A Systems Theory Approach for Studying Safety Management Systems for Operations of Small Helicopter Organizations

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Approval Page

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Abstract

Implementation of safety management systems (SMS) in small helicopter entities is not widespread and the variation in different types of missions (segments) in the helicopter industry make this situation very complex. In 2005, industry, government and manufacturers identified as the International Helicopter Safety Team (IHST) set out to reduce the global helicopter accident rates, and SMS implementation was one strategy. What was missing was measuring the effectiveness of SMS as related to incident or accidents (IA), or the relationship of these on operational effectiveness (OE). Small helicopter entities are the most numerous organizations but experience the most IA in this high-risk sector of aviation, and the existence of SMS in these entities is not regulated. Implementing SMS could have a positive effect on OE and IA and this non-experimental study contained a systems theory framework using structural equation modeling (SEM) in a partially mediated model to determine the relationships between three variables. Further, these results support industry initiatives to target the small helicopter segment. This model could also be useful in promoting SMS implementation by justifying the positive effects of SMS integration, and to address the influence of SMS across the industry. Participants included crewmembers of small helicopter entities in the United States. A total of 205 participants were gathered to participate in the study. The findings of the study indicated that (a) safety management systems can predict incidents and accidents; (b) incidents and accidents mediate the relationship between SMS and OE; and (c) incidents and accidents predict operational effectiveness. Future researchers may expand the results of this study by performing aviation-safety-specific research and by identifying operational benefits of the systems approach.

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It is clear that many people in my life created the possibility and opportunity for completion of this lifelong learning milestone; most especially my wife for patience, reason, and moral support, my son and daughter for being cheerleaders. My mother's support made finishing possible. Support from colleagues in academia (Todd Smith), industry (USHST and HAI) guided my efforts, but finally, to my father Dr. John F. Burgess, for it was he who encouraged me early-on and in these last few years, has watched from above and was the inspiration to this journey. Thanks Dad.

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Chapter 1: Introduction

There are crucial issues to resolve for small commercial helicopter entities concerning how safety systems can enhance their organizational effectiveness in context of the high risk for accidents in this industry (Fernández-Muñiz, Montes-Peón, & Vázquez-Ordás, 2009). Safety management systems (SMS) research in the helicopter industry has primarily been focused on safety culture and framework of systems in place (Herrera, Håbrekke, Kråkenes, Hokstad, & Forseth, 2010; Nascimento, Majumdar, & Jarvis, 2012; Winn, Thomas, & Johnson, 2012). The International Helicopter Safety Team (IHST) is an international organization in formal partnership with governments worldwide (Federal Aviation Administration [FAA], 2013; ICAO 2010), that purposefully seeks to reduce worldwide helicopter incidents and accidents and promote safety (FAA, 2013a, 2013b, 2014a; Mitchell & Braithewaite, 2008).

In the United States, the IHST's regional entity, the US Helicopter Safety Team (USHST) partnered with the FAA, the National Transportation Safety Board (NTSB), and industry entities (FAA, 2014b; ICAO 2010). Elements of the USHST, the U.S. Joint Helicopter Safety Analysis Team (JHSAT) and its follow-on, the U.S. Joint Helicopter Implementation Measurement Data Analysis Team (JHIMDAT)(FAA, 2013a, 2013b, 2014a; Mitchell & Braithewaite, 2008) have found that incidents and accidents were significantly higher among smaller helicopter organizations, and they identified the importance of SMS implementation strategies in accident mitigation (JHSAT, 2007, 2011).

The purpose of SMS is to control risk and provide assurance that the control of risk is effective (FAA, 2006, 2009; ICAO, 2005, 2008; JHSAT, 2009; von Thaden & Gibbons, 2008). A recent JHIMDAT report (2014) indicated a significant increase for incident-accident rates in the small, high-risk helicopter personal and private plus instructional and training industry segments. There are limited regulatory requirements for implementation and measurement of safety systems in the aviation industry (FAA, 2006, 2008, 2009, 2010; ICAO, 2005, 2008; von Thaden & Gibbons, 2008).

In February of 2014, the FAA published a new rule primarily directed only at larger commercial helicopter operators for the integration of safety enhancing equipment requirements and processes (FAA, 2014b). The rule may also affect some smaller business entities that often experience challenges with organizational structures and processes critical to their operation (Daft, 2008; Gartner & Shaver, 2012). Small aviation entities are often less structured, often with few airframes, and employ smaller numbers, thus causing fewer people do more tasks (Stolzer, Halford, & Goglia, 2010). In the study of incidents and accidents in smaller operations, it is important to identify the effects of SMS upon these operations and these elements are well suited to a systems theory framework (JHSAT, 2007; Roskop, 2013).

Background

Aviation safety has experienced an evolution over decades of flight and ground operations and in the civil helicopter industry, this evolution is becoming more critical as it is prompted by consistent accident rates (FAA, 2014; JHSAT, 2007). Industry and government interest spawned the initiation of collaborative investigation and the creation of the IHST (ICAO, 2010). The IHST authored SMS implementation strategies and other helicopter specific safety related knowledge (Roskop, 2013), researchers have analyzed implementation, but there is no clear research or doctrine that reports the effect of SMS implementation.

Research concerning SMS in U.S. helicopter operations mostly exists on areas of aviation safety culture, SMS implementation, accident analysis, crew management, human factors, risk management and engineering, risk analysis and perceptions of safety. Safety culture and climate studies have been on the rise since 2000 (von Thaden & Gibbons, 2008). The industries of these studies are equally diverse with research in manufacturing, construction, aviation, health care and others. A firm consensus however, has not been found on the terminology, and relationships within the safety research community (von Thaden & Gibbons, 2008; Wiegmann, Zhang, von Thaden, Sharma, & Gibbons, 2004). In safety research, von Thaden and Gibbons (2008) also identified the lack of a definitive research community that shares safety information. Thus, the challenge remains that safety research and analysis is not well coordinated.

Smaller helicopter industry entities are commonly identified as those with higher risks (JHSAT, 2007, 2011). Small aviation entities are often less structured, with few airframes, and employ smaller numbers of workers that creates an environment where fewer people do more tasks than would be seen in larger company's (Stolzer, Halford, & Goglia, 2010). There appears to be little available research regarding studies on the influence of safety implementation approaches (Fernández-Muñiz et al., 2009). Additionally, review of the literature has not yielded results of such studies specifically in the helicopter industry. In the study of incidents and accidents in smaller operations, it is important to identify the effects of SMS upon these operations (JHSAT, 2007; Roskop, 2013), and these elements are well suited to a systems theory framework.

Statement of the Problem

A general problem exists in that incidents and accidents are known to occur at higher rates within smaller helicopter businesses relative to other segments of the U. S. aviation industry (JHIMDAT, 2014; JHSAT, 2011). In the helicopter industry, incidents and accidents (IA) destroy major assets (Roskop, 2013). This poses serious consequences for smaller entities without the financial stability of a large corporation (Roskop, 2013; Yantiss, 2011), and this may include impacts on operational effectiveness (OE) as defined by their industry competitiveness and economic-financial performance. Across industries such as general aviation, manufacturing, and construction, the relationships between Safety Management Systems (SMS), IA, and OE are not well understood (Fernández-Muñiz, et al., 2009; Mitchell, Sharma, von Thaden, Wiegmann, & Zhang, 2002; Saleh, Marias, Bakolas, & Cowlagi, 2010; von Thaden & Gibbons, 2008). The specific problem in this study concerns the high rate of IAs among smaller helicopter entities and the impact of SMS on IA and OE. Systems theory provides a perspective that can be used to analyze complex interrelated variables such as those related to safety systems and operations within high risk industries (Heylighen & Joslyn, 1992; Stichweh, 2011).

Larger helicopter entities are implementing safety strategies and techniques to reduce risks that impair the organization's operability (FAA, 2014b; Mitchell & Braithewaite, 2008), but frequency of SMS implementation among smaller entities is unknown because the FAA does not require or track these programs (FAA, 2010, 2011a; ICAO, 2009), likely due to the volume of work involved and a lack of federal infrastructure to support the effort this would require. Without additional understanding of these relationships, the rates of IA may continue to be higher within these smaller high-risk organizations. At the time of this study, answers appear limited as to the influence of SMS upon small helicopter entities (JHIMDAT, 2014).

Purpose of the Study

The purpose of this non-experimental, quantitative study was to assess a partial mediation model using structural equation modeling to determine if the presence of safety management systems (SMS) predicted operational effectiveness (OE) and incidents and accidents (IA), and if OE was predicted by IA or whether IA mediated the relationship between SMS and OE. A Structural Equation Model (SEM) was used for testing causal relationships (Lei & Wu, 2007) between SMS, the independent variable, and IA and OE, the dependent variables (Figure 1). This methodology consisted of a family of statistical methods, including confirmatory factor analysis (CFA) and path analysis (PA) which was used as is appropriately fit by SEM methods to explain the variation in the relationships between these variables. The variables SMS, OE, and IA were measured as composite variables constructed using surveys that have been previously validated (Chen & Chen, 2012; Fernández-Muñiz,et al., 2009). The population consisted of crewmembers of small commercial helicopter entities in the United States. At least 205 participants were recruited to participate in the study. In SEM analysis, power and sample size are difficult to estimate prior to data collection and model fitting, and the general practice for SEM analyses is to plan for sample sizes of 200 or greater and perform a power analysis as is standard for SEM when the model fit is undertaken (Kline, 2011; Lei & Wu, 2007). This sample was drawn from a U.S. population of crewmembers who have operated in small helicopter firms. The Helicopter Association International membership directory shows in excess of 650 regular organizational members and over 2200 individual members and is one of several sources of industry professionals. The software package SPSS AMOS was used for statistical analyses and SEM.

Theoretical Framework

Systems Theory (ST) is a transdisciplinary framework for describing principles of complex systems in their structure, interaction, and behavior in relation to each other and outside actors (Heylighen & Joslyn, 1992; Johnson, 2005; Nicholson, Schuler & Van de Ven, 1998; Stichweh, 2011). Skyttner (2005) suggested that ST is characterized by the interaction of independent parts. Systems theory has been used to search common principles that are found across distinct and diverse types of systems. These include properties such as adaptive selfregulation and emergent relationships between parts of a system (Hollnagel, 2004; Laarson, Dekker & Tingvall, 2010; Leveson, 2002; Marais, Dulac, & Leveson, 2004). In this study, the relationships between some variables related to safety in the helicopter industry were explored through the lens of systems theory.

As a theory of analysis for complex systems, ST emphasizes the design of the whole not only in its components, but also for its emergent system properties (Leveson, 2004). The variables examined within this study were SMS; a part of the overall safety system of an organization, OE, which is a part of business performance, and IA, occurrences of hazard or loss within an organization. These variables are thought to be interrelated components of safety in aviation organizations. Because safety systems are generally thought to exhibit complex properties, the relationships between these variables may be emergent when viewed as an interrelated system.

An early ST pioneer was biologist Ludwig Von Bertalanffy, who suggested that emerging ideas in different fields could actually be brought together as a general theory of systems (Levenson, 2004). Systems theory spans the fields of engineering, biology, organizational behavior, management, and social science (Hollnagel, Nemeth, & Dekker, 2008; Saleh, Marais, Bakolas, & Cowlagi, 2010; Skyttner, 2005; Stichweh, 2011). In social science studies, ST had been used to analyze socio-political equilibrium (Waltz, 2010) both at macro and micro levels to solve a specific social issue (Colapinto & Porlessa, 2012). Systems Theory had been used also in the analysis of a system within a system (Fernández-Muñiz et al., 2009), particularly in organizational studies that determine the contribution of specific subsystems within the organization to the overall service performance (Chi & Han, 2013; McGuiness, Aasjord, Utne & Holmen, 2013; McGuinness & Utne, 2014; Porter, 1996).

The framework for this study was an extension of Firenze's systems theory model for safety systems (1978). Through the analysis of traditional and evolutionary processes in safety causation, Firenze (1978) determined through empirical means and meta-analysis that there were relationships between three components: human behavior, machine reliability, and accident causation. In this study, the variables of SMS, OE, and IA, were considered likely to have similar relationships to the human, physical and environmental variables as postulated in the work of Firenze (1978). Operational effectiveness in organizations involves interaction between human factors and economic performance (Porter, 1996). Managers or aircrews would make decisions that ultimately affect the economic performance and/or competitiveness of their organization (Porter, 1996). Safety management is related to interaction of human and environmental elements (FAA, 2009, 2010; Firenze, 1978). The goal of the standards and processes of an SMS in the helicopter industry is to create potential interaction between individuals who can prevent occurrences of IA (USJHIMDAT, 2014).

Firenze (1978) explained that systems often contain emergent properties. As an example, he found empirically, that hazards and losses occurred where efforts to control loss through processes were not perfect. Firenze (1978) explained that in dynamic environments where systems exist, new processes must evolve to provide solutions to the changing environment. Further, businesses must be capable of meeting the demands of their environment, their customers, and other organizations. When analyzed in a business, the model in this proposal would likely contain evolving processes with emergent properties prompted by changes in the operational environment (as Firenze empirically found). In the examples Firenze (1978) discussed, systems were composed of several related components of complex systems and their interoperation created new or emergent conditions that could not be predicted. In this model, aviation safety designed systems offer a framework whereby the independent components are brought together in order to study their properties and how the components within this system perform within this structure.

Incidents and accidents (IA) involve human (pilot) and machine (helicopter) fallibility as well as environmental (weather, obstacles, light, regulatory, etc) variability (Authority C.A.S., 2012). Operational Effectiveness involves the elements in place to make the organization competitive, economically and financially viable, requiring proper decision-making (Porter, 1996). Safety management is a set of standards, knowledge, and actions established to mitigate risk (FAA, 2009), and in combination with the elements above, defines the system identified used in this study.

In the reviews of the literature of safety in high-risk industries, Leveson (2002) and Hollnagel (2004) concluded that accidents can be considered an emergent phenomenon in that accidents emerge from the interaction of other variables within the system. By using a ST approach, there is evidence to suggest that complex interactions lead to accidents (Firenze, 1978; Hollnagel, 2004; Leveson, 2002). In this study, intuitive relationships were found using diagrams and models such as in Figure 1 and this is shown by others (Bertalanffy, 1972; Hollnagel, 2004; Leveson, 2002, 2004; Marais, Dulac & Leveson, 2004). Diagrams or systems models can be essential for translating ST in to problem solving when analyzing complex interacting systems.

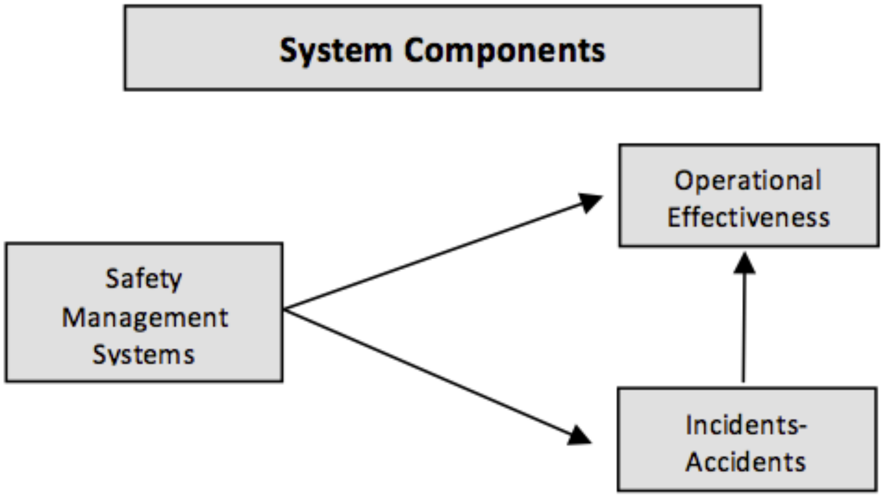

Figure 1. Adaptation of Firenze's (1978) model based on systems theory with three variables; Safety Management Systems, Operational Effectiveness, and Incident-Accident Potential.

Research Questions

The following research questions were addressed in this study:

Q1. To what extent, if any, do safety management systems predict operational effectiveness, and incidents and accidents?

Q2. To what extent, if any, are incidents-accidents a mediator of the relationship between safety management systems and operational effectiveness?

Q3. To what extent, if any, do Incidents and Accidents predict operational effectiveness?

Hypotheses

Correspondingly, the following hypotheses were tested in this study:

$H1_0$: Safety management systems do not predict operational effectiveness.

$H1_a$: Safety management systems predict operational effectiveness and incidents and accidents.

$H2_0$: Incidents and accidents do not mediate the relationship between safety management systems and operational effectiveness.

$H2_a$: Incidents and Accidents do mediate the relationship between safety management systems and operational effectiveness.

$H3_0$: Incidents and Accidents do not predict Operational Effectiveness.

$H3_a$: Incidents and Accidents predict Operational Effectiveness

Nature of the Study

This quantitative research study was an examination into the relationships between SMS, OE and IA using structural equation modeling (SEM). Using the systems analyses techniques of SEM, the testing of statistical model fits for all variables occurred simultaneously. Using SEM, it is possible to examine the directionality of relationships between the variables and the variation and co-variation of variables to determine the best methodological fit. The interrelated multi-dimensional variables present in the model in Figure 2 are parts of a system of dynamic relationships that can be analyzed using SEM analyses techniques (Bentler, 2010; Kline, 2011; Ullman, 2006). As observed from Figure 2, variables related to helicopter safety systems are complex and directional. A quantitative design allows the analyses of complex relationships between variables. The SEM family of techniques includes path analysis [PA] and factor analyses, and this study included a diagram (Figure 1) of relationships between variables to be tested using the appropriate combination of techniques (Kline, 2011).

Structural equation modeling techniques begin with intuitive inferences concerning dependent relationships between variables (Kline, 2011) that are typically designated within schematic models (Figure 3). To explain the variation in the relationships between the variables of interest, SMS, OE, and IA (Bentler, 2010; Herda, 2013; Kline, 2011; Ringle, & Sarstedt, 2010; Lei & Wu, 2007), CFA and PA were used simultaneously in making causal inferences. However, Confirmatory Factor Analysis was used to independently test latent constructs. Path Analysis was used to identify structural relationships (Hair et al., 2011), and testing of directionality (Kline, 2011).

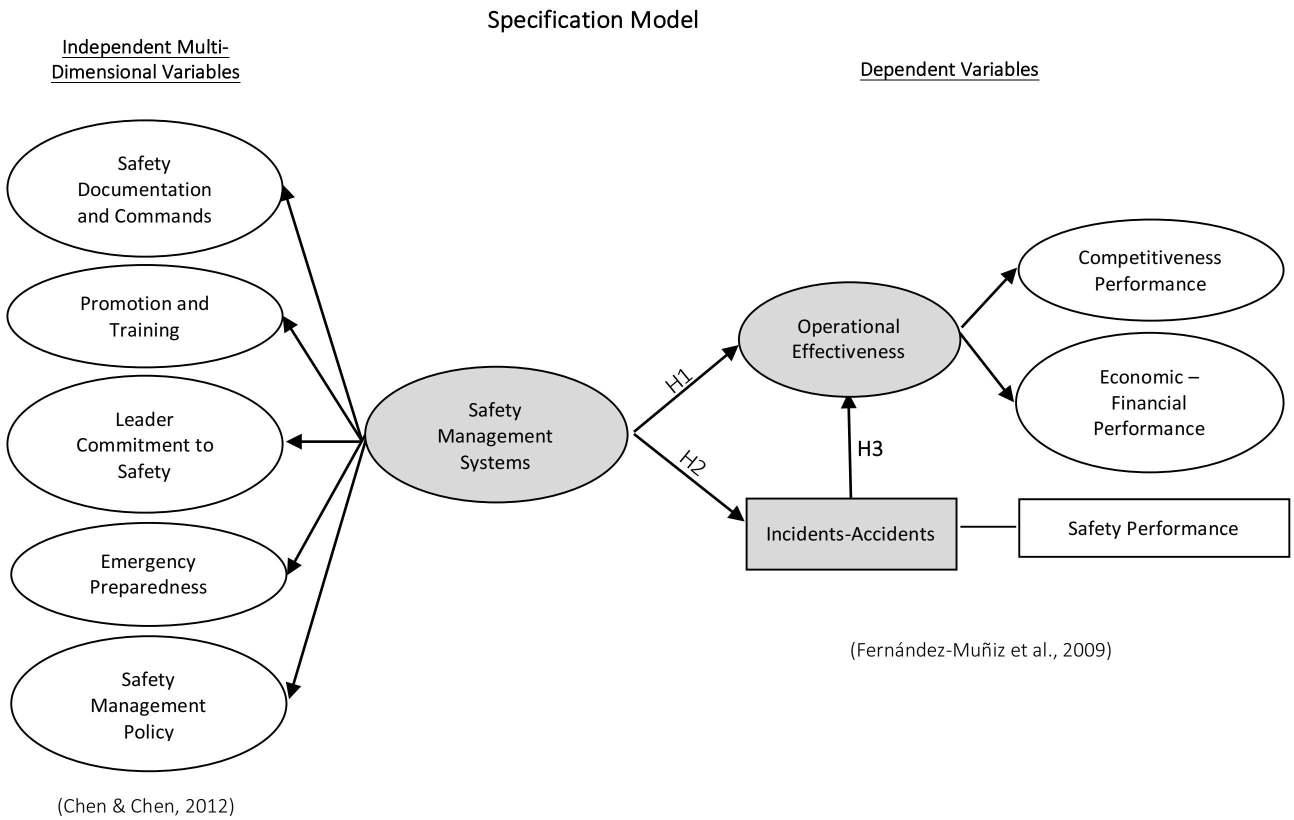

Figure 2. System components and hypothesized relationships are identified in this SEM specification model. The far left column shows SMS constructs from Chen and Chen (2012) as the independent multi-dimensional variables of SMS (defined below). Far right column represents dependent variables derived from the model by Fernández-Muñiz et al. (2009) (defined below).H1= the relationship of SMS to OE; H2= the relationship between SMS and IA; H3= the relationship between IA and OE. The systems theory components are adapted from Firenze's systems theory model (1978), and are defined in the text. Hypotheses are indicated on pathways between components.

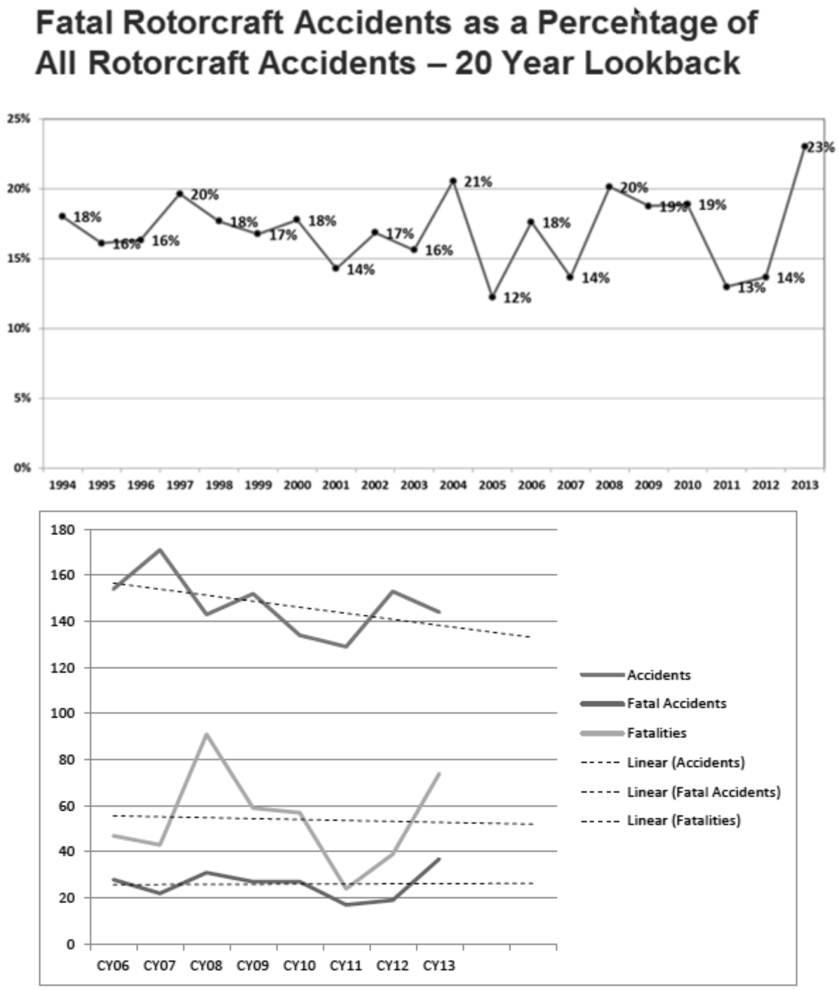

Figure 3. These figures are from the FAA Aviation Safety, Aircraft Certification, and the Rotorcraft Standards staff and come from the Rotorcraft Safety Initiative (FAA, 2013), which accompanies the IHST reports at ihst.org

Significance of the Study

Since 2010, entities in the helicopter industry have developed strategies to lower accident rates and this is seen in the work of the IHST (JHSAT, 2009), and recently the USHST (JHIMDAT, 2014). Accident analyses, comparative studies and reports, and related training and educational materials are all the purposeful efforts of the organizations, which include government, industry, manufacturers and concerned aircrew (FAA, 2013d). Unfortunately, there continues to be high fatal accidents and fatalities though the total accident numbers appear to be trending downward (FAA, 2013d).

Safety management systems are present in aviation, but their effectiveness is assumed. No accidents in an entity could mean that SMS works; however, aviation safety research found in the review of literature is present from a cultural perspective, lacking in the actual study of the effectiveness of safety systems and their direct relationship to elements such as incidents and accidents, or the effectiveness of a business because of an implemented safety system (Herrera, Håbrekke, Kråkenes, Hokstad & Forseth, 2010; Nascimento, Majumdar & Jarvis, 2012; Mitchell & Braithwaite, 2008; Tiamfook-Morgan et al., 2008; Winn, Thomas & Johnson, 2012). These relationships appear to be taken for granted.

The consideration in this study was that empirical testing of the relationships described above could enhance a layman's perceptions of SMS to further define its utmost importance, and these results could contribute to a much needed improvement of accident trends. This could be possible through publication of the results of this study to the rotorcraft industry. The results may also contribute to broader application of SMS in industry areas where SMS is not prevalent, and quite possibly contribute to a lowering of typically high insurance rates for entities who integrate safety management strategies. There is an intuitive relationship between safety systems, incidents and accidents, and the effectiveness of an entity. Not conducting this study to confirm or deny these relationships may contribute to the continued increase in fatal accidents and fatalities.

Definition of Key Terms

The topic associated with this concept paper contains specific industry associations not found in other parts of the aviation industry, but have direct relationship to issues and actions of discussion.

Accident/ mishap. Common terms associated with the departure from a normal condition. Accidents are unplanned and can include a series of events. They often result in damage, through and up to including death. They are often characterized as incidents and mishaps (Aviation Glossary, 2013; IHST, 2009).

Entity. For the purpose of discussion in this study, the term entity was used to identify a business operation and in context, was normally aligned to identify helicopter operations. The size of helicopter operations examined in this study was identified as less than five aircraft. This could be a single owner operator as an entity (for discussion) using their aircraft for pleasure, personal business, transportation for business, or other personal work or business. This could also be a small two-ship business entity conducting ranching operations. This term may also be used to describe the operation of single or multiple helicopters for the purpose of business, and operating under specific federal aviation regulations that are or are not deemed commercial (such as FAR Part 91). The FAA rulemaking (2014) regarding helicopter operations addresses the definition of small helicopter entities from the U.S. Small Business Administration and use the North American Industry Classification System (NAICS) codes. Additionally, the Internal Revenue Service discusses business structures that include numerous forms organizing (IRS, 2014).

Federal Aviation Administration (FAA). The FAA regulates provisory custody for safety, environmental responsibility, global leadership and efficiency of the U.S. aerospace system (FAA, 2010).

Federal Aviation Regulations (FAR). According to the Code of Federal Regulations, Title 14, Aeronautics and Space, Volumes 1-3, Parts 1-199, the FARs are an annual database or repository for all federal documentation relating specifically to the regulatory aspects of civil aviation in America (FAA, 2014c).

Helicopter Association International (HAI). A member affiliated organization providing services and support to the international helicopter community since 1948. HAI directs efforts in the promotion of the industry as a trade association primarily. Efforts include lobbying in Washington, D.C., safety enhancement, promotion of all helicopter related education, professionalism and economic viability. HAI supports and promotes FAA and IHST information to the international helicopter industry (FAA, 2014b).

High-reliability. Industries like rotary-wing aviation operate in a high-risk environment where aircraft regularly operate close to obstacles, in inclement weather and in limited visibility and light conditions. Mainly large aviation organizations are those who apply resources and effort to maintain high levels of safety. These are high-reliability organizations (HRO). The trend within HRO's is the use of resilience engineering and systems approaches to SMS (Herrera et. al, 2010; IHST, 2011, 2014; Lofquist, 2010).

Incident. An incident is often confined to an episode where there was a near miss. This is also unplanned and could have resulted in an accident. This also indicates that a hazardous condition exists (FAA, 2010; FAA, 2014b).

Instructional and training. In this high-risk small entity segment of the helicopter industry, flight crew training is the primary mission for instructional flights that include both ground and flight instruction (FAA, 2014b; JHSAT, 2007). Students at flight schools have been progressing in initial through commercial flight training in small, light-weight, less complex helicopters (primarily with reciprocating engines) in small flight school/training entities. These less-complex aircraft, if not flown properly, can be harder to control.

International Civil Aviation Organization (ICAO). The ICAO is an agency affiliated to the United Nations, which was created in 1944. Their charter is the promotion of safe and orderly development of worldwide civil aviation. ICAO sets standards and regulations for aviation that allow for conduct of safety, security, efficient operations, regularity, and environmental protection. There are 191 countries/states as members (ICAO, 2013).

International Helicopter Safety Team (IHST). The IHST is a volunteer international organization formed in 2005 after an international safety symposium in Montreal. As a result, the organization formed as a partnership with industry safety experts and government regulators specifically to coordinate efforts to address the worldwide helicopter accident rates. The IHST chartered two teams to carry out the work, the U.S. JHSAT team, reformed today as the JHIMDAT, and tasked with data analysis of helicopter accidents for recommendations; and the U.S. Joint Helicopter Safety Implementation Team (JHSIT), tasked for the application of JHSAT recommendations into plans to implement safety enhancements in the industry. In March of 2013, the IHST began to separately form an American entity called the US Helicopter Safety Team (USHST). The JHSIT and JHIMDAT groups became subordinate entities to the USHST. Globally, regional teams support the efforts with partner countries from North America, Europe, South America, the Middle East, Oceana, Asia and Africa. All teams worldwide consist of industry and government members to conduct this work (FAA, 2013; ICAO, 2010; Roskop, 2013).

Mission/flight operation. This term identifies an activity and appears throughout many official aviation texts. Missions, flights, flight operations are generally tasks combined with a purpose, which is clearly defined with a predetermined conclusion (Department of Defense, 2012; Headquarters Department of the Army, 2007). This term can also connote aircraft that are airborne and is used in various forms in the FAA text Pilot's Handbook of Aeronautical Knowledge (FAA, 2008).

National Transportation Safety Board (NTSB). The NTSB is a subset of the U.S. Department of Transportation. The board is charged with the maintenance of independent, objective accident investigation, safety studies, and certification appeals for transportation of professionals. They fulfill an advocacy for safety in transportation, and assist those affected by transportation accidents. The board works with and responds to requests from the IHST for support (FAA, 2014b; NTSB, 2013).

Operator. An operator can be described as a pilot performing as a principal of his own one aircraft operation. This term can also be attributed to the FAA designation of an Air Operator Certificate that is further broken down into categories such as aerial surveying, firefighting, and air ambulance. Typically, the term operator is also referred to in the helicopter industry as an entity or business that conducts helicopter flight operations (FAA, 2014b).

Operation. Common aviation vernacular refers to the organization or entity responsible for the production of flight operations. This is also termed as 'operational control' by ICAO and the U.S. military. Operations are the vehicle by which authority is exercised over the planning, conduct and completion of an actual flight or mission. In the term operator, this refers to the organization or entity responsible as a body for the conduct of missions or flight operations (ICAO Aviation Glossary, 2013; FAA, 2014b).

Operational Effectiveness. Operational Effectiveness is the application of work activity in an organization that includes functions to enhance performance (specifically as used in this study, competitiveness and economic-financial performance). These functions must fit the entity and its operation and allow for the implementation of strategies to improve an entity's performance. Continually improving functional performance can occur by reducing defects (Porter, 1996).

Personal and private. These high-risk small entity flight operations primarily consist of privately-owned aircraft and rented aircraft. Aircraft in this helicopter industry segment are most often the single-engine (turbine or reciprocating) light helicopters. FAR Part 61.113 (FAA, 2014b) identifies the privileges for the private pilot. These flights are generally non-commercial and operated under FAR Part 91 with little regulatory oversight.

Safety Management System (SMS). The safety management system also known as SMS includes a systematic approach for a group of individuals to manage safety. This may include specific structures within an organization, processes, procedures, technology, and accountability. The term essentially encompasses these components, and appears to be defined in accordance with the associated industry (i.e. aviation, manufacturing, construction). SMS can become a top-down fundamental business process (FAA, 2009, 2010).

Safety culture. There is always an existing thought, value and priority regarding safety in any organization. Safety culture is the level of participation and commitment to which all members of an organization participate. Safety culture also includes a temporal indicator often referred to as safety climate (von Thaden & Gibbons, 2008; Wiegmann, Zhang, von Thaden, Sharma, Gibbons, 2004)..

Summary

Rotorcraft accidents continue to occur at higher rates for small organizations where the presence of SMS is limited. The purpose of this study was to determine whether the variation in incidents and accidents (IA) and operational effectiveness (OE) is explained significantly by an implemented Safety Management System (SMS), and whether variation in IA is explained by the OE, for small high-risk helicopter entities. These elements intuitively appeared interrelated as a system in this analysis. The variables (SMS, OE, and IA) are related from the aspect of risk mitigation, and require measurement to determine their complex relationships.

In the proposed research plan, the three variables of SMS, OE and IA, was studied through the lens of ST using SEM. Structural equation modeling also has broad use across disciplines (Herda, 2013; MacCallum & Austin, 2000). This allowed for the use of statistical techniques to examine causal relationships between multiple independent variables and dependent variables simultaneously. The use of path analysis and confirmatory factor analysis was used to help to validate SEM developed in this study.

Chapter 2: Literature Review

Aviation safety has undergone an evolution over decades of flight and ground operations and in the civil helicopter industry, this evolution in industry practices and technology have not critically affected accident rates, which remain consistent over time (FAA, 2014; JHSAT, 2007). Industry and government interest spawned the initiation of collaborative investigation and the creation of the International Helicopter Safety Team (IHST) (ICAO, 2010). The IHST conducted accident analysis of existing data, then authored Safety Management System (SMS) implementation strategies and other helicopter specific safety related knowledge (Roskop, 2013). Researchers have analyzed SMS implementation; however, in my process of conducting this literature review, no empirical reports were found on the effect of SMS implementation upon incidents or accidents (Ballard, 2014; GAO, 2014; Müller, Wittmer, & Drax, 2014). The purpose of this non-experimental quantitative study is to assess a partial mediation model to determine if the presence of safety management systems (SMS) predicts operational effectiveness (OE) and incidents and accidents (IA), and if OE was predicted by IA or whether IA mediates the relationship between SMS and OE. This literature review starts by establishing the background of safety management systems research and analysis, targeting aviation disciplines, and more broadly to compare and contrast to identify gaps. Understanding the status of safety and safety management in the helicopter industry where accidents and incidents happen, and what has been done about it in the last several years help established a foundation that supported this research to determine the effectiveness of SMS. The utility of safety systems in business operations must be reviewed to help set conditions to evaluate the variables presented above. The establishment of safety systems and doctrine where it exists in the helicopter industry must be understood to identify its diversity, determine its levels of implementation within organizations, and identify its promotion.

Documentation

This literature review entailed the use of a collection of online library databases at Embry-Riddle Aeronautical University and Northcentral University. Additionally, the use of the author's extensive aviation on-site library was accessed. General internet searches were also conducted and all online work was supported using Google Scholar, and Crossref.org. Searches conducted were first intended towards scholarly journals, as well as other peer reviewed content. Key terms in the searches were directed towards aviation safety, safety management systems, systems theory, helicopter safety, incidents and accidents, accident analysis, aviation rulemaking, safety reporting, operational effectiveness, aviation technology, safety strategies, SMS implementation, safety culture, safety promotion, risk management, human factors. While countless searches rendered abundant results, the most relevant results were applied in this study.

This literature review is organized to promote the direction of the research and contains eight essential themes: SMS research and analysis, SMS in the helicopter industry, helicopter industry safety focus, incidents and accidents and reporting, SMS in business, technology and safety strategies, SMS promotion, implementation and culture, and finally SMS doctrine. This structure takes the line of thought on the deployment of SMS in the aviation industry and most specifically, the helicopter industry and even further down to the small sized organizations. The literature takes into account how systems approaches, safety research and analysis are employed and their actual and perceived effects within the industry and many segments therein, and considers ancillary factors bearing on the problems associated with safety, incidents and accidents.

Safety Management Systems Research and Analysis

Research concerning SMS in U.S. helicopter operations is mostly focused on aviation safety culture, SMS implementation, accident analysis, crew management, risk analysis and perceptions of safety (Herrera et al., 2010; Nascimento, Majumdar & Jarvis, 2012; Mitchell & Braithwaite, 2008; Tiamfook-Morgan et al., 2008; Wiegmann, Zhang, von Thaden, Sharma, & Gibbons, 2004; Winn, et al, 2012). There has been an increasing number of studies on safety culture since the 1990's (Antonsen, 2009; Chow, Yortsos & Meshkati, 2014; Guldenmund, 2000; Heese, 2012; Helmrich, Merritt & Wilhelm, 1999; von Thaden & Gibbons, 2008; Wiegmann et al., 2004; Zhang et.al., 2002), and studies focus on diverse topics such as risk management, human factors, management and engineering. The industry contexts of these studies are equally diverse, with research in manufacturing, construction, aviation, health care and others.

There are no commonly established definitions for safety culture and climate, and the relationship between these two concepts has not been empirically defined as well (Pessemier & England, 2012; von Thaden & Gibbons, 2008; Wiegmann, Zhang, von Thaden, Sharma, & Gibbons, 2004). Safety culture and safety climate are terms that appear broad and dynamic (Patankar, Brown & Sabin, 2012) and in some respects, challenge consensus as they are meant to address similar dimensions (attitudes, beliefs, behavioral norms, and organizational context) as they are applied to different industries (Pessemier & England, 2012). As an example of a broad view, the International Civil Aviation Organization (ICAO) Safety Management Manual (2013) identifies that a safety culture as that which seeks to improve safety, has awareness of hazards, and uses systems and tools. The JHIMDAT (2014) of the IHST, and the Rotorcraft Directorate of the FAA form a few of the organizations performing definitive rotorcraft safety research and address definitions and organize the safety research and analysis processes and standards in the context of only their efforts (IHST, 2011). Thus, the challenge remains that the practices of aviation safety research and analysis efforts are not well coordinated (von Thaden & Gibbons, 2008). In the helicopter industry there was one series of related safety research and analysis efforts, however this was not a coordinated function. In 2006, the IHST started their efforts by using the model designed by the Commercial Aviation Safety Team (CAST) who began their efforts in 1998 (Stolzer, Halford & Goglia, 2010). The CAST was formed as a group of commercial aviation entities of manufacturers, industry, employees and observers (CAST, 2009). Their goal is stated as a reduction of fatal accidents in the commercial aviation industry by half from 2010 to 2025 (Rohn, 2012). The model developed by the CAST was specifically designed for the commercial airline industry (Stolzer, Halford & Goglia, 2010). The CAST effort was followed by the IHST for the helicopter industry however there is no evidence that this was a planned or coordinated effort.

The lack of coordinated effort in safety research has driven industries to assume the task of coordinating their own collaboration, and devising methodologies to fit the research and analysis needs of their participants. As an example, the National Institute for Occupational Safety and Health (NIOSH) works with the Occupational Safety and Health Administration (OSHA) in a common effort to protect worker health and safety, yet the FAA is responsible for issuing and enforcing safety regulation (Rodrigues & Cusick, 2012). In 2005, there was an effort on behalf of the worldwide helicopter industry with the inception of the IHST. The IHST was formed as a partnership with the FAA, manufacturers, industry organizations, and helicopter operators (FAA 2013; ICAO 2010). Accident rates for helicopters worldwide from 1995 through 2005 averaged 570 per year and trended upward (IHST, n.d.). This was one of the reasons for the creation of the IHST. An industry organization, the International Association of Oil and Gas

Producers (IAOGP), has collected data to produce a Risk Assessment Data Directory (RADD). While membership is not mandatory, the reporting and collection of information is left to the constituents' willingness to participate, which the RADD identifies. The OGP effort, while aligned with the greater civil helicopter industry is admirable, however the fact remains that there is a lack of collective efforts on a global scale and complete data collection remains a challenge. There have been challenges with the data collection worldwide in obtaining the true amount of flying hours to identify the accident trend numbers since 2005, but the IHST stresses that their analysis holds to a 2% decline, which they still deem unsatisfactory (JHIMDAT, 2014).

In the United States, the FAA initially had limited rulemaking, i.e. the process of developing regulations, which specifically targeted helicopter safety; however the increasing number of accidents prompted the creation and follow-on research and analysis by the IHST since 2007 (JHSAT, 2011). Accident investigations by the NTSB that ruled accidents as preventable, subsequently prompted increased rulemaking. The best examples of this are recent NTSB aircraft accident reports on the 2009 New Mexico State Police accident (NTSB, 2011) and the 2008 public service (firefighting helicopter) crash investigation (NTSB, 2010). These two helicopter accidents were determined to be preventable and yet the NTSB reports highlighted that safety systems problems were present in the industry. A notice for proposed rulemaking followed these accident investigations closely, yet beyond the very detailed NTSB reports, little research and analysis has been performed (FAA, 2014b) into the major contributing factors, which were systemically occurring in the industry.

A comprehensive scale to measure the most important dimensions of SMS was derived by two Taiwanese aviation safety researchers (Chen & Chen, 2012). Their goal was to develop an aviation centric, SMS measurement scale. They used a three-stage scale-development procedure (Schwab, 1980) to identify a method to measure the performance of an airline SMS program through a sample of aviation managers from various sized organizations. Schwab determined that his scale development approach is effective when the theoretical foundation is strong (Schwab, 1980). Best scale development practices were found to include correct sampling of the material for testing subjects (Schriesheim, Castro & Cogliser, 1999). Conceptual development, that is the effort to measure specified constructs adequately, may be best supported by strong scale development research according to Wymer and Alves (2012). They indicate the importance of adequate empirical research and not a purely statistical approach. A measure will not function appropriately if the variable is improperly defined, and relying purely on statistical methods is not the only procedure in the process (Wymer and Alves, 2012). Chen and Chen (2012) shared this philosophy in their scale development.

Past research concerning SMS in U.S. helicopter operations had been focused mostly upon aviation safety culture, SMS implementation, accident analysis, crew management, risk analysis and perceptions of safety. More recently, Chen and Chen (2012) identified the need for a comprehensive scale to measure the most important dimensions of SMS. Their goal was to develop an aviation centric, SMS measurement scale. They developed a method to measure the performance of an airline SMS program by sampling aviation managers from various sized organizations. Their scale can be used to obtain perspectives on aviation safety from members of an aviation organization across different levels of expertise, and the scale was devised to acquire information concerning organizational policies and individual performance. Using this instrument, Chen and Chen (2012) identified the potential utility of SMS implementation in upgrading safety performance; however, they did not directly measure performance as a part of their study. In this study, the relationships between OE, IA, and SMS were addressed at the performance level.

In later work, Chen and Chen (2013) extend the use of safety management scales to study behaviors exhibited by airline cabin crews. Chen and Chen (2013) attempted to develop an integrated model to explore various effects on cabin crew safety behavior. Similar to their previous study, the authors examined organizational factors, but in the newer study they specifically use two sub-constructs of policy and practice. This differs because in the their earlier study the sub-constructs used were documentation, promotion and training, management commitment, emergency response, and safety policy. The differences in the two studies may offer more perspective in the analysis of SMS performance relationships. The work by Chen and Chen over the last several years (2012, 2013) in aviation SMS scale developments lend support to this study with regard to studying the relationships between OE, IA, and SMS. Their work is extended in this proposal by adding the measurement of SMS performance on an entity.

Fernández-Muñiz et al. (2009) assessed the effect of implementing SMS on a business entity, specifically the influence of accidents on the operation, including competitiveness, economic-financial performance, and safety performance. A confirmatory factor analysis was performed on the latent variable of SMS explained by six constructs, then examined to identify if SMS had a positive influence on the variables of performance areas of safety, competiveness and economic-financial. They found that there were positive effects of safety management upon safety performance in a non-aviation sector of business. Their variables of competitiveness performance (indicated by quality, productivity, innovation, customer satisfaction, and reputation) and economic-financial performance (indicated by market share, profit margin, and profitability) were adapted and defined as OE in this study. These variables were originally and similarly defined by Porter (1996) who referred to OE as exceeding the performance of competitors engaged in similar activities, and effective economic-financial performance as that which enables an organization to reduce deficiencies and deliver higher quality. Considerations are present in their study to similar discussions in the US helicopter industry (FAA, 2014; JHSAT, 2007) regarding expenditures on safety which directly relate to business objectives of profit and competitiveness. The initial JHSAT analysis in 2007 identifies a challenge with regard to safety investment areas and the need for cost effective measures to be taken within the entire industry.

The Fernández-Muñiz et al. (2009) study differs from Chen and Chen (2012) by their study of components that may have been previously separated in an aviation safety study. They examined if SMS had a positive influence on performance for safety, competeviness and economic-financial elements, which Chen and Chen did not do. They studied the influence of safety management on safety performance in a non-aviation discipline, and while they did not directly measure incidents-accidents, they did measure injuries and damage, and injuries and damage have a direct correlation to incidents-accidents (Khanzode, Miati & Ray, 2012).

In relation to systems theory, Fernández-Muñiz et al., did not extend their study to examine variables specifically related as in a system. Their variables of competitiveness performance and economic-financial performance variables were adapted to test OE in this study as they are similar in nature to the seminal work in OE by Porter (1996). Porter referred to performance of activities better than rivals in the same task, akin to competitiveness, and practices that allow an organization to reduce defects or deliver higher value at lower cost, akin to economic-financial performance. The FAA's 2014 ruling discussed herein does not express the methodology of the FAA competitiveness analysis, but highlights the results and are only related to the HAA missions. The available information indicates the RFA includes limited analysis of relationships between the variables as in the study by Fernández-Muñiz et al. (2009), and only focuses on HAA operations within an otherwise broad industry. There are expected to be variations in relationships present in a complex system (Laarson, Dekker & Tingvall, 2010). The associations presented in this proposal regarding individual components using a system theory approach (Firenze, 1978) with SEM, bring together the work by Fernández-Muñiz et al. (2009), and Chen and Chen (2013) in a way not yet attempted in SMS research and analysis.

Systems theory is a perspective through which the information about a system is analyzed and interpreted (Leveson, 2002). Aviation safety doctrine provides a basis for analysis, interpretation, and actions for risk management, reduction of human interference and hazard identification through which entities can reduce the possibility of human or property damage or maintain them to acceptable levels (ICAO, 2009; Reason, 1990; von Thaden & Gibbons, 2008). Safety theory provides a lens through which complex subsystems in aviation such as culture, probable accident causes, human factors safety issues, and safety management can be understood (Herrera et al., 2010; Leveson, 2002; Nascimento, Majumdar & Jarvis, 2012; Mitchell & Braithwaite, 2008; Tiamfook-Morgan et al., 2008; Wiegmann, Zhang, von Thaden, Sharma, & Gibbons, 2004; Winn, et al, 2012). Therefore, the analysis of safety systems through a systems approach was sought to determine its benefits. Much of the reviewed aviation safety research contained studies of these complex sub-systems, and there was no consensus for a theoretical framework from which to analyze the effectiveness of SMS (FAA, 2006; ICAO, 2013).

Chi and Han (2013) demonstrated the weakness of safety aviation research in the context of the analysis of systems and subsystems in the SMS. Chi and Han (2013) incorporated a systems theory approach to study the relationships between accident causation and risks in the construction industry. Their research objectives were two, first, to understand relationships between the variables of accidents and elements of injuries (level of injury, body part injured, and type injury) and the nature of injuries by type accident. Their second objective was to understand relationships between accidents and variables of human, mechanical, and physical risk factors. Chi and Han (2013), through an analysis of over 9000 construction accidents, provided evidence that there were interrelationships between risk and causation. The model for their study incorporated a combination of Firenze's (1978) systems theory model (injury source, environmental conditions, and worker behavior), and Heinrich's (1941) domino theory, which stated that an accident is but one factor in the sequence leading to injury. Their goal was to prioritize risks to determine the likelihood of accident occurrence. However, Chi and Han (2013) did not explain the variation of IA and OE in relation to SMS. The work of Chi and Han (2013), was an extension of the research works made by Heinrich (1941) and Firenze (1978). Meanwhile, Firenze's (1978) ST approach articulated the relationships between human behavior, machine reliability, and accident causation. Using these evidences, there is a strong argument that the work of Chi and Han (2013) (with accident causation and risk) and Firenze (1978) can be combined to hypothesized relationships of SMS, OE and IA within a new model.

In another construction industry safety study of how certain components influenced safety performance, Khosravi, Asilan-Mahabadi, Hajizadeh, Hassanzadeh-Rangi, and Behzadan (2014) developed an SEM model to hypothesize several relationships. They hypothesized that a general safety climate would have a significant effect on individual features of safety motivation and prohibition, and safety attitudes and beliefs. Their second hypothesis was that the general safety climate would have a significant effect upon safety performance features of psychological conditions, and accidents and near-miss engagements. The final hypotheses tested the relationship between the individual features (safety motivation, prohibition, and attitude and belief) and the safety performance features (accident and near-miss engagements). Khosravi et al. (2014) concluded that structural models can be used to provide test relationships between safety related indicators (that is climate, human factors, and occurrence). This further provides support to use SEM to determine relationships between variables related within SMS in high-risk operations.

In their association with the FAA, von Thaden and Gibbons (2008) studied safety culture using a sociotechnical systems approach to safety. A sociotechnical systems approach involves complex relationships between organizational and regulatory systems and interactions of technology, environments and humans. They developed safety culture indicator scale measurement system (SCISMS) as a tool for exploring complex safety relationships between human social interactions and technical systems. The SCISMS measurement process was developed to provide standard metrics to predict outcomes within the safety culture of organizations but it does not allow for an assessment of the effectiveness of an SMS as related to other essential variables such as operational effectiveness, or incidents-accidents that are emphasized in this proposal. Aviation business, management and culture remain as important components to be examined using ST due to their complex interrelationships (von Thaden & Gibbons, 2008). In this study, the researcher extended past studies on social/human and cultural factors to determine complex interrelationships resulting from SMS implementation, which von Thaden and Gibbons (2008) chose not to review. Beyond explaining the interrelationship of these variables, in the present study structural equation modeling was used as opposed to the traditional approaches utilized by previous researchers.

In their association with the FAA, von Thaden and Gibbons (2008) studied safety culture using a sociotechnical systems approach to safety. A sociotechnical systems approach involves complex relationships between organizational and regulatory systems and interactions of technology, environments and humans. They developed safety culture indicator scale measurement system (SCISMS) as a tool for exploring complex safety relationships between human social interactions and technical systems. The SCISMS measurement process was developed to provide standard metrics to predict outcomes within the safety culture of organizations but it does not allow for an assessment of the effectiveness of an SMS as related to other essential variables such as operational effectiveness, or incidents-accidents that are emphasized in this proposal. Aviation business, management and culture remain as important components to be examined using ST due to their complex interrelationships (von Thaden & Gibbons, 2008). Past studies on social/human and cultural factors were used to determine complex interrelationships resulting from SMS implementation, which von Thaden and Gibbons chose not to review. Beyond explaining the interrelationship of these variables, in the present study, structural equation modeling was used as opposed to the traditional approaches such as descriptive statistics, or regression analysis, etc. Previously, safety culture surveys would be used to evaluate safety program and safety culture efficacy (Gibbons, von Thaden & Weigman, 2006).

Remawi, Bates and Dix (2011) studied the relationship between the implementation of SMS and attitudes of employees at airports regarding unsafe acts in aviation. They hypothesized that successful implementation of an SMS program at an airport would result in a measurable improvement of the safety culture (attitudes toward safety). Through study, the authors revealed the implementation of SMS on organizational culture influenced employees' level of security knowledge, which significantly affected employee attitudes towards safety. Their work informs the field on the effects of an SMS upon the attitudes of employees toward unsafe acts but not on variables related to business performance and the impact SMS could contribute to employees' accidents. This limitation motivated this proposed study.

In 2010, Lofquist accomplished a three-year longitudinal case study and meta-analysis to analyze effects of organizational change on safety outcomes in high-reliability organizations. In his mixed-method study, Lofquist (2010) used SEM and examined the effects of rapid, deliberate change on perceptions of safety in an SMS implementation. Lofquist (2010) used embedded case studies of air traffic controllers to design safety management models. In the study, Lofquist (2010) found that organizations undergoing rapid change viewed accidents as opportunities for evaluations of the safety culture. This finding is consistent with the conclusions made by previous scholars (Reason, 2006; Weick & Sutcliffe, 2006). Further, the conceptual SEM model Lofquist (2010) used included variables of perception and commitment. These variables are broadly linked to aviation safety culture (von Thaden & Gibbons, 2008).

In his literature review, Lofquist (2010) explained that safety management research had been conducted primarily through the perspectives of psychology, sociology, and engineering, and distinctions can be found across these various fields in how safety and safety cultures are defined and measured. Lofquist stated there was a gap between traditional safety management processes that could be filled through more proactive and reactive safety management measures. His conclusion was supported by an analysis of studies on historical events which led to the determination of the need for SMS in HRO's to contain proactive, interactive and reactive measures within in an SMS to determine the systems true safety state (Gehman, 2003; Perrow, 1984; Snook, 2002; Weick, 1993).

Larger, high-reliability helicopter entities are engaged in higher levels of safety with fully implemented SMS programs (FAA, 2014b), but there is evidence SMS is not widely implemented in smaller helicopter entities (JHSAT, 2014). Lofquist used SEM in generating evidence for the relationships between leader commitment, attitude toward change, and safety climate. However, the Lofquist study is limited in analyzing SMS in HRO/low-risk industries. Loquist's (2010) analyses indicated that there is a gap in research concerning high-risk industries during organizational change and safety outcomes from catastrophic events.

In the third iteration of a major helicopter safety study that spans nearly 50 years of operations for offshore operators in the Norwegian oil industry, The Foundation for Industrial and Technological Research (SINTEF), a Scandinavian independent research firm established a comprehensive analysis of risk quantification and safety improvement. This peer-reviewed study coordinated by the Norwegian oil industry and in conjunction with researchers, industry experts and the Norwegian Civil Aviation Authority (Herrera et. al, 2010) included research into risk quantification methodology and risk analysis estimates. These data revealed a very safe segment of the helicopter industry; researchers recommend measures for minimum safety improvement. Their findings support the assessment that larger corporate entities have and continue to invest in SMS implementation (Saleh, 2010). The SINTEF results lend support for the need to conduct similar SMS assessment in the smaller segments of the helicopter industry where most of the incidents and accidents are occurring (JHSAT, 2014).

In the FAA 2014 rulemaking for helicopter air ambulance (HAA) operations, commercial helicopter and helicopter flight operations, commentary proffered by leaders in the industry addressed the increased expenditures necessary for the implementation of helicopter safety contained in the new rule. While many of the comments in the final rule are directed at hardware integration, the rule requires implementation of safety procedures, advanced hardware for aircraft, revised pilot testing, and flight based weather requirements. The majority of comments in this rulemaking came from large corporate entities with adequate resources to address the safety expenditures estimated at $100 million annually (FAA, 2014), though clearly, smaller entities will feel the impact in areas like training, leadership and quality control as implied by von Thaden and Gibbons (2008). In the period between the FAA Notice for Proposed Rulemaking (FAA, 2010) and the final rule, the aviation industry was invited to provide commentary as a regulatory requirement in support of or against the proposed rulemaking. The analysis and commentary provided by industry entities did not directly address competitiveness or economic performance (FAA, 2014) as was done in the Fernández-Muñiz et al. (2009) study, though the FAA (2014) implied that new rules could provide enhancement in safety performance. In development of the new FAA rule (2014), and included in the ruling documentation, there was discussion on economic factors, which suggested the need for analysis of regulatory influences on small entities. The FAA conducted a regulatory flexibility analysis (RFA) and determined there was a significant economic impact from this ruling on a large number of small helicopter entities (FAA 2014b). The FAA claimed in their analysis that the typical economic significance threshold is a 2% annual compliance cost, however, the FAA chose to lower the threshold to 1% in this action without justification. The FAA concluded that small air ambulance entities would potentially incur compliance costs to annual revenues in the range of 1.76 to 1.87 percent which they determined to be significant. The RFA is mandated by the Regulatory Flexibility Act of 1980 to address several factors such as the reason for a rulemaking (such as the high number of accidents in the industry, specifically for helicopter emergency medical operators), and the legal basis (as result of accident rates and those entities affected), and normal reporting, recordkeeping and compliance (FAA, 2014). Other areas in the FAA ruling also address disagreement in some of the FAA findings in how money should be spent regarding aviation safety. There is also discussion in the rulemaking on the affordability for small entities and some discussion on competitiveness that does not appear extensive.

The review of research and analysis of SMS in the helicopter industry is present from many different perspectives and approaches in the interest of incident and accident reduction, risk management, organizational improvement and accountability. Specific research areas focus on aviation SMS implementation, accident analysis, crew management, safety culture, risk analysis and perceptions of safety (Herrera et al., 2010; Nascimento, Majumdar & Jarvis, 2012; Mitchell & Braithwaite, 2008; Tiamfook-Morgan et al., 2008; Wiegmann, Zhang, von Thaden, Sharma, & Gibbons, 2004; Winn, et al, 2012). Safety management research is broadly based across industries and concentrated for larger entities and appears typically limited for smaller entities (Chi and Han, 2013; JHSAT, 2014; Lofquist 2010; NTSB, 2010; von Thaden & Gibbons, 2008). The effort in this genre is decidedly uncoordinated across disciplines (von Thaden & Gibbons, 2008), however appears to garner industry interest (IHST, 2011). This review highlights the broad aspects in safety research and gaps that exist. Safety management system research for smaller entities in the helicopter industry can fill a gap that exists in this industry and across others.

General Industry Helicopter SMS. Aviation safety in general takes its origin from the 1920s where early laws were passed in the Aeronautics Branch of the U.S. Department of Commerce in order to regulate safety. Helicopter operations began in earnest in the 1940s and continued (Fox, 2005). Production increased and the industry experienced successes and challenges in safety related design and technologies by integrating research, development, and safety (Fox, 2005). Early safety actions included design improvements, better pilot training, maintenance and training that are more effective, and evolution in systems and components (Fox, 2005). Safety systems appear to have origins in helicopter operations in the 1950's and 1960's. Safety related articles appear in the first Army Aviation Digest in 1955. In this period, a significant interest was present in determining causal factors or individual action or hardware, and not specific to safety management. During this era, a systems approach began to be integrated with safety (Fox, 2005) but the approach primarily remained in the military (Flight Safety Foundation, 1960). Consider that helicopters were fairly new to aviation in the 1950's, and that their uses in combat roles (Korean War) were new and more frequent than in the civil sector (Chiles, 2007). Hazards were an acceptable component of military aviation and resources abundant. Their development and use evolved and by the Vietnam War, grew exponentially. The integration of safety was applied more so to crash survivability and less so towards systems safety (Fox, 2005).

Of the evolution in safety and systems from early developments and into the 1990s, SMS appears to have remained entrenched in military and air transport industries (Hansen, McAndrews & Berkeley, 2008). Helicopter EMS in the civil sector grew in the early 1980's and using single engine airframes with Vietnam era pilots, and during that time, the accident data began to reflect the need for more integration of safety into the operation (Chiles, 2007). This fact is important in that the civil industry was starting to evolve in the 70's and 80's and led by the experience gained from wartime pilots whose primary experience evolved from a war zone where safety and rules were less strict, sometimes followed, and less important than flying and getting the job done (Chiles, 2007). This environment did not necessarily create a fit for safety management. As one could expect, statistics of civil crashes in this period increased, and necessarily, so did the interest for safety management (Chiles, 2007).

In 2006, Advisory Circular 120-92 Introduction to Safety Management Systems for Air Operators (FAA, 2006) was published and established the FAA recommendation for aviation service provider SMS programs. During this time, the cultural shift towards Safety Management System promotion in the worldwide helicopter industry began in earnest by a consortium of professional organizations, regulators, and helicopter operators (JHSAT, 2007). The advisory circular preceded further development of what helicopter industry SMS programs could consist of and was a resource for what the IHST used to construct their SMS Toolkits. The SMS Toolkit was developed as an organizational SMS document to start and progress through a full SMS program implementation (JHSIT, 2009).

The worldwide efforts with regional partners of the IHST, helped to promote SMS implementation to the industry beginning in 2006 (FAA, 2014a). Early interest in this movement came from those who could afford the investment such as the offshore petroleum industry, and the larger HAA companies. Providing impetus to an FAA regulatory change were HAA accident rates in US civil industry (FAA, 2014b; Frazer, 2009; McGinnis et al., 2007). Accident rates for HAA were the second highest rate for a commercial helicopter operation in JHSAT analysis (2007). In rulemaking published by the FAA (2014b), there were numerous comments received from commercial and HAA helicopter entities that reflect the challenges of SMS implementation and efforts to date.

Other government documents (FAA, ICAO) and industry documentation (of IHST members from corporations, manufacturers, and organizations) were also a resource used by the IHST to construct their SMS toolkits (JHSIT, 2009). The toolkits were published in several languages and specifically for the international helicopter community as an organizational SMS document to start an SMS program (JHSIT, 2009). IHST regional partners indicated on the organizations website include the U.S., Canada, South America, Europe, Middle East/Africa, Asia, Russia/CIS, and Oceana. The worldwide efforts with regional partners of the IHST, helped to promote SMS implementation to the industry beginning in 2006 (FAA, 2014a). Efforts in the U.S. at that time were performed by committees (JHSAT and JHSIT) under the IHST Executive Committee (EXCOM) which is different than regional partner organization. Regional partners had their own EXCOM and the working committees (equivalent to U.S. JHSAT and JHSIT). This U.S. organization was to reduce the footprint and not have two EXCOM entities located in the U.S., which changed in 2013 when the U.S. IHST members broke off and formed a U.S. Helicopter Safety Team with their working groups formed underneath. This alignment mirrored regional partner organizations. The early interest in the SMS promotion and implementation movement came from those who could afford the investment such as the offshore petroleum industry, and the larger HAA companies (Chiles, 2007).

Industry Interest and Efforts. A major effort began worldwide in 2006 to address helicopter accident rates. This effort was established by the IHST, a global organization started then by national aviation regulatory entities, manufacturers, industry organizations, major and minor operators, and individual aircrews; virtually the entire industry was reliably represented (FAA, 2014a; Mitchell & Braithewaite, 2008). JHSAT published accident data analysis in two reports (2007 and 2011) to determine characteristics and causes of all US helicopter accidents that included a rollup of calendar years 2000, 2001, 2006. The JHSAT Compendium Reports (Vol. I and II) (2011) were the combined analysis of three separate year reports on the NTSB aviation accident database for the years 2000, 2001, and 2006, categorizing helicopter accident data, classifying the accident activity, then providing recommendations for prevention. The JHIMDAT then performed another analysis on a year group of 2009 – 2011 to measure progress within the industry. The 2014 JHIMDAT Comparative Report includes an analysis of accident data comparisons between the 2011 JHSAT report (the analysis of data from 2000, 2001, and 2006) and the internal JHIMDAT analysis of the year group 2009 – 2011. The comparative report contains data segregated by the various components of operation, some of which are described below:

- Industry. The type of work or predominant flight operation in which an airframe is utilized in the civil helicopter industry. This generally broad grouping includes public use, personal and private, and commercial operations (with many specific missions such as instructional and training, HAA, OGP, and electronic news gathering, etc.).
- Activity. This category is the actual function in which an airframe was engaged upon at the time of an accident. This is separated in the reporting of industry data. As an example, an airframe could be used for aircrew training while the primary industry function of that airframe may be completely different (such as HAA).
- Industry and Activity Pairs. Data in this category is a combination of Industry and Activity components. This data helps to establish operational relationships to help the industry better understand the potential nature of an accident, thus providing a more clear representation in context.
- Occurrence Category. The occurrence category data is a discriminating and analyzed data set. This data establishes a detailed and concise description of what happened in a reported accident through a combination of available evidence using an expert panel.

The Occurrence Category also contains sub-categories to filter each potential item for accident causation.

The tables below reflect the comparisons of personal and private with instructional training segments to illustrate the current situation in the helicopter industry.

Table 1.

Industry Comparisons of USHST Analyses

Industry Segment	JHIMDAT (Calendar Year 09-11) Accidents	JHSAT (Calendar Year 00, 01, 06) Accidents
Personal and Private	20.7% (86 of 415)	18.5% (97 of 523)
Instructional and Training	20.5% (85 of 415)	17.6% (92 of 523)

Note. This data was derived from the USJHIMDAT Comparative Report (2014). The data reflects the primary area of operation of the accident aircraft. These percentages indicate the amount of accidents by industry segment pertaining to the total for that calendar year group.

Table 2.

Flight Activity Comparisons of USHST Analyses

Industry Segment	JHIMDAT (Calendar Year 09-11) Accidents	JHSAT (Calendar Year 00, 01, 06) Accidents
Personal and Private	19.3% (80 of 415)	14.0% (73 of 523)
Instructional and Training	17.8% (74 of 415)	12.4% (65 of 523)

Note. This data was derived from the USJHIMDAT Comparative Report (2014). The data reflects the primary function of the aircraft at the time of the accident. These percentages indicate the amount of accidents by industry segment pertaining to the total for that calendar year group.

In drafting the 2014 Comparative Report, the JHIMDAT sought to measure progress between the two report periods (calendar years 2000, 2001, 2006, then 2009-2011). The team had intended to identify areas of progress, and use the results in the focus of effort, which has been to reduce accidents in the industry. The comparison of data among the time periods showed no decrease or stagnation. Additionally, the team conducted a chi-square analysis to identify areas of statistical significance by industry segment and between time periods. The results for the industry segment analysis showed stagnation in accident rates for personal and private, and for instructional and training. Results for the flight activity however identified that there was a statistically significant increase in accidents between data sets for both Personal and Private, and for Instructional and Training segments. The results of the assessment are below in Table 3.

Table 3

Personal Private Chi-Square Analysis

% of Accidents CY 00-01, 06	Industry	Accidents Observed CY 09-11	Accidents Expected CY 09-11	Chi Squared Value	Conclusion
18.5%	Personal / Private	86	77	0.256	>0.01 Not Significant

Note. This data was derived from the USJHIMDAT Comparative Report (2014). The data shows the aggregate group of accident data sets were statistically different. By separating industry segments, it was found that there was no significant change in the Personal and Private segments.

According to the FAA (2014b), there have been no verified peer or government reviewed research regarding helicopter SMS operation and its influence on small operations (FAA, 2014b). The accident research and analysis by JHSAT (2007, 2011) includes data of personal and private plus instructional and training industry segments in the U.S. civil helicopter industry from the NTSB accident database, offers potential benefits to small business operations. The benefits could occur by promoting a safety program in areas most susceptible to hazards, which do not currently engage in safety management processes nor possess a safety culture. Some areas of safety culture explored in previous analyses of aviation accident causal factors included aircrew selection and training deficiencies, operational tasks and procedures deficiencies, and lack of advanced technology utilization in airframes (Mitchell, Sharma, von Thaden, Wiegmann & Zhang, 2002; von Thaden & Gibbons, 2008). It would appear that aviation safety could be improved by considering these causal factors. The JHIMDAT Comparative Report (2014) comparing accident analyses of two sets of year group data, showed no statistically significant change over recent time periods in accident rates for helicopters in the high-risk smaller organizations. However, if compared to FAA and NTSB accident data, this industry segment is still statistically well above accident rates in other components of the aviation industry.

Although much of the USHST effort has been focused on the root causal factors involved in U.S. accidents (JHIMDAT, 2014), no detailed analysis was directed at the impact to operations as related to accident statistics based upon the entity size. There are many factors involved in any aviation operation and a small business or private entity low on operational resources must be diligent and conservative (Eschenfelder, 2013). In the aviation industry there is evidence that the loss of an aircraft presents large risks for helicopter businesses (Eschenfelder, 2013). There are many causes of helicopter accidents, such as incorrect power management, exceeding operational limits, and interferences with controls and from (JHSAT, 2011). According to the JHSAT analysis, most involve some aspect of safety management, either present or not present in the organization (JHSAT, 2011).

The airline industry integrated safety management by regulation despite evidence that there is positive effect to airline safety from deregulation (Gattuso, 2013; Lawrence, 2014).

Arguably, airlines that crash frequently should stand to suffer economic losses. The loss of life and airframes are issues with which large and small aviation companies must respond. It is likely that the abilities to cope with the negative effects of catastrophic accidents in a small entity in the helicopter industry would therefore be more challenging to cope with than the capabilities of large aviation companies.

The helicopter industry is diverse and that the services are distributed among over 25 different types of missions (IHST, 2011). This diversity requires investigation concerning the capabilities of small aviation entities in sustaining safety in the operation because sustainability of business operation is dependent with the trust and demand of customers for business (Ballard, 2014). The creation of new information in this area could help companies make beneficial decisions regarding expenditures for SMS implementation and continuing aircrew training. The JHSAT (2007, 2011) claimed that small aviation companies may need to invest in professional development training and implement SMS. The JHSAT further claimed that small entities should address low overhead cost and profit margins to ensure safety for passengers. Regulations from the FAA will remain ineffective unless management of these entities is supportive in financing the training and professional advancement of their crews (FAA, 2005).

Determining how poor or non-existent SMS programs, or limited pilot experience could affect a helicopter business' operation is an important issue to address. The potential creation of new knowledge in this area does have cause and effect ramifications. The analysis by JHSAT (2007, 2011) supports that progression for pilots in the industry begins within the high-risk small entity segment with low overhead, few assets, and low profit margins. Practical test standards (PTS) from the FAA (2005) exist for helicopter pilots in the industry and are annually updated. Private pilot safety standards in the PTS involve individual pilot knowledge on safe aircraft operation (FAA, 2005). As the pilot advances to the commercial and then airline transport pilot ratings, the only safety knowledge required involves safe pilot flight operation. The closest that the PTS get to safety management is in the flight instructor certification (FAA, 2005). Required knowledge here requires pilots to know about single-pilot resource management, which specifically deals with safety of operation for one pilot in an aircraft in flight. No other safety management knowledge is required for helicopter pilot certification at any level (FAA, 2005). The FAA only requires safety specific training to occur for safety of flight operation. Pilots are required to use the PTS for each rating or certification they accomplish. Comprehensive and recurrent pilot training produces very capable aircrew members over time, though as accident statistics from the NTSB indicate, the preponderance of accidents resulted in poor pilot judgment and actions (JHSAT, 2007, 2011). Further research may be beneficial by addressing other aviation safety areas such as less experienced pilots, which were found to be problematic in the JHSAT (2007, 2011) and JHIMDAT (2014) analyses.

Incidents, Accidents, and Safety Reporting. In order for any safety system to function correctly, there must be established policies and procedures from which to operate. Within the aviation industry, these guidelines are established by the FAA through regulatory means. Within the Code of Federal Regulation (CFR), Title 49 encompasses transportation regulations (CFR, 2015). There are several volumes within title 49, which regulates the aviation industry and are designated as FARs. Regarding incidents and accidents, compliance issues are separated by function within 14 separate regulations, and in the accompanying Aeronautical Information Manual (AIM). Due to the complexities of Aircraft functions by type, regulations must necessarily be separated in order to satisfactorily cover each component of the very broad aviation industry. Specifically regarding notification and reporting of accidents, incidents, and overdue aircraft, FAR 830 contains rules identifying initial notification and then procedures for reporting accordingly (CFR, 2015). Further delineation of specific regulatory and procedural aspects containing specific information regarding incidents and accidents are contained in the following documents with parentheses regarding specific incident or accident items:

- FAR Part 91. General Operating and Flight Rules apply to anyone operating an aircraft and specifically identifies the responsibilities and authority of pilots and aircrew. This rule includes requirements for internal safety related reporting and safety related information contained within areas of flight rules, weather, equipment requirements, instrument and certification requirements, special flight operations, maintenance and alterations, fractional ownership, noise limitations, waivers, and airworthiness.
- FAR Parts 23, 25, 27 and 29. Airworthiness Standards covering various categories of airframes (exceeding maneuver limits, structural damage).
- FAR Part 61. Certification: Pilots, Flight Instructors, and Ground Instructors (physical nature, procedures and performance limitations).
- FAR Part 117. Flight and Duty Limitations and Rest Requirements (establishing prevention measures).
- FAR Part 119. Certification: Air Carriers and Commercial Operations, that meet large capacity requirements (demonstrate presence of SMS).
- FAR Part 120. Drug and Alcohol Testing (operator requirements pre/post incident or accident testing).
- FAR Part 121. Operating requirements: Domestic, Flag, and Supplemental Operations (hazardous materials, emergency situations, fatigue management, operational events). These are airline operations.

- FAR Part 125. Certification and Operations (large aircraft).
- FAR Part 135. Operating requirements: Commuter and On-Demand Operations and Rules Governing Persons on Such Aircraft (materials and emergency training)
- FAR Part 172 and 175. Hazardous Materials (materials for transportation)
- FAR Part 1544. Aircraft Operator Security (applicable Transportation Security Administration responses)

In the helicopter industry, the specific difference between an incident and accident maybe considered broader than in other parts of the aviation industry (JHSAT, 2010). The definition of an airframe receiving substantial damage and thus how it is reported, it is sometimes difficult to define. The information contained in FAR 830 identifies substantial damage is that which negatively affects performance, flight characteristics or structural strength to a point which would require substantive repair or replacement of the damaged components. However, numerous examples in the regulation do not constitute substantial damage (CFR, 2015). It is important to note that in several of the JHSAT reports (2009, 2010), a clear delineation is present regarding substantial and major damage versus minor or no damage in the reporting. Between the two JHSAT reports (2009 and 2010), the averages indicate 82% of aircraft were substantially damaged, and over 15% were classified as major damage. Clearly, reported incidents or accidents consist of substantial or major damage. The NTSB criteria for incidents or accidents investigation is somewhat inconsistent. Where the board may choose to investigate or not investigate a type of occurrence, seems mainly predicated upon the situation. As an example, NTSB report DFW06IA151 (NTSB, 2007) indicates an individual walking into a turning tailrotor that causes is serious injury was not considered an accident by the NTSB but a suicide in report SEA06LA052 (NTSB, 2006), was considered an accident. Whether a disagreement upon interpretation of the regulation in defining incident versus accident, incidents are not required to be reported and thus will not have record in the NTSB database

The analysis by the IHST and the inconsistency on NTSB definitions can be problematic with regard to the study of helicopter accidents in general. With regard to safety research, the inclusion surveys to account for a participants' experiences with both incidents and accidents would further support an overall analysis for accuracy. Previous work by elements of the IHST and in their reports attempts to account for these anomalies (Doepker, 2015; European Helicopter Safety Team, 2015; Sparks, 2015). Thus, the use of the results from accident research analysis by the IHST still supports the work herein and is necessary for comparison to validate the incident vs. accident differences and relationships, which also illustrate the existence of safety systems.

Babič, Lukáčová, and Paralič (2015) analyze NTSB accident/incident datasets to determine influences upon hidden relationships to generate prediction models. They compare their work with other works in the domain and it is clear that the consideration of both incidents and accidents in this analysis is necessary. In further validation that incidents and accidents are associated in the research and analysis of safety in the helicopter industry, a HAA risk analysis review from Nix, Buckner and Cercone (2014) contained analysis of both incidents and accidents in pre-flight risk factors and programs. In the Flight Standards Information Management System (FAA publication 8900.1) Volume 4 Chapter 5, there is displayed, a distinct relationship and consideration between incidents and accidents.

Safety Management Systems in Business Operations, and Accident Analysis

The commercial helicopter industry became more interested in SMS implementation, led partly by manufacturers (FAA, 2014b). Supplementing this effort were large helicopter operators such as ERA Helicopters LLC, Petroleum Helicopters Inc., and Bristow Group Inc., as they publicly highlight their work on corporate websites. Parallel to this movement, were efforts of the professional organizations, such as HAI, and the IHST, with backing from the FAA, as they all combined efforts to promote SMS, and develop materials for implementation (FAA, 2014b). Safety in business is not an aviation only enterprise. The American Society of Safety Engineers began addressing safety in business by creating the Business of Safety Committee in 2004 (Hill, 2011). Their goal was to house business safety information through its website for various business safety needs. They house substantive data on the influence that accidents have on businesses. While not directly focused on aviation industry, their information spans industries where helicopters from the smaller segments of the helicopter industry operate.

Before the helicopter industry's safety focus shift in 2005 with the creation of the IHST, NTSB data showed consistent accident rates were occurring in the industry. As an example, a 2009 aviation safety report from the Government Accountability Office (GAO) on HAA indicates that rapid increases in HAA operations between 2003 and 2008 had grown by nearly 50% (Government Accountability Office, 2009). In the period from 1998 through 2008, NTSB accident data showed an average of 13 HAA accidents annually, and a high of 19, but a high of 29 accidents in 2008. The GAO report's author, Gerald Dillingham, Ph.D., indicates challenges in data gathering in these HAA operations to identify flight hours, and survey response rates (Government Accountability Office, 2009). Many of these entities are stand-alone provider businesses as opposed to a large, regional or national HAA provider. These entities also fit into the small high-risk segment of this study. It was clear in the GAO report that competition is healthy and potentially leads to unsafe practices.

After the safety-focus shift by the helicopter industry began JHSAT analysis (2007, 2011) and the comparative report from the JHIMDAT (2014) identified that accident rates continued to be a problem in the small helicopter personal and private plus instructional and training operations. Consensus in the popular press indicated that the fiscal challenges involved in the integration and implementation of safety measures, equipment and programs were potentially a contributing factor to the incident and accident rates experienced by the smaller high-risk entities (JHSAT, 2007, 2011; JHIMAT, 2014).

Daft (2008) supports that smaller business entities are often hampered in implementing non-regulated, resource intensive involved processes within their organization. Gartner and Shaver (2012) reviewed research on nascent entrepreneurship and found aversion to risk-taking (such as SMS implementation) in strategic terms. Implementation of an SMS program would be considered a strategic move in a small helicopter entity. The 2014 FAA final rule for helicopter operations supports these factors and indicated that the proposed safety implementations will pose a significant impact on many small helicopter entities. Gartner and Shaver (2012) also indicate the lack of distinct data available in research on the success of business planning related to startup success, which illustrates the challenges in assessing this area. Many operational helicopter entities are established who do not yet have an SMS program (FAA, 2014b), thus indicative that this proposed research is necessary. SMS efforts continue to evolve in the larger segments of the helicopter industry (FAA, 2014b; Lu, Schreckengast, & Jia, 2011) and the high-risk small entity segment could benefit from similar integration. The recent release of the Helicopter Air Ambulance, Commercial Helicopter and Part 91 Helicopter Operations; Final Rule (2014b) directs specific safety related implementations targeting equipment, operational procedures (internal, airspace and aerodrome related). By design, these new rules will effect larger helicopter organizations less than small organizations.

Technology and Safety Strategies. One of the pillars of SMS is safety assurance, which includes as a subset, safety performance monitoring and measurement. The evolution in aviation safety continues through the first several decades of the new millennium and technology and other operational integrations have become an active part of SMS programs for the ability to monitor performance and enable measuring. Advisory Circular 120-92A titled SMS for Aviation Service Providers (2010) contains the framework for SMS and contains numerous related documentation that refers to the integration of safety related strategies and technologies. Together with SMS programs, the integration of technologies and other strategies is becoming more commonplace. The 2014 FAA rulemaking also explains that these integrations are driven by accident rates and advancing technologies. Examples of these implementations include crew or cockpit resource management (CRM) (Yantiss, 2011), flight data monitoring, and the increased use of simulation technology (FAA, 2014b).

Crew Resource Management is not a new concept, but developed using industry and government efforts (Lofaro, 2014). Beginning officially in the early 1980's in the airline industry as cockpit resource management and focused on psychological concepts and interpersonal skills in an effort to reduce pilot error (Dumitras, 2013). The next evolution in CRM came in the late 1980's with the shift in terminology from Cockpit to Crew Resource Management with more specific and modular flight operations focus and then followed by yet another more broadening evolution in CRM in the early 1990's (Dumitras, 2013). This third shift was more focused upon the multifunctioning environment (integration of specific skills) and dealing with more systems related aspects or organizational culture, and automation on the flightdeck. In each of these evolutions of CRM, training concepts and other programs spun off from the effort. Examples of these ancillary programs are Line Oriented Flight Training that integrates full spectrum simulation training, and another being the Advanced Qualification Program that allowed carriers to create innovative solutions targeted to specific company needs. As CRM did not evolve to a worldwide distribution due to language and cultural differences, a fifth evolution is next and likely nearing its existence as other industry-FAA implemented programs arrived since 2000, such as the Aviation Safety Action Program (FAA, 2002), and the Flight Operational Quality Assurance (FOQA) programs (discussed below) (FAA, 2004), all of which are interconnected with an SMS program. Finally, the most important detail regarding these safety programs is that they were initiated by airlines, and made their way into the large helicopter entities by virtue of their FAA regulatory status as air carriers, commercial operators, or other certifications used by large companies (FAR, 2014).

Aircraft technologies are another aspect related to an SMS program that are beginning to take hold in the helicopter industry and considered supporting components of an implemented SMS (FAA, 2014b). The recent rulemaking change by the FAA (2014b) has even prescribed technology integration with several components from the list below. These technologies are both mechanical and electronic (avionics) in nature in that advancements in materials yields higher performance capabilities, and translates into safer operations (Chiles, 2007). With regard to advances in the fields of avionics, the primary applications of these technologies in the helicopter industry are clearly affordable primarily in the larger carriers (FAA, 2014b), but as with any technology, as it advances and populates an industry, it usually becomes more affordable. Advanced technologies in use today on helicopters include the following (Croucher, 2013; Pourdehnad & Smith, 2013):

- Flight Management System (FMS). This system is normally linked between the autopilot and the flight director to optimize navigation, performance, and accurate flight controlling and instrument approaches.
- Electronic Flight Instrument System (EFIS). Often referred as a component of the glass cockpit, this is a multi-functional display that combines limited navigation and performance information, with the full array of detailed flight information onto one screen.
- Terrain Avoidance Warning System (TAWS). Also known as a ground proximity warning system, this component guards against controlled flight into terrain through lights and sounds, and with graphic terrain representation for aircrew to identify distance and direction of terrain obstacles.
- Radio Altimeters. Also known as radar altimeters, these are dated instruments that are still very accurate. They rapidly measure height above ground or sizable objects (buildings etc.) directly underneath the aircraft.
- Flight Data Monitoring (FDM). These are more advanced systems with position stamping, audio sensor, instrument recording, cockpit viewing, and control input recording. When used, FDM is considered integral to the flight operations quality assurance (FOQA) program according to the FAA.
- Cockpit Voice Recorders (CVR). This device is primarily located in large airliners but is beginning to be utilized on the larger helicopters.

Flight simulation is a continually evolving technology that has been integrated into standardized training for primary flight training, instrument flight training and skill sustainment, and emergency training (Aji & Khan, 2015). Simulation is a low cost effective manner for these training goals. Fidelity in the helicopter flight simulation industry has always been challenging (Aji & Khan, 2015). In fact, the FAA has awarded more credit for fixed wing simulation than for similar helicopter simulation because the level of fidelity available to simulate hovering flight and it has long been cost prohibitive (U.S. Department of Transportation, 2010). Alternatively, an adequate level of simulation can save thousands of dollars over time as typical costs of operation of single turbine aircraft versus twin turbine can range from $1,000 to near $7000 per hour (Wesolek, 2009). Integration of these technologies is beginning to occur in base models from some manufacturers but primarily are after-market additions.

Flight Operations Quality Assurance is an accident prevention program that supplements the SMS programs, and is being utilized in the commercial helicopter industry (FAA, 2014b). Real-time tracking of aircraft (Sahjian, Spencer, and Branconnier, 2010) is a new safety technology of the NextGen air traffic control system (FAA, 2014b), has been extensively tested in offshore helicopter operations. New FAA regulations (2014b) identify that some commercial entities such as air ambulance operators, must be equipped with advanced flight data monitoring helicopter and terrain avoidance technology. While this technology is costly (FAA, 2014b), current safety doctrine identifies these technologies as safety enhancing. Purchasing this technology has consistently proved challenging (FAA, 2014b). Organizations with large operations such as offshore, air ambulance, and the military, were shown capable of affording these SMS compliant technologies, where smaller operators would not (FAA, 2014b). Purchasing SMS compliant technology for small helicopter personal and private plus instructional and training operations remains elusive due to the costs involved (FAA, 2014b) and at present, the regulatory changes requiring these new technologies, procedures, and strategies is limited to specific commercial entities. Until broadly regulated, available safety-enhancing technology will primarily be integrated in larger organizations outside the high-risk small entity segment of the helicopter industry (FAA, 2014b).

Implementing Safety, Safety Culture, and Promoting SMS. The previous section outlined the final ruling of a 2010 FAA proposal that mandates the implementation of safety related processes in operations, specialized training and safety related technologies, which are also recommended within SMS publications and doctrine (FAA, 2014b). One large gap still missing in the rulemaking is no requirement for an SMS program to be present in an organization. Implementation of SMS remains optional (FAA, 2014b).

The target group of this research proposal is generally more inexperienced than larger helicopter organizations that have shown their involvement in the safety management evolution (FAA, 2014b). Results of the JHSAT study of NTSB accidents (JHSAT, 2007, 2011) showed a majority of operators within small helicopter personal and private plus instructional and training operations are utilizing more economically feasible aircraft certified to fly under the regulatory umbrella from which they operate. In their industry segment, less complex operations are more affordable and implementing SMS with all of its perceived encumbrances is a challenge (Lu, Schreckengast, & Jia, 2011; Thomas Groke, & Handrahan, 2011). The lack of widespread SMS participation in small high-risk helicopter entities is partially assumed (evident in accident statistics), however an effective SMS implementation does seem to provide operational benefits.

Small helicopter entities operate on narrow margins and integrating SMS, flight operations and pilot certifications, and flight safety and monitoring equipment has been challenging this market to bear (FAA, 2014b). I have not found in available research, the operational benefit to SMS implementation, or of the cost of SMS implementation for the target group.

Safety Management System Doctrine

The study of safety management in the aviation industry is a contentious issue as evidenced by the post-accident attention given by the NTSB to numerous large aviation accidents such as the TWA flight 800 over the Atlantic in 1996 (Miller, 2002). In July 17, 1996, TWA flight 800 terminated soon after take-off from Kennedy International Airport bound to Paris. Results of the investigation are disputed amongst conspiracy theories as to the actual cause of the accident and subsequent NTSB findings (Miller, 2002). None of the 230 people on board survived. This accident coincided with a similar incident that occurred a few months prior, with the ValuJet flight 592 on May 11, 1996. The NTSB faulted only one of the named contributors to the accident which included lack of FAA oversight, sparking controversy (Matthews & Kauzlarich, 2000).

This attention has led to direct involvement by both regulatory agencies and industry organizations in the implementation of required safety management as discussed below. Safety doctrine is primarily an industry produced and accepted content, expressly developed for entities to apply SMS for orderly use (FAA, 2010). This doctrine is a derivative of the Federal Aviation Administration's Advisory Circular 120-92A (2009), regulations, and materials developed by industry entities such as those published on the IHST website. Further, development of SMS doctrine is supported through this FAA circular and under the new FAA rules (FAA, 2014b), requiring some safety strategies (aircraft hardware, procedures, etc.) for those entities that will operate under Federal Aviation Regulation (FAR) Part 135 (commercial helicopter operators). There are likely some Part 135 air ambulance operations with less than three aircraft in the population intended for this study. These new regulations (FAA, 2014b) will affect the larger Part 135 operations, specifically air ambulance entities more significantly, while those entities that typically fit into smaller industry segments less. The FAR Part 91(general operating and flight rules) entities have far fewer safety-based changes in the new regulations (FAA, 2014b). This research will concern small helicopter entities such as instructional and training (commercial operations) under FAR Parts 135 and 91, and those operating as a personal or private operation (not commercial) under FAR Part 91 only. Concurrently, as these new regulatory rulings have been in development (FAA, 2010; FAA, 2014b), the FAA as members of the IHST, have published many documents directed at industry safety (FAA, 2010, JHSAT, 2011, JHSIT, 2009) to promote many of the elements found in the ruling and thus are part of the safety doctrine.

Aircraft accidents weigh heavily on any organization in terms of loss of life and assets as suggested by the NTSB and is one of the prime reasons for the 2014 FAA rulemaking (FAA, 2014b). This interest in incident and accident volumes has been building since the 1990's in the industry as they continually trended upward (IHST, n.d.; JHSAT, 2011). Limited incident and accident prevention actions by the helicopter industry allowed for continued loss of airframes and lives, which has been addressed by organizations such as HAI, and IHST discussed herein. Accident rates for helicopters have been notable across all segments of the industry, and have yielded federal interest as evidenced in the final ruling by the FAA (2014b) regarding helicopter air ambulance, commercial helicopter and in limited ways for general aviation helicopter operations as discussed above. The recent FAA rulemaking (2014b) contains discussion that losses from incidents and accidents of the target sample of the population were unacceptable and formal action was necessary. The sentiment to reduce incident-accidents did not appear to generate industry action to show any significant change or reduction in incident – accident rates before formal action by the FAA.

The IHST, its regional partners, ICAO, the FAA and other international regulatory agents continue to address criterion to measure safety procedurally. These organizations suggest the implementation of measures to enhance safety performance (JHSIT, 2009). However, in review of their published safety analysis and data, they have yet to address how to measure safety performance or to determine the influence of SMS upon performance.

Helicopter accident analyses from the JHSAT 2011 compendium volumes I and II, were used to support this research study. Analyses by the JHSAT team members addressed issues regarding helicopter accident causes in operational terms but not the influence of accident preventing SMS programs on an entity. The importance of SMS within the helicopter industry has been illustrated through the specific SMS related research and analysis efforts and reports published by the IHST and its affiliates. Medium and large helicopter operators are deeply involved in SMS integration and smaller entities are not moving in that direction (Baker et al, 2006; de Voogt, Uitdewilligen, & Eremenko, 2009; FAA, 2014b; Herrera et al., 2010). Many support a theory that the integration of SMS could provide an operational benefit (FAA, 2006, 2014a; Herrera et al., 2010; Mitchell & Braithewaite, 2008; Skogdalen & Vinnem, 2011). In the literature, the implementation of SMS is explained to provide structure to meet legal responsibilities, but also as a business tool, providing more structured management, internal evaluation, quality assurance and continuous improvement. Finally, it is important to acknowledge the work of the industry in not only espousing the importance of SMS implementation (as represented by the member entities of the IHST), but also in the detailed accident research that is conducted. The recent FAA rulemaking (2014b) contained an NTSB recommendation for helicopter air ambulance entities to implement SMS, but the recommendation did not include personal or private or instructional or training segments. The

SMS recommendation for air ambulance entities was not adopted. Research, analysis, and recommendations of accidents from IHST entities lead to extensive information on the topic through reports and implementation measures (ICAO, 2010; FAA, 2012b; Roskop, 2013).

Summary

Incidents and accident trends in the civil helicopter industry continue (JHIMDAT, 2014; Roskop, 2013) and action to address the trends include the efforts discussed herein from industry entities. Much of the safety doctrine and literature rests within FAA circulars, orders (FAA, 2013c), IHST and their affiliates' websites and in trade journals. The IHST and affiliates appear to have conducted the most detailed research and analysis effort regarding industry-wide helicopter safety. Literature found in this review mostly focused on safety culture, safety implementation, accident analysis, crew management, risk and perceptions. What was not found, was aviation safety specific research that can conclusively identify operational benefits in the implementation of safety management systems for small helicopter private-business and instructional-training entities.

The IHST broad industry work on incident and accident research and analysis and mitigation strategies will continue and experts will continue to identify challenges, provide recommendations, and develop and establish SMS doctrine (JHIMDAT, 2014). Several recent studies identify the need to utilize a systems approach to study the influence of SMS. Continued interest exists within the industry to reach those areas of the where most accidents occur as illustrated in programs fostered by the IHST and HAI (JHIMDAT, 2014; Roskop, 2013).

The reviewed literature in this chapter supports the framework and understanding of the problem, and the theoretical framework from which the purpose of this research may continue. The target group of this research operates in a financially confined environment and often chooses to not implement SMS due to perceived increased expenditures (Stolzer, Halford, & Goglia, 2011). Articles about this situation appear in the industry journal Rotor & Wing as recently as 2015, thus supporting the direction of this research. The application of systems theory in this research to test and validate the model for further use to relate the components of SMS, OE, and IA, could very well prove an operational benefit to these small entities, which choose to implement safety management systems.

Chapter 3: Research Method

The purpose of this non-experimental, quantitative study was to assess a partial mediation model using structural equation modeling to determine if the presence of safety management systems (SMS) would predict operational effectiveness (OE) and incidents and accidents (IA), and if OE was predicted by IA or whether IA mediated the relationship between SMS and OE. A Structural Equation Model (SEM) will be used for testing causal relationships (Lei & Wu, 2007) between SMS, the independent variable, and IA and OE, the dependent variables (Figure 1). The population consisted of crewmembers of small commercial helicopter entities in the United States. A total of 205 participants were enlisted to participate in the study. Specifically, this study was developed to answer the following research questions:

Q1. To what extent, if any, do safety management systems predict operational effectiveness, and incidents and accidents?

Q2. To what extent, if any, are incidents-accidents a mediator of the relationship between safety management systems and operational effectiveness?

Q3. To what extent, if any, do Incidents and Accidents predict operational effectiveness?

Correspondingly, the following hypotheses were tested in this study:

$H1_0$: Safety management systems do not predict operational effectiveness.

$H1_a$: Safety management systems predict operational effectiveness and incidents and accidents.

$H2_0$: Incidents and accidents do not mediate the relationship between safety management systems and operational effectiveness.

H2$_a$: Incidents and Accidents do mediate the relationship between safety management systems and operational effectiveness.

H3$_0$: Incidents and Accidents do not predict Operational Effectiveness.

H3$_a$: Incidents and Accidents predict Operational Effectiveness.

This chapter contains a detailed discussion of the methods for conducting the proposed research study. This chapter also provides a discussion of the research method and design, followed by the participants and sample size. The instrumentation is described, along with the data collection methods, the validity and reliability of the instruments, the operational definition of the variables, data analysis methods, and ethical assurances. This chapter ends with a summary of the research methodology for this study.

Research Methods and Design(s)

A quantitative, non-experimental, cross-sectional correlational design will be employed in this study considering partial structural equation modeling. The research design considered in this study was appropriate to achieve the purpose of the study which was to determine if the presence of safety management systems (SMS) would predict operational effectiveness (OE) and incidents and accidents (IA), and if OE was predicted by IA or whether IA mediated the relationship between SMS and OE. A quantitative research design as opposed to a qualitative research design was appropriate for this study because the variables considered in this study were represented numerically. A quantitative design allows the analyses of complex relationships between variables. Quantitative approaches are employed when the focus of the study is to determine relationships or impact of a variable to another variable (Babbie, 2012). Quantitative approaches make use of objective measures through numerical representations of the constructs considered in the study.

A non-experimental, cross-sectional research will also be conducted because data will only be collected at one point in time (Matthews & Ross, 2010). There will also be no manipulation of variables and random sampling of participants to control and experimental groups. Data was collected using a survey technique wherein participants were asked to respond to a set of items that represents the constructs identified for this study. For the purpose of this study, SMS was considered as the independent variable while OE and IA were treated as dependent variables.

A correlational research design was deemed appropriate because the focus of this study was to investigate potential relationships between variables (Bryman, 2012). Correlational research is appropriate to investigate whether an increase in the independent variable also results in an increase or a decrease in the dependent variable. In addition to the correlational approach, a structural equation model (SEM) was employed to investigate the mediating effect of IA on the relationship between SMS and OE. In investigating the mediating effects of variables, SEM was appropriate because it examines the correlations and covariances between variables in order to identify the extent to which the mediating variable impacts the relationship between the independent and the dependent variables (Kline, 2011).

Population

The target population consisted of crewmembers of small commercial helicopter entities in the United States. This sample of over 200 participants was drawn from a U.S. population of crewmembers who had experience in small helicopter firms. A convenience sampling technique was considered for this study to ensure that a sufficient number of samples would be included. In SEM analysis, a large sample size is necessary to achieve statistical validity (Kline, 2011; Lei & Wu, 2007). A convenience sampling technique is a non-probability sampling technique wherein all prospective participants are invited to participate in the study, however, only participants who are willing and available would be considered as study participants. Based on the recommendation of Kline (2011), it is necessary to gather at least 200 participants to achieve adequate power for SEM considering a significance level of .05 and a medium effect size

Sample

A convenience sampling technique was considered in order to evaluate the availability and the willingness of prospective participants to participate in the study. This was not conducted as the strength of potential respondents come from sources used to solicit participation have access to an excess of 60,000 industry representatives. Safety experts from the JHIMDAT, JHSIT, and HAI were solicited along with helicopter insurance professionals at the to discuss the parameters of the study and if the study was viable and would garner participation and the response was overwhelmingly positive. Dr. Dinh-Zarr-Vice Chairman of the NTSB was also briefed with the others discussed above at the annual HAI Heli-Expo 2016 in Louisville, Kentucky and all responded very positively. A priori sample size calculation using G*Power for SEM was employed to determine the minimum sample size necessary for the study. Considering a power of 90%, a .1 effect size, and a significance level of .05, it was necessary to gather at least 200 samples for the study. The minimum sample size is also aligned with the recommended sample size identified by Kline et al. (2011). To achieve the minimum sample size for this study, crewmembers in small helicopter firms (<5 aircraft) in the U.S., or who have recently worked in those firms for the last 10 years, were sought.

Materials/Instruments

A survey technique was utilized to gather data from pilots in small helicopter firms in the U.S., or who have recently been in those firms in the last 10 years. The survey questionnaire will contain items on the demographic profile of the helicopter firm such as the number of employees, number of helicopter units, years in service, and target market. The survey questionnaire will also collect data on the variables considered in this study such as the presence of safety management systems (SMS), operational effectiveness (OE), and incidents and accidents (IA).

Incidents and accidents (IA) involve human (pilot) and machine (helicopter) fallibility as well as environmental (weather, obstacles, light, regulatory, etc.) variability (Authority C.A.S., 2012). Operational effectiveness involves the elements in place to make the organization competitive, economically and financially viable, requiring proper decision-making (Porter, 1996). Safety management is a set of standards, knowledge, and actions established to mitigate risk (FAA, 2009), and in combination with the elements above, defines the system identified for this study.

Operational Definition of Variables

The variables considered in this study were operationalized as follows:

Independent Variables. The independent variable of SMS was measured using the five-factor SMS construct proposed by Chen and Chen (2012) in their study of SMS components within established international aviation agencies (Australia, Canada, Taiwan, England, the U.S. and ICAO). Chen and Chen (2012) identified 23 items constituting the five constructs in measuring the performance of SMS in the aviation industry. These were: "documentation and commands, safety promotion and training, executive management commitment, emergency preparedness and response plan and safety management policy" (Chen & Chen, 2012, p. 177).

Documentation and commands. This variable is operationalized by the degree of clarity of an SMS program within the organization. This includes the levels to which safety directives are explicitly contained within a manual, the level of activities related to tracing and cataloging of vital safety information, and the level to which procedures are incentivized. The standards within the organization are known, which could be utilized for the purpose of measuring the degree of SMS program implementation. In this study, the items identified by Chen and Chen (2012) were evaluated following the 5-point Likert scale (from 1=strongly disagree to 5=strongly agree) that addressed the sub factors: (a) managers order clear commands for SMS operation, (b) the contents of SMS manual are readily understood, (c) system can precisely save, secure, and trace the information, (d) establish an incentive system to reward the good SMS performance, (e) there is an intranet system to share the SMS related information, (f) simple and unified standard for safety behavior, and (g) documents are reserved and updated in a standardized format.

Safety promotion and training. This variable is operationalized by the level of SMS implemented into all aspects of operations. This consists of recurrent employee and management safety training, and distinct training programs. Attitudes toward safety should be enhanced through promotion of the program. In this study, the items identified by Chen and Chen (2012) were evaluated following the 5-point Likert scale (from 1=strongly disagree to 5=strongly agree) that addressed the sub factors: Employees learn the concepts through training, (b) employees know how to execute SMS through training, (c) employees upgrade the self-managed ability through training, (c) company provides training continuously, (d) company holds SMS promotion activities regularly, and (e) company provides diverse training and programs.

Management commitment. This variable is operationalized as the levels of commitment and participation in SMS by personnel at all levels of management, the organizational involvement in a just culture, and transparency in safety declarations. In this study, the items identified by Chen and Chen (2012) were evaluated following the 5-point Likert scale (from 1=strongly disagree to 5=strongly agree) that addressed the sub factors: (a) top management participates in the SMS related activities, (b) management handles safety issues following just culture, (c) top management declares the determination to execute SMS, even when the company finance is in the down cycle, and (d) top management declares commitment in formal documents.

Emergency preparedness and response plan. This variable is operationalized by levels of knowledge and practice of SMS as shown by an established plan for simulation and exercise of safety procedures. In this study, the items identified by Chen and Chen (2012) were evaluated following the 5-point Likert scale (from 1=strongly disagree to 5=strongly agree) that addressed the sub factors: (a) employees acquainted with the plan, (b) employees are trained to execute the plan periodically, (c) company simulates the plan periodically, and (d) company establishes the plan with clear procedures and individual responsibility.

Safety management policy. This variable is operationalized as the level of standards that are present that enable those responsible to monitor SMS performance. In this study, the items identified by Chen and Chen (2012) were evaluated following the 5-point Likert scale (from 1=strongly disagree to 5=strongly agree) that addressed the sub factors: (a) company develops the precise standard to monitor and evaluate the SMS performance, (b) company continuously improves the SMS performance, (c) company's internal reporting channel is highly accessible.

Dependent variables. A scaled survey was used that is based on that developed by Fernández-Muñiz et al., (2009). In this study, the safety performance variable from Fernández-Muñiz et al., was synonymous with IA, and competitive and financial performance variables were synonymous with OE, and these are defined below. The variables will be measured as composites of survey items.

Incidents-accidents. This variable is operationalized as the number of safety incidents or accidents experienced in the organization within a recent period of time. This is a ratio variable that was also tested for mediation. This variable was measured as the numbers of personal injuries and incidents of material damage experienced by an organization. This variable is based on the work by Fernández-Muñiz et al., (2009). This variable is operationalized as the number of safety incidents or accidents experienced in the organization before and after being introduced to SMS, and within the last 10 years. This variable was measured as the numbers of personal injuries and incidents of material damage experienced by an organization. This variable was based on the work by Fernández-Muñiz et al., (2009).

Operational effectiveness. Competitiveness performance is operationalized by the levels of quality, productivity, innovation, customer satisfaction, and reputation. Economic-financial performance is operationalized by the levels of market share, profit margin and profitability. Operational effectiveness consists of activities within an organization that are meant to enhance its performance. This variable was used to reflect the effectiveness of small private operations in the helicopter industry. Competitiveness performance and economic-financial performance scales are closely aligned with operational effectiveness concepts within the literature (Fernández-Muñiz et al., 2009; Porter, 1996). In this study, the items identified by Fernández-Muñiz et al. (2009) were evaluated following the 5-point Likert scale (from 1=strongly disagree to 5=strongly agree) that addressed the sub factors described above.

Data Collection, Processing, and Analysis

Prior to collecting data, approval was sought from the Institutional Review Board (IRB) and upon approval, a formal recruitment message shown in Appendix A was sent to selected small helicopter firms and organizations and broadcast online as explained below. The recruitment message included an informed consent process to ensure that crewmembers knowingly agreed to participate in the study. The formal recruitment message was emailed to firms, published through the HAI daily news to their members and through Flight Safety Information, a daily aviation safety news publication with 60,000 viewers. By accessing the survey site, the crewmembers were provided the IRB approved informed consent language and if they agree to participate in the study, they selected the link that clearly identifies their acceptance of the terms if they proceed to the next page of the survey. Once the survey was closed, the data was extracted for processing in SPSS v21.0 for data analysis.

After data collection, the responses to the survey questionnaire was input to SPSS v21.0 to prepare for data analyses. Descriptive statistics of study variables was presented to describe the sampled small helicopter firms in the study. Measures of central tendencies such as mean, standard deviation, and range values were identified. Variables of SMS, IA, and OE were presented using descriptive statistics. For the analysis of data, inferential statistics were employed in the study. To determine relationships between variables, a correlation analysis was conducted between SMS and IA as well as between SMS and OE. Spearman's correlation analysis as opposed to Pearson's correlation analysis was employed to test the significance of a relationship because the independent variable of SMS was considered a binary variable. Therefore, this variable is assumed to be non-normally distributed.

To further analyze the mediating effect of IA on the relationship of SMS and OE, a structural equation model (SEM) was developed. Using the systems analyses techniques of SEM, the testing of statistical model fits for all variables occurred simultaneously. Using SEM, it is possible to examine the directionality of relationships between the variables and the variation and co-variation of variables to determine the best methodological fit. The interrelated multi-dimensional variables are parts of a system of dynamic relationships that can be analyzed using SEM analyses techniques (Bentler, 2010; Kline, 2011; Ullman, 2006). Variables related to helicopter safety systems are complex and directional. A quantitative design allows the analyses of complex relationships between variables. The SEM family of techniques includes path analysis [PA] and factor analyses, and this study includes a diagram of relationships between variables that was tested using the appropriate combination of techniques (Kline, 2011). Structural equation modeling techniques begin with intuitive inferences concerning dependent relationships between variables (Kline, 2011) that are typically designated within schematic models. To explain the variation in the relationships between the variables of interest, SMS, OE, and IA (Bentler, 2010; Herda, 2013; Kline, 2011; Ringle, Sarstedt & Zimmerman 2010; Lei & Wu, 2007), CFA and PA was used simultaneously to make causal inferences. However, Confirmatory Factor Analysis was used to independently test latent constructs. Path Analysis was used to identify structural relationships (Hair et al., 2011), and test directionality (Kline, 2011).

The SEM analysis was conducted in the following order: specification and base model development, path diagramming, assessing model identification, estimates and model fit evaluation, model interpretation and analysis, and the final model. The base model development involves the establishment of the relationship between variables of SMS, IA, and OE. As for path diagramming, a main model tested the significance of the different determinants and the corresponding weights of the independent variable to the dependent variables. The focus of SEM is on exploring the mediating effect of variables on the relationships between the independent and the dependent variables (Stapleton, 2008). The SEM confirmed whether the data used in this study fit as well as in a case of using manifest variables. In addition, a part of the main model tested the significance of the different correlations or covariance amongst the constructs based on the hypothesis as well. Using SPSS AMOS assisted in modelling the mediating variables in this study. SPSS AMOS helps perform statistical analysis, which determined whether the data fit the model utilized in the study (Bagozzi & Yi, 2012). All statistical analyses considered a significance level of .05.

Assumptions

There are several assumptions that that were considered in this study. One assumption is that participants would have respond honestly to the survey questionnaire. As crewmembers are exposed to each variable as they perform their duties within the organization, there was a logical assumption that participants would have similar understandings and interpretations of the variables considered in this study. The samples gathered in this study were assumed to provide a representation of the total population of aircrew members in the small helicopter industry. The population associated with small helicopter operations would likely be younger aircrew members that have less flight time and total experience except for the few senior aircrew members. Younger aircrew infers less experience and the likelihood that a higher population of these people have experienced or observed an incident or accident. Validation might be the resulting statistic as compared to the industry results as outlined in the USJHIMDAT Comparative Study (2014). Participation in this study was enhanced through the researcher's association with the

Helicopter Association International, FAA Rotorcraft Directorate and AFS-800 Directorate (General Aviation), and the US Helicopter Safety Team who have expressed interest in assisting with promoting the survey to their constituents.

Limitations

The involvement of the researcher in the small helicopter industry could have posed biases in participation and in the responses of participants. To limit this bias, participants were informed that their responses in the survey questionnaire would not, in any way, affect their work performance as there was no personally identifiable information that would be obtained. The participants were also be informed that all responses would be kept confidential and anonymous and would only be used for the purpose of this study. Another limitation in this study was the personal interpretation of the researcher on the constructs considered in this study. To limit this bias, the interpretation was guided by the operationalization of the variables. Moreover, the numerical responses of participants provided an objective interpretation of the variables considered in the study.

Delimitations

This study was delimited in terms of the geographic area considered. The data collection was focused on aircrew members of small commercial helicopter entities in the United States. This study was delimited to the population of samples that would be willing and available in participating in the study. Instructional and Training entities are generally smaller in this industry segment with usually less than ten aircraft and are normally a commercial enterprise. Personal and Private entities are very small and usually consist of a single airframe. Therefore, the results of this study may only be applicable in this population and not with any other geographic area, specifically where there is high cultural diversity.

Ethical Assurances

This study involved humans as study participants. With this, it was important to make sure that the study procedures followed ethical standards. Prior to gathering data from prospective samples, participants were provided with an informed consent form. The informed consent form included the details regarding the study such as the background of the study, the purpose of the study, the information that would be collected, and the contact details of the researcher in case there were concerns that needed to be raised. Participants were also informed that they could withdraw from the study at any point in time without any foreseeable risks. Only individuals with signed informed consent forms would be considered in the study.

There was also no identifiable information to be collected in this study. The data collection will involve the use of a confidential internet survey that was similar across all study participants to ensure that data from any firm cannot be identified. Encoding of data was only completed when all prospective participants submitted their responses. This study also presented aggregate data to prevent any association with any of the considered firms. All documents and data files are to be stored in a locked room which only the researcher can access. All documents and data files will remain stored for three years after the completion of this study, after which, all documents and data will be destroyed, discarded, and deleted.

Summary

The purpose of this non-experimental, quantitative study was to assess a partial mediation model using structural equation modeling to determine if the presence of safety management systems (SMS) would predict operational effectiveness (OE) and incidents and accidents (IA), and if OE predicted by IA or whether IA mediated the relationship between SMS and OE. A structural equation model was considered for the study because the focus was on identifying whether IA mediates the relationship between SMS and OE. The target population consists of small commercial helicopter entities in the United States. This sample was drawn from a U.S. population of aircrew members from small helicopter firms, with a goal to exceed the minimum target sample size of 200 participants. A convenience sampling technique was employed in this study to ensure that a sufficient number of samples would be included in the study. At least 200 participants were needed for this study and participants completed 206 surveys. Descriptive statistics, correlation analysis, and SEM was used to analyze the data collected using survey questionnaires. Descriptive statistics was used to present the profile of the small helicopter firms sampled in this study. Spearman's correlation analysis was used to determine whether there was a significant relationship between SMS and IA as well as between SMS and OE. Finally, SEM was employed to test whether IA mediated the relationship between SMS and OE. A significance level of .05 was used for all statistical analyses.

Chapter 4: Findings

In this quantitative study, the purpose was to assess a partial mediation model using structural equation modeling to determine if the presence of safety management systems (SMS) predicted operational effectiveness (OE) and incidents and accidents (IA), and if OE was predicted by IA or whether IA mediated the relationship between SMS and OE. To test the causal relationships between SMS, the independent variable, and IA and OE, the dependent variables (Figure 1), a Structural Equation Model (SEM) was utilized. A family of statistical methods was used that included confirmatory factor analysis (CFA) and path analysis (PA) to explain variation in relationships between the variables.

Information in this chapter includes the discussion of data collection, the analysis techniques in assessment of the research hypotheses and consists of results and the evaluation of the findings. The results section contains discussion on data collection, including treatment of missing data, any outliers and normality issues; survey instrument reliability; demographics of participants, CFA and model results of the relationships between SMS, OE and IA. At the conclusion of the chapter, key elements will be summarized.

Results

Data collection from 205 participants occurred over a 65-day period. Participants were screened for eligibility via a series of demographics questions. Within the dataset, 13 returned incomplete surveys, accounting for .06% of the total.

Basic Demographics. In the sample population of pilots in this survey, 90.7% were males, and 9.3% were female. The majority of respondents fell between the ages of 31 and 60 years of age. Over 70% of the population were under Parts 91, 133, 135 or 137 of the Federal Aviation Regulations when they were operating in small organizations. Most respondents became qualified in the civil aviation sector, possessed commercial certification or better, and had been exposed to safety management. There were 206 participants of which 90% were male (n=186). The demographics of the participants are shown in Table 4.

Table 4..

Participant demographics

		Count	%
Gender	Male	186	90.7
	Female	19	9.3
Start Age	21-30	38	18.5
	31-40	52	25.4
	41-50	44	21.5
	51-60	71	34.6
Helicopter Type	Civilian	152	74.1
	Military	53	25.9
Certificate Type	ATP	66	32.0
	Commercial	130	63.1
	Private	10	4.9
Instructor Rated	Yes	135	65.9
	No	70	34.1
Number of Helicopters	<5	94	75.2
	6 or more	31	24.8

Due to the high number of missing values, AMOS was used to impute missing values with using regression imputation. When there are missing values, AMOS cannot compute bootstrapping p-values and confidence intervals which is necessary for the mediation analysis for hypothesis 2. The remaining analyses were performed using the imputed values.

A principal components exploratory factor analysis (EFA) with a varimax rotation was performed on the SMS, IA, and OE variables. A factor was retained if the Eignevalue was >1, and items were retained to a factor if the factor loading was >0.40 or <-0.40. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy should be as close to 1 as possible. Bartlett's Test of Sphericity should have a p-values less than 0.05.

Table 5.

Exploratory factor analysis for SMS items

	Factor 1	Factor 2
DC1	**0.87**	0.28
DC2	**0.79**	0.24
DC3	**0.74**	0.24
DC4	**0.71**	0.27
DC5	**0.73**	0.33
DC6	**0.80**	0.22
DC7	**0.78**	0.30
PT1	**0.81**	0.33
PT2	**0.84**	0.31
PT3	**0.74**	0.30
PT4	**0.74**	0.28
PT5	**0.72**	0.39
PT6	**0.77**	0.37
PT7	**0.70**	0.39
EMC1	**0.81**	0.29
EMC2	**0.77**	0.35
EMC3	**0.75**	0.33
EMC4	**0.71**	0.38
MP1	**0.76**	0.48
MP2	**0.74**	0.51
MP3	**0.72**	0.36
EP1	0.22	**0.81**
EP2	0.35	**0.83**
EP3	0.36	**0.77**
EP4	0.31	**0.84**
alpha	*0.98*	*0.90*

KMO=0.96, Bartlett's Test of Sphericity = 5440.21, $p<0.001$
See Appendix B for item explanation

Table 5 shows the factors loadings for SMS. A two factor solution was the best fit. The EP items loaded separately from the other SMS items. The alpha was 0.98 for factor 1 and 0.90 for factor 2

The IA items also showed a two factor solution, separated by whether there was SMS or no SMS. The alpha was 0.83 for factor 1 and 0.76 for factor 2.

Table 6.

Exploratory factor analysis for IA items

	Factor	
	1	2
IA1	**0.81**	0.02
IA2	**0.74**	0.17
IA5	**0.85**	0.05
IA6	**0.71**	0.24
IA3	0.00	**0.76**
IA4	0.15	**0.71**
IA7	0.07	**0.70**
IA8	0.24	**0.75**
alpha	0.80	0.73
KMO=0.66, Bartlett's Test of Sphericity=579.45, p<0.001		
See Appendix B for item explanation		

The OE items showed a two factor solution. The alpha for both factors was 0.88.

Table 7.

Exploratory factor analysis for OE items

	Factor	
	1	2
OE1	**0.79**	0.30
OE2	**0.74**	0.42
OE3	**0.87**	0.09
OE4	**0.88**	0.13
OE5	0.48	**0.55**
OE6	0.33	**0.82**
OE7	0.16	**0.92**
OE8	0.11	**0.93**
alpha	0.88	0.88
KMO=0.85, Bartlett's Test of Sphericity = 1124.07, p<0.001		
See Appendix B for item explanation		

A confirmatory factor analysis (CFA) was run on the 8 factors from the EFA. The model fit was assessed with the chi-square (χ^2), the comparative fit index (CFI), the Tucker-Lewis index

(TLI), the chi-square adjusted by its degrees of freedom (CMIN/DF), and the root mean square error of approximation (RMSEA). A good-fitting model would have a χ^2 that is insignificant ($p > 0.05$), CFI ≥ 0.95, TLI ≥ 0.95, CMIN/DF < 3.00, and RMSEA ≤ 0.08 (Hair, 2011). Discriminant and convergent validity were also examined. Convergent validity is the average variance extracted, which measures the amount of variance captured by the construct in relation to the amount of variance attributable to measurement error (Hair et al., 2011). Convergent validity is judged to be adequate when average variance extracted equals or exceeds 0.50 (i.e. when the variance captured by the construct exceeds the variance due to measurement error). The AVE (average value extracted) should be >0.50 and the CR (composite reliability) should be greater than the AVE (Hair 2011). MSV (maximum shared variance) and ASV (average shared variance) should be less than the AVE. Discriminant validity addresses the concept that each of the factors in the model are different from the other factors within the model. Variables should relate more strongly to their own factor than to another factor. Correlations between factors should not exceed 0.7.

The base CFA model was run using the results from the EFA. Items and/or factors were dropped until the model with the best fit and adequate reliability was observed. The best fitting model is shown in Table 5. Only one IA factor was retained, which contained the items indicating that an SMS program was in place. The model showed a moderate fit (CFI=0.84, TLI=0.82, CMIN/DF=2.84, RMSEA=0.095).

The convergent validity of this model was acceptable (Table 9). For all of the factors, the AVE was >0.50, the ASV and MSV were less than the AVE, and the CR was greater than the AVE.

Table 8.

Best fitting model from CFA

			B*	S.E.	P	b
IA6	<---	IA_SMS	0.77	0.10	***	0.61
IA5	<---	IA_SMS	1.02	0.09	***	0.90
IA2	<---	IA_SMS	0.77	0.10	***	0.62
IA1	<---	IA_SMS	1.00			0.84
OE4	<---	OE_perform	1.00			0.82
OE3	<---	OE_perform	0.89	0.07	***	0.79
OE2	<---	OE_perform	0.93	0.08	***	0.80
OE1	<---	OE_perform	0.90	0.07	***	0.82
OE8	<---	OE_Econ	1.00			0.92
OE7	<---	OE_Econ	1.06	0.05	***	0.96
OE6	<---	OE_Econ	0.86	0.06	***	0.77
DC1	<---	SMS	1.00			0.90
DC2	<---	SMS	0.85	0.05	***	0.80
EMC1	<---	SMS	1.04	0.06	***	0.86
EMC2	<---	SMS	0.96	0.06	***	0.83
EMC3	<---	SMS	0.96	0.06	***	0.82
EMC4	<---	SMS	0.94	0.06	***	0.80
PT7	<---	SMS	0.83	0.05	***	0.79
PT6	<---	SMS	0.93	0.05	***	0.84
PT5	<---	SMS	0.84	0.06	***	0.77
PT4	<---	SMS	0.94	0.06	***	0.83
PT3	<---	SMS	0.81	0.05	***	0.78
PT2	<---	SMS	0.98	0.05	***	0.88
PT1	<---	SMS	0.95	0.05	***	0.86
DC7	<---	SMS	0.94	0.06	***	0.82
DC6	<---	SMS	0.91	0.06	***	0.80
DC5	<---	SMS	0.90	0.06	***	0.78
DC4	<---	SMS	0.74	0.06	***	0.73
MP1	<---	SMS	0.93	0.05	***	0.89
MP2	<---	SMS	0.97	0.05	***	0.89
MP3	<---	SMS	0.91	0.06	***	0.79
EP1	<---	SMS_EP	1.00			0.77
EP2	<---	SMS_EP	1.22	0.09	***	0.88
EP3	<---	SMS_EP	1.15	0.09	***	0.82
EP4	<---	SMS_EP	1.15	0.09	***	0.86

$\chi^2(585)=1660.26$, $p<0.05$, CFI=0.84, TLI=0.82, RMSEA=0.095, CMIN/DF=2.84

*B=standardized beta, b=unstandardized beta; ***p<0.001

See Appendix B for item explanation

Table 9.

Validity of CFA model

	CR	AVE	MSV	ASV
SMS_EP	0.900	0.692	0.558	0.235
IA_SMS	0.838	0.571	0.094	0.050
OE_performb	0.883	0.653	0.230	0.133
OE_Econb	0.916	0.787	0.230	0.153
SMS	0.977	0.679	0.558	0.242

Composite variables were created using the results of the CFA. For the SMS and OE factors, the composite variables were created by taking the mean of the items and for the IA composite variable the items were summed. The composite variables were used to build the model for hypothesis testing (Table 10). Skewness and kurtosis should be within -2 to 2, and all of the variables are within this range.

Table 10.

Descriptive statistics for composite variables

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
IA_SMS	206	4.00	8.00	5.30	1.24	0.83	-0.14
EP_Prepare	206	1.00	5.00	3.06	1.04	-0.23	-0.60
OE_perform	206	1.00	5.00	3.81	0.77	-0.81	0.92
OE_Econ	206	1.00	5.00	3.18	0.92	-0.06	-0.15

Hypothesis testing

Figure 4 shows the SEM model with the estimates in Table 11. The model shows a good CFA and TLI (0.96 and o.90, respectively), but the RMSEA was >0.08 and the CMIN/DF was >3.0 (Table 9).

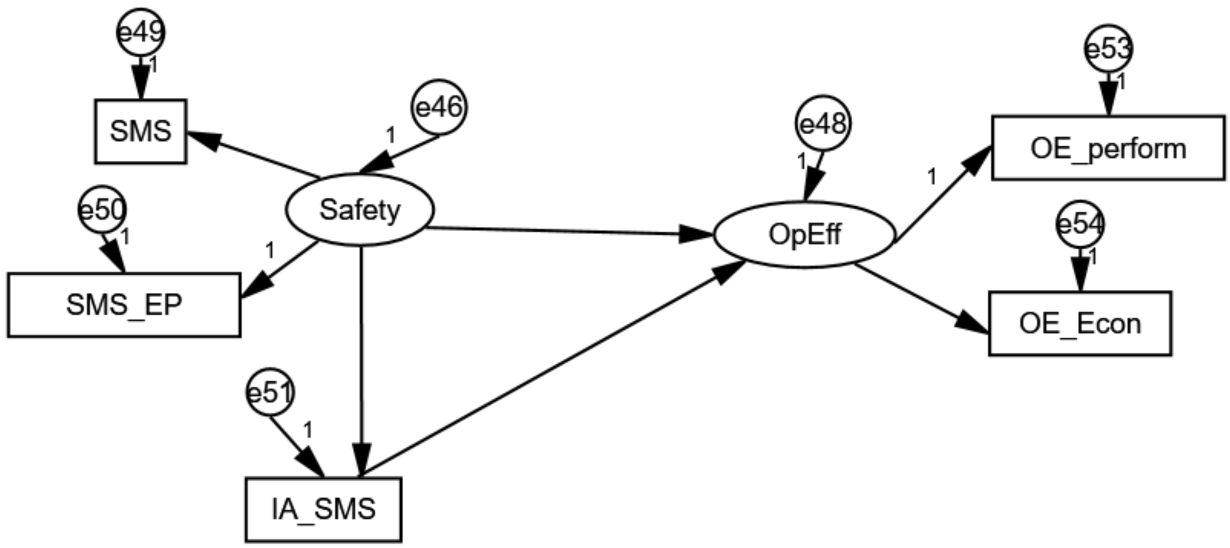

Figure 4: SEM model for hypothesis testing

Table 11.

Estimates from SEM model

			B	S.E.	P	b
IA_SMS	<---	Safety	0.37	0.11	***	0.25
OpEff	<---	Safety	0.45	0.07	***	0.73
OpEff	<---	IA_SMS	-0.09	0.03	0.01	-0.22
SMS	<---	Safety	1.12	0.12	***	0.87
SMS_EP	<---	Safety	1.00			0.80
OE_perform	<---	OpEff	1.00			0.67
OE_Econ	<---	OpEff	1.27	0.21	***	0.71

$\chi^2(3)=11.20$, p=0.01, CFI=0.97, TLI=0.90, RMSEA=0.12, CMIN/DF=3.76
*B=standardized beta, b=unstandardized beta; ***p<0.001

Research Question 1. The first research question asked, "To what extent, if any, do safety management systems predict operational effectiveness, and incidents and accidents? Hypothesis 1 states that Safety management systems predict operational effectiveness and incidents and accidents. The model shows that the estimate from Safety to IA_SMS was 0.25, p<0.001 and the estimate from Safety to OppEff was 0.73, p<0.001. Both of these paths were positive and statistically significant indicating that hypothesis 1 was supported.

Research Question 2. The second research question asked, “To what extent, if any, are incidents-accidents a mediator of the relationship between safety management systems and operational effectiveness?” Hypothesis 2 states that Incidents and Accidents do mediate the relationship between safety management systems and operational effectiveness. Mediation was examining the direct effects with and without the mediator and the indirect effect. If there is a difference in the estimate when the mediator is added to the model, there is indication of mediation. If the indirect effect is significant, then mediation occurred. Figure 2 and Table 10 represent the model to test for mediation.

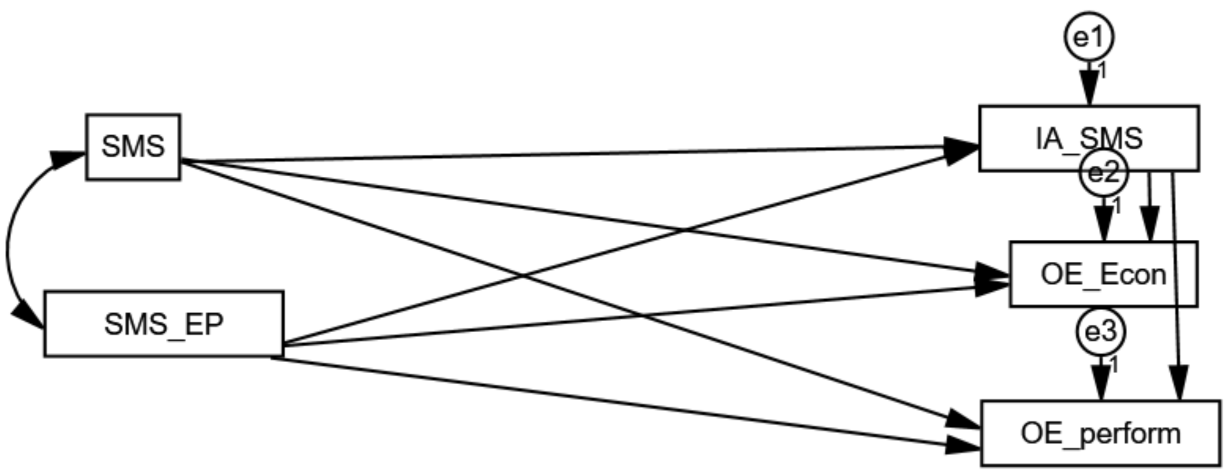

Figure 5: Mediation model

There was an indication for mediation of EP_IA on the relationship between SMS_EP and OE_perform. There was not a significant relationship between SMS_EP and OE_perform without the mediator, however, when the mediator was added to the model, the path trended toward significance (p=0.07). The indirect effect was also significant (p=0.007). Hypothesis 2 was partially supported given that 1 of 4 mediation paths were significant.

Research Question 3. The third research question asked, “To what extent, if any, do Incidents and Accidents predict operational effectiveness?” Hypothesis 3 states that Incidents and Accidents predict Operational Effectiveness. Table 9 shows the estimate from IA_SMS to OpEff was -0.22 ($p=0.01$). There was a significant negative relationship, therefore, this hypothesis was supported.

Table 10

Mediation estimates

Relationship	Direct without mediator	Direct with Mediator	Indirect
SMS-IA-SMS-OE_perform	0.30 ($p<0.001$)	0.31 ($p<0.001$)	0.00 ($p=0.79$) No mediation
SMS-IA-SMS-OE_Econ	0.37 ($p<0.001$)	0.37 ($p<0.001$)	0.00 ($p=0.63$) No mediation
SMS_EP-IA_SMS-OE_perform	0.10 ($p=0.25$)	0.16 ($p=0.07$)	-0.04 ($p=0.007$) Full mediation
SMS_EP-IA_SMS-OE_Econ	0.12 ($p=0.16$)	0.13 ($p=0.14$)	-0.01 ($p=0.49$) No mediation

Evaluation of Findings

The model used for this study was derived from using Systems Theory (ST), a transdisciplinary framework used to describe variables from complex systems. Important in this framework is the existence of a structure, interaction, and behavior relative to each variable, but also with outside actors (Heylighen & Joslyn, 1992; Johnson, 2005; Nicholson, Schuler & Van de Ven, 1998; Stichweh, 2011). The model structure in Figure 1 as a framework, enabled the analysis herein to determine relationships between variables.

Research Question One. The first finding of this study is that safety management systems can predict operational effectiveness. Additionally, safety management systems can also predict incidents and accidents. Model results indicate that hypothesis 1 is supported. This finding is also supported in the literature (Fernández-Muñiz et al., 2009; JHSAT, 2007; Krosrav et al., 2014).

Research Question Two. In this study it was hypothesized that incidents and accidents would mediate the relationship between safety management systems and operational effectiveness. The analysis for mediation indicates there was a change with the addition of mediation and it trended toward significance as was the indirect effect. Hypothesis 2 was partially supported in that incidents and accidents mediate between SMS and OE. This relationship is also supported similar findings the literature, such as Lofquist's (2010) claim that accidents are treated as an opportunity for organizational improvement.

Research Question Three. Finally, the third hypothesis 3 indicated that incident and accident would predict operational effectiveness. The results indicated that there was a significant relationship supporting these ideas, thus the hypothesis was supported. Porter's (1996) definition of organizational effectiveness as exceeding the operations of one's competitors supports this finding; an increase in accidents/incidents would correlate with a drop in organizational effectiveness when compared with competitors with lower accident rates.

Summary

Exploratory factor analysis showed a two factor solution for IA and OE. Confirmatory factor analysis was used to determine the best fit of the items and factors. The CFA showed a good fit and acceptable convergent validity. Hypothesis 1 was supported, as the path from Safety to IA_SMS was significant and negative and to OpEff was positive and significant. Hypothesis 2 was partially supported as there was evidence of mediation of IA_SMS on SMS_EP and OE_Perform. Finally, there was a significant relationship between IA_SMS and OpEff, meaning hypothesis 3 was supported.

Chapter 5: Implications, Recommendations, and Conclusions

Aviation safety has evolved significantly in the civil helicopter industry. Many changes have resulted in improvements to flight and ground operations. This evolution was necessary because of previously growing accident rates (FAA, 2014; JHSAT, 2007). The purpose of this study was to investigate a partial mediation model using structural equation modeling.

It was further determined that the presence of safety management systems (SMS) predicted operational effectiveness (OE) in relation to incident and accidents (IA). The study sought to identify if OE was predicated by IA or whether IA mediated the relationship with SMS and OE. Structural Equation modeling (SEM) was used for testing and establishing a causal relationship between SMS, the independent variables IA and OE, the dependent variable (Lei & Wu, 2007).

The purpose of this non-experimental quantitative study was to assess the partial mediation model and determine if SMS can predict OE at large. A great number of researchers have analyzed SMS implementation. Nevertheless, empirical reports on the effectiveness of SMS implementation upon incidents or accidents show that significant changes were not made (Ballard, 2014; GAO, 2014; Müller, Wittmer, & Drax, 2014).

Chapter 2 established the background of safety management systems. Research, analysis as well as targeting aviation disciplines are useful strategies in addressing these core issues. Despite significant technological developments, incidents and accident trends in the civil helicopter industry continue (JHIMDAT, 2014; Roskop, 2013). Much of the safety doctrine and literature rests within FAA circular as well as IHST and affiliates' websites (FAA, 2013c). Ultimately, these contributions have only been marginally effective.

Operating in a financially confined environment and choosing not to implement SMS due to its perceived increased expenditures are some of the limitations to the study results (Stolzer, Halford, & Goglia, 2011). The application of systems theory validates the use of related SMS, OE, and IA components. It could very well provide operational benefits to small entities that choose to implement safety management systems.

The design selected for research was appropriate to achieve the study purpose. The presence of SMS was analyzed in relation to OE. These factors were identified within a paradigm of incidents, accidents and operational effectiveness. Structural equation modeling was used to determine these relationships amongst independent and dependent variables.

The status of safety and management systems in the helicopter industry requires identification of incidents and accident over the past several years. This evidence has provided a solid foundation for the study. It is vital to review the reliability of safety systems in business operations for effective outcomes. Without understanding the establishment of safety systems and measures, safe implementation cannot be adequately taken into account.

This study followed ethical standard procedures to gather data from prospective samples. Participants were provided with an informed consent form that gathered individual confirmation. The demographic questions were slightly modified in relation to industry segments to further clarify for participants. The form collected details regarding the study background, purpose, and contact information. Data collection was done by the use of confidential Internet surveys. All study participants were required to follow the same methods in order to ensure consistency amongst the results. The data was encoded completely and all prospective participants submitted their responses. All the data collected was confidentially and will be stored for three years after the completion of the study. This chapter will address the implications, recommendations and conclusion of the study.

Implications

The first null hypothesis stated that safety management systems do not predict operational effectiveness. The results of the study concluded that it is true because the implementation of SMS does not necessarily mean efficiency in the operations. The second hypothesis was partially supported in the study indicating that incidents and accidents should mediate a relationship between safety management systems and operational effectiveness. The third hypothesis stated that incidents and accidents predict operational effectiveness and was further supported by the study. The results from SEM showed positive results for the entire hypothesis.

Hypothesis 1 stated that safety management systems predict operational effectiveness. The results from the model showed that the estimate from Safety to IA_SMS was 0.25, $p<0.001$ and the estimate from Safety to OppEff was 0.73, $p<0.001$. The presence of both positive paths indicated that hypothesis 1 is supported.

Hypothesis 2 stated that incident and accident IA should mediate the relationship between safety management systems (SMS) and operational effectiveness (OE). While performing the analysis for mediation it was seen that there is a significant change with the addition of mediation. There was an indication for mediation of IA_SMS on the relationship between SMS_EP and OE _perform. There was no significant relationship between SMS_EP and OE_perform. However, when the mediator was added to the model, the path trended toward significance ($p=0.07$). The indirect effect was also significant ($p=0.007$). Such results concluded that the Hypothesis 2 was also partially supported. Hypothesis 3 states that incident and accident IA predict operational effectiveness OE. The estimate showed that from IA_SMS to OpEff was -0.22 (p=0.01). There was a significant negative relationship supporting these ideas.

It was identified that safety management systems predict operational effectiveness to some degree. The data gathered suggests that this hypothesis is true and that it supports claims regarding safety management systems. The confirmatory analysis found that OE is not predicted by SMS. This data is notable because it assumes the correlation between safety management systems and operation effectiveness. It further substantiates a reduction to the incidents and accidents prevalent within helicopter usage (Fernández-Muñiz,et al., 2009).

Incidents-accidents act as a mediator of the relationship between safety management systems and operational effectiveness. The study found that there is a partial relationship between safety management and operational effectiveness as mediated by incidents and accidents. The study was concerned with a high rate of incidents in smaller helicopter entities.

According to Stichweh (2011) safety management measures should lead to more operational effectiveness and reduced IA. Results of the study found that the two variables are related to a limited degree. Links between these variables are not significant suggesting that SMS and OE do not necessarily influence the occurrence of IA. The study supports that the occurrence of incidents in the helicopter industry does predict operation effectiveness. Incidents and accidents can occur even if there are good operational measures put in place. That is because incidents and accidents involve human, environmental factors, machine errors and fallibility. On the other hand, operational effectiveness is the collection of strategies to make a company financially competitive (Porter, 1996).

Aviation safety has gone through a great evolution in regards to flight, ground operations, and the civil helicopter industry. Evolutionary changes in technology have not had a great impact on aviation accident rates (FAA, 2014; JHSAT, 2007). Therefore, it is important that further investigations proceed. New technologies have been developed in significant areas including the following (Croucher, 2013; Pourdehnad & Smith, 2013):

- Flight Management System (FMS)
- Electronic Flight Instrument System (EFIS)
- Terrain Avoidance Warning System (TAWS)
- Radio Altimeters
- Flight Data Monitoring (FDM)
- Cockpit Voice Recorders (CVR)
- Flight Operations Quality Assurance
- Real-time tracking of aircraft (Sahjian, Spencer, and Branconnier, 2010)

According to information gathered in the last few decades, accidents have only slightly decreased. The key to establishing a foundation that supports this research is determination of how effective SMS is. Doing so can identify its diversity, levels of implementation and potential areas of improvement. The civil helicopter industry is expanding with the passage of time because civil helicopters offer a number of capabilities which cannot be achieved by using other aircraft. As technology is evolving, the civil helicopter industry is also changing in order to make safety improvements. The string of high-profile accidents (IHST, 2011) has created pressure to make extra safety measures. Despite these operations and measures there has been no significant decrease in overall accidents rates (JHIMDAT, 2014). Elements of the International Helicopter Safety Team (JHIMDAT, 2014) have also conducted different studies and research to analyze accident data in an effort to identify higher population segments of accidents in the industry.

Two Taiwanese scientists derived the dimension on SMS. They used a three-stage scale development procedure to measure the performance of airlines. Chi and Han also incorporated a systems theory approach to study based on the relationship between accident causation and risks in the construction industry. Their study provided evidence that there were interrelationships between risk and causation. Larger, high-reliability helicopter entities are engaged in higher levels of safety with fully implemented SMS programs (FAA, 2014b). However, SMS is not widely implemented in smaller helicopter entities (JHSAT, 2014).

Partnerships between the government and helicopter companies can further this research. Such confluence resulted in the creation of the International Helicopter Safety Team (IHST) (ICAO, 2010). The entity has conducted continuous accidents analyses on existing data and have authored safety and training implementation strategies for helicopter-specific safety knowledge (Roskop, 2013).

According to the findings of this study, technology did not critically affect accident rates. It was found that accidents are higher amongst smaller helicopters. Researchers tell us that there was no effect on SMS upon IA (Ballard, 2014; Wittmer & Drax, 2014). A quantitative research method was used in this study through a partial mediation model. Structural equation modeling was used to determine if the presence of SMS can predict the operational effectiveness and incidents and accidents or not.

The study also explored whether operational effectiveness can be concluded from the incidents and accidents. Numerous factors mediated the relationship between safety management systems and operational effectiveness. Incidents, accidents and operational effectiveness were used in this analysis. Incidents and accidents were independent variables while operational effectiveness was a dependent variable.

The statistical methods confirmatory factor analysis (CFA) and path analysis (PA) were used to explain variation in these relationships. Exploratory factor analysis showed a two-factor solution for IA and OE. Meanwhile, confirmatory factor analysis was used to determine the best fit of the items and factors. The CFA showed a good fit and acceptable convergent validity. The results not only answered all questions but also supported the entire hypotheses within the study paradigm.

Research in the US about SMS is focused on the aviation safety culture, SMS implementation, accident analysis, crew management, risk analysis and perception of safety. The practices of aviation safety research and analysis efforts are not well coordinated in the industry (Thaden & Gibbons, 2008). The Commercial Aviation Safety Team (CAST) was originally formed to reduce the fatal accidents in the commercial (airplane) aviation industry by half from 2010 to 2025 (Rohn, 2012). This effort predated but informed the work of the IHST.

Accident rates in the helicopter industry from 1995 through 2005 averaged to be 570. This high accident rate forced action and the IHST was created. The findings from the current research provides a great source of information in the field of safety measurement and this research should be expanded to other segments of the aviation industry.

The investigation about safety management systems, operational effectiveness and incidents and accidents for small organizations has provided a more comprehensive perspective on helicopter safety. It also elucidates the relationship between IA and safety measures in the helicopter industry. The potential impact of this study is positive because it helps to understand safety measures and the best practices of implementation. The safety measures are very important because incidents and accidents affect industry and society. When an accident results in loss of human life then it affects individuals and questions the safety posture of an organization.

The study utilized calculations and measurements through structural equation models which represent a diverse set of mathematical models, computer algorithms, and related statistical techniques. This is a very general and powerful analysis technique exploring implications of study outcomes within existing boundaries.

Recommendations

Recommendations for practice. Through the findings of the current study, it was determined that safety measures are evolving with the passage of time. Thus, in practice, there is a need for better implementation of safety management systems to prevent incidents and accidents. In terms of safety, further recommendations can be provided by using key trends and previous data such as been done in the IHST and by incorporating these research results therein.

Aviation safety specific research would inform the identification and implementation of safety management systems for the helicopter industry as a whole, but specifically where it is needed the most, in the small high-risk segments. The research data would also help in identifying the operational benefits in the future. Several recent studies identify the need to utilize a systems approach to study the influence of SMS. Continued interest exists within the industry to reach those areas of where most accidents occur as illustrated in programs fostered by the IHST and HAI (JHIMDAT, 2014; Roskop, 2013).

Recommendations for research. Future researchers could employ a systems approach to study the management infrastructure. The management system plays a very important role in the overall safety of systems or organizations. This system is not only based on leadership and accountability but also hazard identification, risk management, and information control. Further areas include training and auditing approaches to achieve optimal results from the safety measures.

The methodologies used in this study were: family of statistical methods, confirmatory factors analysis (CFA) and path analysis (PA). The successful implementation of this process suggests that future research can be conducted utilizing the same techniques. Non-experimental research was conducted because there was a need to collect data at various points in time (Matthews & Ross, 2010). In the future, researchers could perform further manipulation of variables, because random sampling does not represent the entire control and experimental groups. Participants involved in non-sampling may lack appropriate data that represent the construct identified for this study. Correlations and covariance between variables used in the investigation may vary in this calculation hence affecting the outcome of the study.

Last, future researchers may wish to expand this research to explain areas of discrepancy in the current findings. According to Chen (2012) the present study supports their work regarding the relationships between OE, IA, and SMS. There could be some perceived contradictions between this study and literature review; however, these are related to research by various stakeholders. Unexpected positive relationships regarding incidents and accidents may have caused a “reverse causation” condition. Reverse causation occurs when the presence of incidents or accidents actually influence safer behaviors or investments which then influence employees to believe that safety has improved (Smith & DeJoy, 2014). Such areas of discrepancy provide clear guidelines to conduct research that can be beneficial to this case study.

Conclusions

Helicopter operations have been augmented and researched since the 1940s (Fox, 2005). Worldwide efforts with regional partners of the IHST helped to promote SMS implementation to the industry beginning in 2006 (FAA, 2014a). A report from the JHIMDAT (2014) identified that in smaller helicopter entities, accident rates were still consistent (FAA, 2014b). Much of the safety doctrine and literature rests within FAA circulars, orders. The present research is valuable within this cause because of its confirmation and valuable evidence towards reducing the rate of incidents and accidents.

Overall, the study found the null hypothesis to be true. This conclusion claims that safety management systems do not predict operational effectiveness. The confirmatory analysis was done to determine this statement and it found that OE is not predicted by SMS. The correlation between safety management systems and operational effectiveness is critical to understanding how incident and accident prevalence has been concerned (Fernández-Muñiz, et al., 2009).

Incidents and accidents are mediators of the relationship between safety management systems and operational effectiveness. The study found that there is a partial relationship between safety management and operational effectiveness and this is mediated by incidents and accidents. It was further concerned with the high rate of accidents and incidents amongst smaller helicopters.

The study supported the hypothesis that the occurrence of incidents and accidents in the helicopter industry does predict operation effectiveness. Accidents and incidents can occur even if there are good operational measures put in place. That is because incidents and accidents (AI) involve both human, environmental factors and machine fallibility. On the other hand, operational effectiveness is the collection of strategies to make a company financially competitive (Porter, 1996).

The International Helicopter Safety Team (IHST) had set a target of reducing incidents and accidents in the helicopter industry by about 80% in the year 2016. To implement safety management measures it is necessary to enhance operational effectiveness and reduce alarming rates of incidents and accidents. Research from this study would be valuable in furthering the initiative.

This strategy would be good for both helicopters and human life. Nevertheless these findings are disputed because of limited relationships between key variables. The study findings can be a great source of data that is needed to bring the much-needed change in the aviation industry that can lead to a reduction in the occurrence of incidents and accidents.

The purpose of setting up helicopter SMS by the Helicopter Safety Team was to control risk and uncertainties and provide a mechanism to control them whenever they occur (Majumdar, & Jarvis, 2012). Limitations to this strategy have been identified and part of that is based on safety culture and tangential systems that are already in place. This should change because research has shown that the safety management strategies put in place do not necessarily improve the operational performance or reduce the incidents and accidents.

Since the year 2000, the SMS in helicopter safety has for a long time been concerned with issues such as safety culture; human factors, engineering issues and accident analysis (von Thaden & Gibbons, 2008). There is a need for a change in order to see different positive results as this study has clearly shown. There are several ways that the research study findings are in agreement with the existing literature. The purpose of this study was to determine a partial mediation model using structural equation modeling to assess if the presence of safety management system (SMS) predicted operational effectiveness (OE) and incidents and accidents (IA), and if OE was predicted by IA mediated the relationship between SMS.

The kind of change needed as a result of this study would take place at an organizational level. Influencing policies would provide greater benefits regarding air safety. There is a need to integrate research in the design of new strategies and the inclusion of a broader number of stakeholders in the design of these strategies especially in relation to involvement amongst smaller helicopter organizations.

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Appendices

Appendix A: Participant Recruitment Letter

PhD Research Request

Fellow Helicopter Crewmember,

The aviation industry promotes safety management systems (SMS). Incidents and accidents still occur. How many small companies use SMS? How well does SMS work? Is SMS related to incidents and accidents? Does SMS affect company performance? Do incidents and accidents affect company performance?

My name is Scott Burgess and I am a veteran, and Ph.D. candidate from Northcentral University. My study is an attempt to determine the relationship between SMS, incidents and accidents, and company performance. The results of this study will be shared with the industry.

Please follow the link below and fill out pre-survey questions to confirm your eligibility. The survey does not include any identifiable data about the crewmember or place of employment. The survey will take about 12 minutes.

[hyperlinked to survey website]

Thank you very much for your help!

Principal Investigator
Scott Burgess
Ph.D. Candidate
Northcentral University
940-232-1179
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Appendix B: Internet Survey Instrument

Section 1 (Demographics)

1. In your experience with a small helicopter operation (5 ships and less), what "FAA Part" did you most operate under (Choose one)?
    a. FAR Part 61
    b. FAR Part 91, 133, 135, 137
    c. FAR Part 141
2. What is your gender?
    a. Female
    b. Male
3. What was your age when working with the small entity?
    a. 21-30
    b. 31-40
    c. 41-50
    d. 51-60
4. Type of initial Helicopter flight training?
    a. Civilian
    b. Military
5. Years of flying experience
    a. 1-3
    b. 4-6
    c. 7-9
    d. 10 or more
6. Number of flight hours
    a. (fill in the blank)
7. Type of airman certificate?
    a. Private
    b. Commercial
    c. Airline Transport Pilot
8. Are you Instructor rated?
    a. Yes
    b. No
9. Number of helicopters in the small organization you were affiliated with?
    a. 1
    b. 2
    c. 3-5
    d. 6 or more
10. Type of helicopters in your organization
    a. Reciprocating Engine
    b. Turbine Engine
    c. Mixed
11. Have you ever heard of the International Helicopter Safety Team?
    a. Yes
    b. No

12. Incident/Accident Occurrence: Were you exposed to or did your organization experience an incident or accident in a small helicopter organization with under 5 aircraft since January 1st, 2006?
    a. Yes
    b. No
13. When were you first exposed to some form of safety management?
    a. Never
    b. When in Instructional Training and/or Personal Private
    c. Commercial Operations
    d. Beyond all of the above choices

Safety Management System Evaluation Scale

Documentation and Commands (DC)						
DC1	Managers order clear commands for SMS operation.	1	2	3	4	5
DC2	The contents of SMS manual are readily understood.	1	2	3	4	5
DC3	System can precisely save, secure and trace the information.	1	2	3	4	5
DC4	Establish an incentive system to reward the good SMS performance.	1	2	3	4	5
DC5	There is an intranet system to share the SMS related information.	1	2	3	4	5
DC6	Simple and unified standard for safety behavior.	1	2	3	4	5
DC7	Documents are reserved and updated in a standardized format.	1	2	3	4	5
Safety promotion and training (PT)						
PT8	Employees learn the concepts through training.	1	2	3	4	5
PT9	Employees know how to execute SMS through training.	1	2	3	4	5
PT10	Employees upgrade the self-managed ability through training.	1	2	3	4	5
PT11	Company provides training continuously.					
PT12	Employees construct the correct safety attitude through training.	1	2	3	4	5
PT13	Company holds SMS promotion activities regularly.	1	2	3	4	5
PT14	Company provides diverse training programs.	1	2	3	4	5
Executive management commitment (EMC)						
EMC 15	Top management participates in the SMS related activities.	1	2	3	4	5
EMC 16	Management handles safety issues following just culture.	1	2	3	4	5
EMC 17	Top management declares the determination to execute SMS, even when the company finance is in the down cycle	1	2	3	4	5
EMC 18	Top management declares commitment in formal documents	1	2	3	4	5
Emergency preparedness and response plan (EP)						
EP19	Employees acquainted with the plan	1	2	3	4	5

EP20	Employees are trained to execute the plan periodically	1	2	3	4
EP21	Company simulates the plan periodically.	1	2	3	4
EP22	Company establishes the plan with clear procedures and individual responsibility	1	2	3	4
	Safety management policy (MP)				
MP23	Company develops the precise standard to monitor and evaluate the SMS performance	1	2	3	4
MP24	Company continuously improves the SMS performance	1	2	3	4
MP25	Company's internal reporting channel is highly accessible.	1	2	3	4

<u>Section 2 (SMS Exposure)</u>

Questions in this segment relate to your exposure to the components of SMS as defined within the context of our industry (regulators, manufacturers, and industry organizations).

Again, please as you answer, only consider your exposure to SMS in the context of the time you were with a small helicopter entity with less than five aircraft, and within the last 10 years. <u>*Your answers indicate agreement of the presence of the items under each dimension in the small helicopter organization.*</u>

Each of the dimensions below were compiled by researchers and consider SMS documentation from the FAA, ICAO, CASA, Transport Canada, UKCAA, and Taiwan CAA.

Safety Management System Evaluation Scale

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

<u>Section 3 (Incident and Accident Exposure)</u>

Questions in this segment relate to the presence of an incident or an accident in the organization you were affiliated with.

Please only consider your exposure to incidents and/or accidents in the context of the time you were with a small helicopter entity with less than five aircraft, and within the last 10 years.

Incidents – Accidents (IA)

In the helicopter organizations you have been affiliated with (training, personal, and professional) that did or did not have an official SMS in place, and with regard to the occurrence of an incident or accident, please indicate your assessment of these occurrences with a “yes” or “no” indication.

Consider in your answering that IA occurrence happened in one of two levels of operations:

- Personal or private (PP), or an instructional or training (IT) environment (defined below)
- Other than PP/IT such as agriculture, tours, law enforcement, surveying etc.

If you were a part of both levels of organizations, then please answer for both. If not part of both levels, then please only answer according to that organization.

Definitions

Incident. Often confined to an episode where there is a near miss. This is also unplanned and could have resulted in an accident. This also indicates that a hazardous condition exists.

Accident. Common terms associated with the departure from a normal condition. Accidents are unplanned and can include a series of events. They often result in damage, through and up to including death. They are often characterized as incidents and mishaps.

Personal and private (PP). These high-risk small entity flight operations primarily consist of privately-owned aircraft and rented aircraft. Aircraft in this helicopter industry segment are most often the single-engine (turbine or reciprocating) light helicopters. FAR Part 61.113 (FAA, 2014b) identifies the privileges for the private pilot. These flights are generally non-commercial and operated under FAR Part 91 with little regulatory oversight.

Instructional and training (IT). In this high-risk small entity segment of the helicopter industry, flight crew training is the primary mission for instructional flights that include both ground and flight instruction (FAA, 2014b; JHSAT, 2007). Students at flight schools have been progressing in initial through commercial flight training in small, light-weight, less complex helicopters (primarily with reciprocating engines) in small flight school/training entities. These less-complex aircraft, if not flown properly, can be harder to control.

26	Incident Occurrence (SMS program in place) at PP/IT level	Yes	No
27	Incident Occurrence (SMS program in place) but other than PP/IT level	Yes	No
28	Incident Occurrence (No SMS program in place) at PP/IT level	Yes	No
29	Incident Occurrence (No SMS program in place) but other than PP/IT level	Yes	No
30	Accident Occurrence (SMS program in place) at PP/IT level	Yes	No
31	Accident Occurrence (SMS program in place) but other than PP/IT level	Yes	No
32	Accident Occurrence (No SMS program in place) at PP/IT level	Yes	No
33	Accident Occurrence (No SMS program in place) but other than PP/IT level	Yes	No

Section 4 (Operational Effectiveness Assessment)

Questions in this segment attempt to determine your assessment of competitiveness and economic performance of the small helicopter organizations you may have been affiliated with in the last 10 years. Your understanding of exact financial status in this case is not relevant, however your exposure to the successes or challenges would be assessable from your position within the organization.

In the helicopter organizations you have been affiliated with, report your degree of satisfaction with these indicators on a 5-point scale where “1 = extremely dissatisfied” to “5 = Extremely Satisfied”

Definitions

Operational Effectiveness. Operational Effectiveness is the application of work activity in an organization that includes functions to enhance performance (specifically as used in this study, competitiveness and economic-financial performance). These functions must fit the entity and its operation and allow for the implementation of strategies to improve an entity's performance. Continually improving functional performance can occur by reducing defects.

34	Product quality	1	2	3	4	5
35	Productivity of the organization	1	2	3	4	5
36	Customer satisfaction	1	2	3	4	5
37	Reputation in the marketplace	1	2	3	4	5
38	Innovation	1	2	3	4	5
39	Growth in the market	1	2	3	4	5
40	Growth in profits	1	2	3	4	5
41	Profit/sales	1	2	3	4	5