation Statistics. Retrieved from http://www.ntsb.gov/investigations/data/pages/aviation_stats.aspx

National Transportation Safety Board. (2016). *NTSB aviation accident database & synopses*. Retrieved from http://www.ntsb.gov/_layouts/ntsb.aviation/index.aspx

Stat Trek. (2016). Random Number Generator. Retrieved from http://stattrek.com/statistics/random-number-generator.aspx

Steckel, R., Lercel, D., Rieser, T., Kostal, E., & Patankar, M. (2013). *Safety Management Systems for aviation service providers: A comparison with current federal regulations, industry standards, and programs* (FAA Grant #08-G-014). Retrieved from Saint Louis University website: http://parks.slu.edu/research/centers-labs-facilities/CASR/research-papers/safety-management-systems-for-aviation-service-providers

Van Dyke, D. (2009). Effective risk management depends on strong rules and not cutting corners. *Professional Pilot*, *43*(6).

Wyvern Consulting LLC. (2016). Wingman certified operators. Retrieved July 17, 2016, from http://www.wyvernltd.com/wyvern-wingman-directory/

APPENDIX

APPENDIX A

Sample of Part 135 Operators and Associated Groups

Operator Name	Group	Operator Certificate Number	SMS Documentation		
			IS-BAO	WYVERN	ARGUS
A G SHOLTON COMPANY	N	O4LC			
ACE TRANSPORT SERVICE INC	N	7ATA			
AERO OPTICS INC	N	OO8A			
AERO S E A T INC	N	3SEA			
AIR SANTA BARBARA INC	N	I93A			
AIR SOUTHEAST INC	N	QESA			
AIR TREK INC	N	FDIA			ARGUS GOLD
AIRBRIDGE ENGINEERING LLC	N	3AGC			
AIRCRAFT MANAGEMENT GROUP INC	N	3CMA			ARGUS GOLD
ALASKA WILDERNESS OUTFITTING COMPANY L L C	N	WU5C			
AMERICAN CHARTER SERVICES LLC	N	6A9A			
AMERICAN JET INTERNATIONAL CORPORATION	S and SP05	A8JA	IS-BAO		ARGUS PLATINUM
ANDREW BETTIS AVIATION LLC	S and SP05	B5ZA	IS-BAO		ARGUS PLATINUM
ARROWHEAD OUTFITTERS LLC	N	AO0A			

Operator Name	Group	Operator Certificate Number	SMS Documentation		
			IS-BAO	WYVERN	ARGUS
ASI CHARTER INC	N	YHPA			
ASPEN HELICOPTERS INC	N	IGAA			
ASTRO STAR AVIATION INC	N	JOPA			
BAER AIR INC	N	BP5A			ARGUS GOLD
BASIN AVIATION INC	N	GYWA			
BROOKS FLYERS LLC	N	X9ZC			
BUTLER AIRCRAFT COMPANY	N	GCVA			
CARDINAL AIR SERVICES INC	N	DNSA			
CARIS AIR SERVICES LLC	S and SP05	L16A	IS-BAO		
CHARTERLINES INC	N	88CA			
CHICKASHA WINGS INC	N	730A			
CHRYSLER, JAMES W	N	GJYA			
COLORADO AIRWAYS LLC	N	3CYA			
CORPORATE AIR LLC	S and SP05	XCGA		WYVERN	ARGUS GOLD
CORPORATE JET LLC	N	YCOA			ARGUS GOLD
COVE PARTNERS LLC	S	2CPA		WYVERN	ARGUS GOLD
COYOTE AIR LLC	N	CY6C			
DAVES AIRCRAFT INC	N	Y2DA			
DELTA JET LTD	N	FUUA			
DESERT AIR AMBULANCE INC	N	U7ZA			
EIDER AIR SERVICE LLC	N	3EVC			

Operator Name	Group	Operator Certificate Number	SMS Documentation IS-BAO	WYVERN	ARGUS
EXECUTIVE AVIATION SERVICES MANAGEMENT LLC	N	EV4A			
EXECUTIVE FLIGHT SERVICES INC	S and SP05	E07A	IS-BAO		ARGUS GOLD
EXECUTIVE HELIJET CHARTERS LLC	N	EH5A			
FALLON AIRMOTIVE	N	XFLA			
FENIX AIRWAYS OF FLORIDA	N	6AQA			
FLIGHT ALASKA INC	N	YAAA			
FLIGHT OPTIONS LLC	S and SP05	DJFA			ARGUS PLATINUM
FLORIDA AIR CARGO INC	N	P3EA			
FRESH WATER ADVENTURES INC	N	BPMC			
GQ AVIATION INC	N	GQ9C			
HELIMOTION LLC	N	H4TA			
HELIQWEST INTERNATIONAL INC	N	H4QA			
HERLIHY HELICOPTERS INC	N	H59A			
HUGHES FLYING SERVICE INC	N	EYAA			
INTER-STATE AVIATION INC	N	GGSA			
ISLAND HELICOPTERS KAUAI INC	N	ILDA			
JET AIR INC	N	JAFA			ARGUS GOLD

Operator Name	Group	Operator Certificate Number	SMS Documentation IS-BAO	WYVERN	ARGUS
JET CENTER LLC	N	VDNA			ARGUS GOLD
JET-A LLC	N	XQJA			ARGUS GOLD
JUNIPOGO LLC	N	3JPA			
KINERT AVIATION INC	N	KNEA			
KINGFISHER AIR INC	N	K0EC			
KOLOB CANYONS AIR SERVICES L L C	N	K51A			
LAKE SUPERIOR HELICOPTERS LLC	N	5LHA			
M C AVIATION CORP	S and SP05	M2GA	IS-BAO		
MAD RIVER AIR LLC	N	5COA			
MAINE HELICOPTERS INC	N	ZIFA			
MALONE AIRCHARTER INC	N	Q3SA			ARGUS GOLD
MEMORIAL HERMANN HOSPITAL SYSTEM	N	GVNA			
METRO AVIATION INC	N	HDNA			
MIAMI CITY FLIGHT	N	MFWA			
MOREY AIRPLANE CO INC	N	AZSA			
MOYER AVIATION INC	N	CDHA			
NEACOLA MTN AIR LLC	N	5NMC			
NORTH DALLAS AVIATION INC	N	DIXA			ARGUS GOLD

Operator Name	Group	Operator Certificate Number	SMS Documentation		
			IS-BAO	WYVERN	ARGUS
NORTHERN ILLINOIS FLIGHT CENTER INC	S and SP05	NTFA	IS-BAO		ARGUS PLATINUM
PEGASUS ELITE AVIATION INC	S	E0XA		WYVERN	ARGUS GOLD PLUS
PM HELI-OPS INC	N	8PQA			
POLARIS AIR LLC	N	1PKC			
POLASEK HELICOPTER SERVICES LLC	N	4HPA			
POTOMAC AIR CHARTER LLC	N	2P7A			ARGUS GOLD
PRODUCTION AIR SERVICES INCORPORATED	N	5PEA			
RAPID AIR II LLC	N	9RPA			
REDDING AIR SERVICE INC	N	AUMA			
ROCKY MOUNTAIN REMODELING INC	N	9ROC			
ROTORWORKS LLC	S and SP05	R96A	IS-BAO		
RSB INVESTMENTS INCORPORATED	N	S2KA			ARGUS GOLD
SALMON RIVER HELICOPTERS INC	N	SR9A			
SAN FRANCISCO SEAPLANE TOURS INC	N	O2QA			
SANFORD MEDICAL CENTER	N	SVBA			
SCHREIB-AIR INC	N	S31A			

Operator Name	Group	Operator Certificate Number	SMS Documentation		
			IS-BAO	WYVERN	ARGUS
SEBASTIAN AERO SERVICES INC	N	VWKA			
SHEARWATER AIR II LLC	S	1SWA	IS-BAO		ARGUS PLATINUM
SKY NIGHT LLC	S and SP05	K6NA	IS-BAO		ARGUS GOLD
SKYDANCE HELICOPTERS OF NORTHERN NEVADA INC	N	1SYA			
SOUTH BAY HELICOPTER SERVICE INC	N	Y9BA			
SWIFT AIRCRAFT MANAGEMENT LLC	N	7SJA			ARGUS GOLD
SWIFT FORK AIR INC	N	1KEC			
TAVAERO JET CHARTER CORPORATION	S and SP05	BN5A		WYVERN	ARGUS GOLD
TISMA INC	S and SP05	T7IA	IS-BAO		PLATINUM
TOMLINSON AVIATION INC	N	T1NA			
TOTAL FLIGHT SOLUTIONS LLC	N	3T9A			
TRUE AVIATION CHARTER SERVICE LLC	N	5TRA			ARGUS GOLD
VENTURE TRAVEL LLC	N	TQ0A			
VERTICAL LIMIT AVIATION LLC	N	5VLA			
VSC AVIATION INC	N	V88A			
WAK AVIATIONS, LLC	N	4WKA			
WORLDWIND HELICOPTERS INC	N	W3HA			