Examining the Relationship between Organizational Safety Culture and Safety Management System Implementation in Aviation

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Abstract

The International Civil Aviation Organization (ICAO) and the national aviation agencies that draft regulations mandating Safety Management System (SMS) implementation require measuring of SMS implementation to demonstrate compliance. There is no current regulatory requirement for air carriers to assess or confirm SMS implementation nor to comply with the ICAO mandate. Member countries of the ICAO convention can refuse to allow commercial air operations for air carriers without an implemented SMS verified by the air carrier's National Aviation Authority. National aviation regulatory agencies postulate that an implemented SMS causes the organization's safety culture development, while organizational behaviorists postulate that it is the organization's safety culture which causes SMS implementation. The specific problem addressed in the current research was that the Federal Aviation Administration (FAA) cannot measure the level of SMS implementation based on the level of safety culture, or measure the level of safety culture based on the level of SMS implementation. The basis for both arguments has been on emergent theory and not empirical evidence. Therefore, this quantitative correlational study examined the relationship between the level of SMS implementation and the level of organizational safety culture. Participants were 404 pilots from four Federal Aviation Regulation Part 135 air carriers that completed the Safety Culture and Safety Management System Survey, a 5-point Likert-type scale, administered through the Internet. The relationship between the level of SMS implementation and the level of organizational safety culture was positive and significant, $F(15,388) = 98.423$, $p < .001$. Relationships were also positive and significant for management commitment and safety promotion. Results suggested higher levels of organizational safety culture correlated to higher levels of SMS implementation. The relationship between organizational safety culture and the moderating variables, management commitment and safety promotion, were also positive and significant. Indications are that the moderating variables are as related to SMS implementation as to organizational safety culture. Indications are that no single measure adequately reflects successful SMS implementation, and that all variables must be measured to determine successful SMS implementation. Future research could examine the role the moderating variables have on influencing implementation of SMS from a systems engineering application.

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Chapter 1: Introduction

The regulatory agencies mandating Safety Management Systems (SMS) implementation postulated that an implemented SMS caused the organization's safety culture (Federal Aviation Administration [FAA], 2006a, 2009a; International Civil Aviation Organization [ICAO], 2005, 2008). Conversely, organizational behaviorists postulated that the safety culture caused SMS implementation (Mitchell, Sharma, von Thaden, Wiegmann, & Zhang, 2002a; von Thaden & Gibbons, 2008). The basis of both arguments was on emergent theories and not on empirical evidence. Researchers have not established an empirical relationship between SMS implementation and safety culture.

The estimate of aviation accidents caused by human error has been as high as 80% (von Thaden & Gibbons, 2008). However, the human error rate reflects safety performance and not a safety record (Mitchell et al., 2002a; von Thaden & Gibbons, 2008). The stated purpose of implementing an SMS is to improve safety by improving safety performance (FAA, 2006a, 2009a; ICAO, 2005, 2008; von Thaden & Gibbons, 2008). Improving the human interface of safety performance requires changing the safety behavior or culture of an organization (von Thaden & Gibbons, 2008). The mandatory implementation of legislation requiring SMS implementation by air carriers and validation of implementation by the National Aviation Authorities presupposes measuring SMS implementation (FAA, 2006a, 2009a; ICAO, 2005, 2008; von Thaden & Gibbons, 2008).

At the time of this study, no established criteria existed through which the Federal Aviation Administration (FAA) could measure or validate SMS implementation or validate improvement in safety performance (FAA, 2006a, 2009a; ICAO, 2005, 2008; von Thaden & Gibbons, 2008). Regulators serve as enforcers of regulation compliance, which is recorded and publicized in the form of a safety record (von Thaden & Gibbons, 2008). Regulators promote the FAA's role as enforcer because no mechanism exists, where the FAA is not required to enforce (Mitchell et al., 2002a; von Thaden & Gibbons, 2008). Validation of an implemented SMS dictates that the FAA measure SMS implementation against regimented standards regardless of any organizational culture that manages safety performance (Mitchell et al., 2002a; von Thaden & Gibbons, 2008). However, only measuring SMS implementation against regulatory standards conflicts with ICAO and FAA frameworks, which stated SMS implementation determined the safety culture (FAA, 2006a, 2009a; von Thaden & Gibbons, 2008). No mechanism exists within the SMS frameworks to measure the safety culture of an organization or the SMS implementation of an organization (FAA, 2006a, 2009a; von Thaden & Gibbons, 2008).

The purpose of this quantitative correlational study was to examine the relationship between positive organizational safety culture and SMS implementation in four Federal Aviation Regulation (FAR) Part 135 air carrier operators. This study addresses the research topic, related literature, methodology, findings, and conclusions associated with the research on a key legislative safety mandate in aviation.

Background

According to the International Civil Aviation Organization (ICAO) in Annex 6, Part II, of the Standards and Recommended Practices mandate, Member States must require commercial air operators to implement a safety management system by January 1, 2009. The State must accept the safety management system in order to operate internationally (ICAO, 2008). The term *Member States* refers to the national aviation authority of the country where an aircraft operator registers an aircraft and under which that national aviation authority has jurisdiction (ICAO, 2008). D. Arendt, FAA SMS Program Manager, stated that currently only Singapore and Canada require operators to implement safety management systems (D. Arendt, personal communication, March 3 and 4, 2009). On February 23, 2009, the acting administrator of the FAA signed the authorization for the Aviation Rulemaking Committee (ARC) to develop SMS regulations (D. Arendt, personal communication, March 3 and 4, 2009).

The ICAO identified organizational safety culture as a key component of SMS (von Thaden & Gibbons, 2008). Safety management systems provide an organizational framework to manage safety and serve as the structure that generates a positive safety culture (FAA, 2006a, 2009a; von Thaden & Gibbons, 2008). As the FAA establishes requirements for United States air carriers to implement SMS, continued research and measurement of organizational safety culture can provide better understanding of organizational performance, accountabilities, policies, and procedures surrounding safety (von Thaden & Gibbons, 2008).

Problem Statement

The specific problem addressed in the current study is that the FAA cannot measure the level of SMS implementation based upon the level of safety culture or measure the level of safety culture based upon the level of SMS implementation because researchers and other entities have not established the relationship between the two. The measures conflict, while the FAA literature assigns causation to both (FAA, 2008c). At the time of this study, no FAA requirements to assess and confirm SMS implementation for air carriers existed (FAA, 2008c). As an ICAO member State, the United States committed to comply with ICAO safety standards (FAA, 2008b). However, the number of FAA accepted or approved SMS programs for commercial air operators in the United States was zero as of January 1, 2009 (FAA, 2009b). The result creates an operational risk for the United States commercial aviation industry, creating the inability to operate internationally between ICAO member States (ICAO, 2008). At the time of this research, there were 1,724 fixed wing turbine aircraft registered FAR Part 135 air carrier operators in the United States (FAA, 2009b). Although operating under Federal Aviation Regulations, the operators had not met the ICAO mandate (FAA, 2009c).

Positive safety culture is a result of successful SMS implementation (FAA, 2006b, 2009a; ICAO, 2008). Organizational culture influences safety management systems (Mitchell, et al., 2002b; Shappell & Wiegmann, 2006). Researchers identified SMS implementation as a constituent part of a positive safety culture (Mitchell et al., 2003a; Shappell & Wiegmann, 2006). Although extensive research defined the characteristics that measure and indicate positive organizational safety cultures, further research should investigate the relationship between positive organizational safety culture and successful implementation of SMS in air carriers (Mitchell et al., 2002b; von Thaden & Gibbons, 2008). The FAA currently has no method to measure safety culture; therefore, the FAA cannot validate SMS implementation even though the key objective is to develop a positive safety culture as a component of SMS implementation (FAA, 2006b, 2008c, 2009c).

Purpose

The purpose of this quantitative correlational study was to examine the relationship between the level of organizational safety culture and the level of SMS implementation in four FAR Part 135 air carriers. The study employed an Internet-based survey to determine whether a correlation existed between the level of SMS implementation and the level of organizational safety culture (FAA, 2006b, 2008c; Mitchell et al., 2003c). Measuring the correlation between the dependent variable of SMS implementation and the independent variables of organizational safety culture, management commitment, and safety promotion indicated the organization's ability to implement a verifiable SMS program (FAA, 2006b, 2008c, 2009a, 2009b, 2009c; ICAO 2005; Mitchell et al., 2003c; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008; Xaiver, 2005).

The survey method allowed access to a large number of the 4,295 pilots in the four FAR Part 135 air carrier operators in the United States participating in the Federal Aviation Administration Safety Team (FAAST) SMS Pilot Project (FAA, 2006b, 2008c, 2009b; Trochim & Donnelly, 2007; Yin, 2009). The assumption was that the survey would garner a medium effect number of responses, thus requiring a minimum sample size of 368 pilots to achieve 0.80 statistical power (Cohen, 1992). Statistical analysis required a two-tailed Wilcoxon-Mann-Whitney t-test using G Power 3.0.10 with an alpha of 0.05. The medium effect size equaled 0.3 and .80 power to validate a required minimum of 368 respondents (Faul, Erdfelder, Lang, & Buchner, 2007). The primary duty location of FAR Part 135 on-demand commercial pilots is normally the flight deck of the aircraft during flight operations. Non-probability convenience sampling using an

Internet protocol permitted participants to respond at a time convenient for their schedules (Trochim & Donnelly, 2007). Non-probability convenience sampling permitted rapid and sufficient data collection (Trochim & Donnelly, 2007).

Theoretical Framework

Efforts to improve safety in aviation are evolving from technical regulations and specifications compliance methodology to a systems management approach (FAA, 2006a, 2009a, 2009c; ICAO, 2005, 2008; Marx, 2009; Vincoli, 2006). Although interrelated, two distinctly different approaches to improving safety performance have emerged. Both approaches have foundations in general systems theory. One method improves safety through changes to the organizational safety culture, a holistic approach examining the system as a complete functional unit. The other method undergoing drafting into Federal regulations, implements an SMS with a reductionist approach that examines the subsystem components downward within the system (FAA, 2006a, 2009a, 2009c; ICAO, 2005, 2008; Marx, 2009; Vincoli, 2006; von Thaden & Gibbons, 2008).

Practitioners of the organizational safety culture approach postulated that the development of a SMS resulted from the organization's safety culture and that safety performance improvements resulted from managing organizational culture (Marx, 2009; von Thaden & Gibbons, 2008). Practitioners of the SMS approach proposed that the organization's safety culture resulted from implementing a SMS and that safety performance improvement developed from applied scientific management techniques as did other business functions within the organization (FAA, 2006a, 2009a, 2009c; ICAO, 2005, 2008; Marx, 2009; Vincoli, 2006). Figure 1 illustrates the two competing theories of managing the safety function in air carriers.

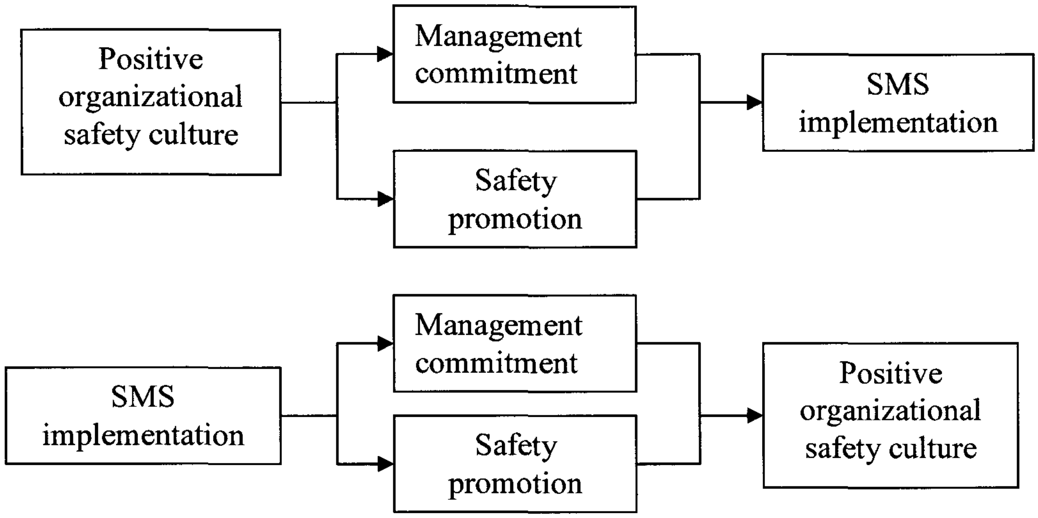

Figure 1. SMS versus safety culture causation models.

Effective safety management implementation requires the senior leader or manager in an organization to be responsible or accountable for the safety culture or attitude of the organization (FAA, 2009c; Gibbons, von Thaden, & Wiegmann, 2007; Helmreich & Merritt, 2005; Johnston, Lee, Maurino, & Reason, 2006; Mitchell et al., 2002a). The senior manager's commitment and direct involvement associated with promoting safety establishes the organization's corporate safety culture and attitudes (Gibbons et al., 2007; Helmreich & Merritt, 2005; Johnston et al., 2006; Mitchell et al., 2002a). Demonstrated, written, and verbal commitment and involvement in the organization's safety indicates management's commitment to assume ownership of the organization's safety program (von Thaden & Gibbons, 2008). At this point, the safety professional becomes a technical resource for the safety program and the organization establishes its safety culture (von Thaden & Gibbons, 2008).

In this type of environment, managers learn to apply safety management skills in the performance of their day-to-day activities. Some of these skills can include hazard and risk identification, risk assessment, root cause analysis, response planning, response implementation, and follow-up (FAA, 2006a, 2009a; ICAO, 2005, 2008). Safety becomes just another area for discussion during business meetings, which reinforce communication and safety promotion (FAA, 2006a, 2009a; ICAO, 2005, 2008). When management advocates safety, the entire organization improves safety awareness and safety performance (Marx, 2009; von Thaden & Gibbons, 2008). As safety culture matures the organization can address at risk behaviors and apply behavior modification techniques, such as reinforcement or correction, which result in long-term sustainable safety performance improvements (Marx, 2009).

The rapid pace in the aviation transportation industry, including changes in technology, environmental conditions, and influence of rising costs, presents tremendous challenges for air carrier managers (Dulac, Leveson, & Marais, 2004). Consumers assume that airlines offer safe, high quality transportation services at reasonable and affordable costs (Dulac et al., 2004; Dupre & Le Coze, 2007). Thus, the goal of air carrier organizations should be to improve safety, while building confidence in customers, regulators, and professionals concerning their safety, processes, and transportation outcomes (Dupre & Le Coze, 2007). Air carrier managers must find new ways to provide transportation services to meet these requirements; safety management can constitute an appropriate response to the challenge (Dulac et al., 2004). Safety management reorganizes safety in air carrier organizations as efficiently and effectively as possible to achieve an optimum outcome in the safety of air transportation services overall performance results (Dulac et al., 2004).

Safety management systems can provide air carrier organizations with a template for safe and successful air operations (FAA, 2006a, 2009a; ICAO, 2005, 2008). Safety management systems develop an organizational safety culture, defined and supported by the constant attainment of safety through an integrated system of techniques and tools (Goldfarb et al., 2001). Safety management systems utilize techniques to improve the effectiveness, efficiency, and flexibility of safety efforts to reduce risks associated with air operations as a whole (Eurocontrol, 2006). Thus, the conceptualization of SMS implementation is a logical and systematic method to integrate system safety concepts throughout an organization (Dulac et al., 2004; Dupre & Le Coze, 2007; FAA, 2006a, 2009a; ICAO, 2005, 2008).

J. Coyne, the President of the National Air Transportation Association and R. Sumwalt, Chairman and board member of the National Transportation Safety Board, agreed that SMS offered a business plan for managing safety much like any other function in a business (J. Coyne, personal communication, March 3 and 4, 2009; R. Sumwalt, personal communication, March 3 and 4, 2009). To achieve production objectives, the management of any aviation organization requires overseeing many business processes (FAA, 2009c; ICAO, 2005; Weinstein, 1996). Managing safety is one such business process. As financial management and human relations management are core business functions. Safety management should also be a core business function (FAA, 2009c; ICAO, 2005; Weinstein, 1996).

Research Questions

Organizations with a positive safety culture implement a sustainable SMS more often than do organizations without a positive safety culture. Therefore, successful SMS implementation relates to the level of organizational safety culture (Gibbons et al., 2007; Helmreich & Merritt, 2005; Johnston et al., 2006; Mitchell et al., 2002a). The research questions used to examine the relationship between successful implementation of SMS and the level of organizational safety culture included:

Q1. To what extent does organizational safety culture relate to SMS implementation?

Q2. To what extent does management's commitment to safety relate to SMS implementation?

Q3. To what extent does safety promotion relate to SMS implementation?

Hypotheses

$H1_0$. There is no significant correlation between organizational safety culture and SMS implementation.

$H1_a$. There is a significant correlation between the organizational safety culture and SMS implementation.

$H2_0$. There is no significant correlation between management's commitment to safety and SMS implementation.

$H2_a$. There is a significant correlation between management's commitment to safety and SMS implementation.

$H3_0$. There is no significant correlation between safety promotion and SMS implementation.

$H3_a$. There is a significant correlation between safety promotion and SMS implementation.

Nature of the Study

The quantitative correlational study examined the relationship between the level of organizational safety culture and the level of SMS implementation in four FAR Part

135 air carriers. An Internet-based survey determined whether a correlation existed between the level of SMS implementation and the level of organizational safety culture (FAA, 2006b, 2008c; Mitchell et al., 2003c). Measuring the correlation between the dependent variable of SMS implementation, and the independent variables of organizational safety culture, management commitment, and safety promotion indicated the organization's ability to implement a verifiable SMS (FAA, 2006b, 2008c, 2009a, 2009b, 2009c; ICAO 2005; Mitchell et al., 2003c; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008; Xaiver, 2005). The Internet-based survey questionnaire employed the abbreviated Commercial Aviation Safety Survey (CASS) instrument developed by Mitchell et al. (2003c) with added questions based on the FAA's SMS Framework Advisory Circular (AC) 120-92A. Participants included 404 of the 4,295 pilots in four FAR Part 135 on-demand air carriers identified as participating in the Federal Aviation Administration Safety Team (FAAST), SMS Pilot Project. Non-probability convenience sampling noted a required minimum of 368 responses. The survey used a 5-point Likert-type style instrument in which respondents selected one of a series of choices from strongly agree to strongly disagree.

Significance of the Study

The regulatory agencies mandating SMS implementation postulated that an implemented SMS created an organization's safety culture (FAA, 2006a; ICAO, 2008). On the other hand, organizational behaviorists postulated that the safety culture caused SMS implementation (Reason, 2000; von Thaden & Gibbons, 2008). The basis of both arguments was on emergent theories and not on empirical studies. At the time of this study, researchers had not established an empirical relationship between SMS implementation and safety culture.

Safety management systems require a safety oriented organizational culture supported by senior management commitment and involvement, organizational learning, team work and collaboration, open communication, continuous improvement, safety focus, and monitoring and evaluation of safety (FAA, 2006a, 2009a, 2009c; ICAO, 2005, 2008; Marx, 2009; Vincoli, 2006; von Thaden & Gibbons, 2008). Lack of organizational and individual safety culture can significantly contribute to aviation accidents, sometimes as much as 80%, and influence the organization's safety performance (Eurocontrol, 2006; Johnston et al., 2006; Mitchell et al., 2002b; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Replicating the current study with different types of air operations and contexts could develop a model of SMS to implement in an organizational culture context (von Thaden & Gibbons, 2008; Xaiver, 2005).

System safety incorporates a systems management approach and methodology for organizations to manage safety performance (Johnston et al., 2006; Reason, 2000; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Organizational safety culture influences implementation of safety management systems (Helmreich & Merritt, 2005; Reason, 2000; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Consequently, improving organizational safety performance can reduce the number of accidents and incidents attributed to human errors and latent organizational pathogens (Gibbons et al., 2007; Helmreich & Merrit, 2005; Reason, 2000). As in any other business function, implementing SMS to manage safety reduces accidents and improves safety performance within the organization and the individual (Gibbons et al., 2007;

Helmreich & Merritt, 2005; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Measuring organizational safety culture predicated on the characteristics of a positive organizational safety culture identified by Mitchell et al. (2003c) provides a working model to evaluate successful implementation of a SMS. Von Thaden and Gibbons (2008) proposed that, to be effective, SMS implementation dictated the need for a positive organizational safety culture.

Definitions

The primary variables in this study are organizational safety culture and SMS implementation (FAA, 2006a, 2009a, 2009c; ICAO, 2005, 2008; Marx, 2009; Vincoli, 2006; Weinstein, 1996). Understanding the concepts of organizational safety culture and SMS is vital in understanding the current research. Both concepts combine several terms or components, which defined individually aids understanding of the whole. Critical to both concepts is the basic understanding of the constituent components of culture, management, safety, and systems. The following definitions will apply to the current study.

Culture. Culture incorporates the behaviors and beliefs of a particular social, ethnic, or age group, and the predominating attitudes and behavior that characterize the functioning of a group or organization (Gibbons et al., 2007; Helmreich & Merritt, 2005; Mitchell et al., 2003a).

Organizational safety culture. Organizational safety culture indicates an enduring characteristic of an organization, reflected in the organization's consistent way of dealing with critical safety issues (Mitchell et al., 2003b). Safety culture includes behavioral aspects, what people do, the situational aspects of the company, and the available safety resources (Health and Safety Executive [HSE], 2005). A useful definition of an organizational safety culture incorporates the predominate characteristics of an organization's attitudes, behaviors, and beliefs towards the action of being safe (Helmreich & Merritt, 2005; HSE, 2005; Mitchell et al., 2003b).

Safety. Safety is the condition or state of being safe, including (a) freedom from danger or hazard; (b) exemption from hurt, injury, or loss; (c) freedom from whatever exposes one to danger or from liability to cause danger or harm; (d) safeness, hence the quality of making safe or secure, or giving confidence, justifying trust, insuring against harm or loss; and (e) the action of being safe (Dekker, 2006; Marx, 2009).

System. A system is a group of interacting, interrelated, or interdependent elements forming a complex whole. These elements include (a) an ordered and comprehensive assemblage of facts, principles, and doctrines in a particular field of knowledge or thought; (b) a system of philosophy; (c) a coordinated body of methods or a scheme or plan of procedure; (d) an organizational scheme; and (e) a system of government (Dulac et al., 2004; Durham, Talso, & Wenner, 2006; Harris & Morley, 2006; Jermier, 2004; Johnston et al., 2006).

Safety management system. Safety management systems offer a quality management approach to controlling risk (Jackson, 2008). The FAA (2009a) defined safety management systems as a formal, top-down business-like approach to managing safety risk. A successfully implemented SMS includes systematic procedures, practices, and policies for the management of safety. To include SMS in the context of aviation (Duffy, 2006), a workable definition of safety based on the acceptability of risk is "If a particular risk is acceptable, then we consider that thing or operation to be safe.

Conversely, when we say something is unsafe we are really saying that its risks are unacceptable" (Woods, 1997, p. 28). The dictionary definition of safety is too simplistic for the complex environment of aviation. The acceptability of risk has significance on the way the public perceives safety (Dekker, 2006; Marx, 2009).

Safety culture. The definition of safety culture is, "the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization" (Mitchell et al., 2003b). Safety culture refers to the extent to which individuals and groups commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to learn, adapt and modify behavior based on lessons learned from mistakes, and receive rewards in a manner consistent with these values (Mitchell et al., 2003b).

Safety management system implementation. Four characteristics, or pillars, of a functioning SMS include policy, safety risk management, safety assurance, and safety promotion (ALPA, 2006; FAA, 2006a, 2009a; ICAO, 2005, 2008; Reason, 2000).

Summary

At the time of this study, no FAA requirements existed either to assess or confirm SMS implementation for air carriers (FAA, 2008c). As an ICAO *Member State*, the United States has committed to comply with ICAO safety standards (FAA, 2008b). However, the number of FAA accepted or approved SMS for commercial air operators in the United States was zero as of January 1, 2009 (FAA, 2008c). At the time of this study, there were 1,724 fixed wing turbine aircraft registered FAR part 135 air carrier operators in the United States (FAA, 2009b) not meeting the ICAO mandate (FAA, 2009c). To date: however, the aviation industry has been successful in aircraft accident prevention.

Title 14 of the Code of Federal Regulations (CFR) FAR Part 135 on-demand sector noted a decrease from 118 accidents in 1986 to 66 accidents in 2005 (FAA, 2009a).

However, lack of compliance created an operational risk for the United States commercial aviation industry, to wit the inability to operate internationally between ICAO member States (ICAO, 2008). The international aviation community, through the ICAO, mandated that member countries institute regulations requiring air carriers to implement a SMS (ICAO, 2008). The effective date of the mandate has passed (ICAO, 2008). Despite the requirement, the FAA has not implemented SMS regulation and has no means to measure or validate implementation of a SMS. However, the international aviation community has effectively adopted a scientific management approach to safety management to reduce aviation accidents (ALPA, 2006; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; ICAO, 2005, 2008).

One of the primary concepts of a SMS is to establish organizational safety culture (ALPA, 2006; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; ICAO, 2005, 2008). Organizational behaviorists postulated that the organization's safety culture enabled development and establishment of the SMS (Braithwaite, 2009; Dulac et al., 2004; Dupre & Le Coze, 2007; Durham et al., 2006; Eurocontrol, 2006; Gibbons et al., 2007; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). The SMS may influence organizational safety culture, but it is the organization's safety culture that determines the success of the organization's SMS (Braithwaite, 2009; Dulac et al., 2004; Dupre & Le Coze, 2007; Durham et al., 2006; Eurocontrol, 2006; Gibbons et al., 2007; Lazidou, 2008; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008).

Chapter 2: Literature Review

Successful implementations of SMS are dependent on and influenced by the organization's culture (Braithwaite, 2009; Dulac et al., 2004; Dupre & Le Coze, 2007; Durham et al., 2006; Eurocontrol, 2006; Gibbons et al., 2007; Lazidou, 2008; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). To examine the effects of the organization's culture on the implementation and success of SMS, the organization must explore the relationship between the level of organizational safety culture and the implementation level of the SMS. Senior managers establish and influence organizational culture, which includes safety culture (Braithwaite, 2009; Dekker, 2006; Dulac et al., 2004; Dupre & Le Coze, 2007; Durham et al., 2006; Eurocontrol, 2006; Gibbons et al., 2007; Lazidou, 2008; Reason, 2000; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008).

The purpose of this quantitative correlational study was to examine the relationship between the level of SMS implementation and the level of organizational safety culture in four FAR Part 135 air carriers. An Internet-based survey determined whether a correlation existed between the level of SMS implementation and the level of organizational safety culture (FAA, 2006b, 2008c; Mitchell et al., 2003c). The correlation between the dependent variable of SMS implementation and the independent variables of organizational safety culture, management commitment, and safety promotion could indicate the organization's ability to implement a verifiable SMS (FAA, 2006a, 2008c, 2009a, 2009b, 2009c; ICAO 2005; Mitchell et al., 2003c; Weinstein, 1996).

The literature review encompassed the development of modern safety management theories and their evolution in aviation. Foundational sources for research included organizational, safety, and management research from other complex socio-technical industries, such as the nuclear power and medical industries, as well as work in the aviation industry. The research focused on the development of modern safety management theory in aviation, and the influences of organizational culture on modern safety management theories.

Heinrich (as cited in Geller, 2000; Manuele, 2002) first developed the groundwork for modern safety theories surrounding SMS and organizational safety in the 1930s. Heinrich's domino theory or accident causation originated from work first published in 1931, known as the safety triangle or pyramid (Dekker, 2006; Geller, 2000; Reason, 2000; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). The safety triangle illustrated Heinrich's theory of accident causation, wherein unsafe acts could lead to minor injuries or to major injuries over time (Dekker, 2006; Geller, 2000; Reason, 2000; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Heinrich (as cited in Geller, 2000; Manuele, 2002) proposed that, for every 300 unsafe acts, there were 29 minor injuries and for every 29 minor injuries, there was one major injury. The sequence of multiple causations created a domino theory; in other words, all accidents occurred due to a variety of contributing factors or multiple causes (Dekker, 2006; Geller, 2000; Reason, 2000; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Heinrich's domino theory became the principle basis for *Root Cause Analysis* used in incident and accident investigations. Root cause analysts investigate the obvious physical circumstances of the incident or accident to determine the root cause or what led to each successive cause, *ad infinitum*, until they identify all latent factors (Reason, 2000; Shappell & Wiegmann, 2006).

Heinrich's theories suggested that preventing fatal accidents did not depend primarily on inspections of mundane lists of compliance items, which might or might not result in serious accidents (Geller, 2000; Reason, 2000; Shappell & Wiegmann, 2006). Accident prevention is typically not the focus of a checklist compliance inspection, but rather compliance with some standard (Reason, 2000; Shappell & Wiegmann, 2006). The root cause analysis focus of the multiple causation model identifies underlying management errors, the need for possibly expensive training, failures in orientation and similar system, or organizational failures (Feldman, 2004; Geller, 2000; Reason, 2000; Shappell & Wiegmann, 2006).

Heinrich's (as cited in Geller, 2000) original work proved foundational in research and study by organizational psychologists and scientific management researchers. Heinrich postulated that most accidents were the results of unsafe acts and unsafe conditions (Reason, 2000; Shappell & Wiegmann, 2006). The theory suggested safety performance indicated the behavior of the organization rather than the behavior of the workers (Reason, 2000; Shappell & Wiegmann, 2006). Unsafe acts and unsafe conditions are principle parts of the Human Factors and Accident Classification System (HFACS) (Reason, 2000; Shappell & Wiegmann, 2006). The theory implies the behavior of those exposed to the hazards cause injuries, not merely the hazards on the job (Reason, 2000; Shappell & Wiegmann, 2006).

Behavior-based safety focuses on individual performance, analyzes why people perform the way they do, and applies research supported corrective action to improve safety performance (Feldman, 2004; Geller, 2000; Reason, 2000; Shappell & Wiegmann, 2006). Application of behavior-based safety identifies the barriers to safe behavior, while developing and implementing a mitigation strategy to ensure the work environment, policies, and practices support safety (Feldman, 2004; Geller, 2000; Reason, 2000; Shappell & Wiegmann, 2006). Behavior-based safety is within the larger scientific field of organizational behavior (Geller, 2000).

Behavior-based safety can identify at risk behaviors on both the individual and organizational level (Dekker, 2006; Marx, 2009). Interestingly, organizations can exhibit at risk behaviors as a sub-component of their safety culture (Dekker, 2006; Marx, 2009). At risk behavior can be an integral component in applying risk management practices as part of SMS implementation (Dekker, 2006; ICAO, 2005; Marx, 2009). Success of a behavior-based safety system concept depends on creating an organizational culture in which individuals assume direct responsibility for their own and their colleagues' safety (Dekker, 2006; Marx, 2009). Therefore, the systems and procedures depend on people implementing and adequately managing the safety system (Dekker, 2006; Marx, 2009). Behavior-based system safety is consistent with the systems management approach of safety policies (ICAO, 2005) and with the organizational culture approach of employee empowerment (Mitchell et al., 2003a).

Based on the behavior-based safety work of Geller (2000, 2002), Williams (2008) postulated that managers played a crucial role in developing and maintaining an ideal safety culture in organizations where SMS were in place and effective. Safety in dangerous industries has improved over the years; in fact, some organizations have reached a plateau in terms of improving safety performance (Williams, 2008). Williams

(2008) noted that effective SMS could optimize the safety culture and allow organizations to continue improving safety performance. Further, Williams indicated that employees were more likely to be injured in organizations with an ineffective SMS or failures in the SMS. Williams identified failures in nine areas within the SMS framework related to safety policies, management commitment and involvement, and safety promotion that could adversely affect an organization's safety culture, leading to at risk behavior and accidents. Williams proposed that managers could improve safety culture by optimizing reporting and investigations, risk management and hazard recognition, communication, feedback, and training, policy and employee involvement, and safety assurance.

Accidents in complex socio-technical systems, such as the aviation industry, nuclear power, and medical industries, are not the result of single active failures, but the consequences of organizational or systemic latent failures (Helmreich & Merritt, 2005; Mitchell et al., 2003a; Reason, 2000). Safety management is scientific management of the safety element and aspects within an organization, and measuring the organizational culture is a part of measuring management's safety performance (Helmreich & Merritt, 2005; Mitchell et al., 2003c; Mohaghegh, 2007; Reason, 2000). Managers are the administrators of safety management, and the organizational culture influences their safety performance (Helmreich & Merritt, 2005; Reason, 2000; Shappell & Wiegmann, 2006). System safety is a systems management methodology for organizations to manage their safety performance (Johnston et al., 2006; Reason, 2000).

Organizational safety culture influences the implementation of SMS (Duffy, 2008; Feldman, 2004; Helmreich & Merrit, 2005; Mitchell et al., 2003b; Mohaghegh, 2007; Reason, 2000; Shappell & Wiegmann, 2006). Improvement in organizational safety performance reduces the number of accidents and incidents attributed to human error and latent organizational pathogens (Amaldi, Joyekurun, & Wong, 2007; Gibbons et al., 2007; Helmreich & Merrit, 2005; Loebbaka, 2008; Patankar & Taylor, 2006; Reason, 2000).

Implementing SMS to manage the safety function as any other business function reduces accidents and improves safety performance within the organization and among the individuals within the organization (Durham et al., 2006; Helmerich & Merritt, 2003; Shappell & Wiegmann, 2006; Stephans, 2000). Therefore, measuring organizational safety culture predicated on the characteristics of organizational safety culture identified by Mitchell et al. (2003c) could provide the basis of a working model to anticipate the expected level of SMS implementation.

Senior management establishes and influences the organizational culture including the safety culture (Reason, 2000). Organizational factors contribute to almost all aviation accidents, and organizational safety culture can be a key predictor of safety performance in a number of industries (Eurocontrol, 2006; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). For SMS to succeed requires a fundamental organizational transformation of the organization's culture (Gibbons et al., 2007). Mitchell et al. (2003c) studied the organizational safety culture in air carrier organizations and identified five basic characteristics of a safety culture, which included organizational commitment, management involvement, employee empowerment, accountability, and reporting systems.

For successful implementation of SMS to occur, senior managers must evaluate their professional and organizational cultures (Geller, 2002; Helmreich & Merritt, 2005; Williams, 2008). Helmreich and Merritt (2005) found that an organization's national, professional, and corporate cultures influenced their safety culture, and those cultures were unique to specific organizations. Helmreich and Merritt also found that a SMS described the organization's culture and attitude. To ensure an organization's safety culture as an enduring characteristic, all aspects of the organization's operations must implement safety (Mitchell et al., 2002a).

Johnston, Lee, Maurino, and Reason (2006) postulated that no matter how well equipment is designed, how sensible regulations are, no matter how much humans excel in their individual or team performance, they can never be better than the system that binds them. Accidents in complex socio-technical systems, such as the aviation industry, nuclear power, and medical industries, are not the result of single active failures, but the consequence of organizational or systemic latent failures (Amaldi et al., 2007; Helmreich & Merritt, 2005; Mitchell et al., 2003a; Perrow, 1999; Reason, 2000). Safety management includes managing the safety element and aspects within an organization, and measuring culture incorporates measuring management's safety performance. Managers are the administrators of safety management, and the organizational culture influences their safety performance (Amaldi et al., 2007; Helmreich & Merritt, 2005; Mitchell et al., 2003b; Perrow, 1999; Reason, 2000; Shappell & Wiegmann, 2006). System safety is a systems management methodology for organizations to manage their safety (Amaldi et al., 2007; Helmreich & Merritt, 2005; Mitchell et al., 2003b; Perrow, 1999; Reason, 2000; Shappell & Wiegmann, 2006). Textbooks, research articles, and journals offer detailed investigative results into the aspects of organizational culture and safety culture at the organizational and individual levels, identifying organizational safety culture as a key component of a SMS (Amaldi et al., 2007; Helmreich & Merritt, 2005; Mitchell et al., 2003a; Perrow, 1999; Reason, 2000; Shappell & Wiegmann, 2006).

Normal Accident Theory

Organizational factors contribute to almost all accidents and are a critical part in understanding and preventing them (Amaldi et al., 2008; Dulac et al., 2004; Gibbons et al., 2007; Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Researchers identified organizational and individual safety culture as significant contributors to as many as 80% of aviation accidents, noting the organization's safety culture influences the organization's safety performance (Eurocontrol, 2006; Gibbons et al., 2007; Johnston et al., 2006; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Two prominent sociological theories, Normal Accident Theory (NAT) (Amaldi et al., 2007; Dulac et al., 2004; Perrow, 1999) and High Reliability Organizations (HRO) (Roberts 1990, cited in Dulac et al., 2004), examined the organizational aspects of safety.

Perrow's (1999) model of accident causation, Normal Accident Theory, resulted from research developed in the aftermath of the accident at the Three Mile Island nuclear power plant in 1979 (Amaldi et al., 2007; Dulac et al., 2004; Perrow, 1999). Perrow (1999), Amaldi et al. (2007), and Dulac et al. (2004) noted that, in technological systems, accidents were inevitable or normal. Perrow proposed two related constructs, interactive complexity and loose/tight coupling, which, together, determined a system's susceptibility to accidents. Simply stated, an organization or industry with a complex organizational structure and high reliance on interdependencies of the components of the organizational system would have a certain level or number of accidents as the normal course of business. According to normal accident theory, the complexity inherent in socio-technical systems was beyond the complete control of tools and preventive barriers (Amaldi et al., 2007; Dulac et al., 2004; Perrow, 1999).

The definition of *interactive complexity* is the presence of unfamiliar, unplanned, and unexpected sequences of events in systems, which are either not visible or not immediately comprehensible (Dulac et al., 2004). Interactive complexity reflects organizational influences (Shappell & Wiegmann, 2006) and refers to latent failures within the organizational structure (Johnston et al., 2006; Reason, 2000). The organizational structure itself is a determinant influence on safety performance and the susceptibility of an organization to an accident (Amalberit, cited in Amaldi et al., 2007; Johnston et al., 2006; Reason, 2000; Shappell & Wiegmann, 2006). Amaldi et al. (2007), Dulac et al. (2004), and Perrow (1999) defined *tightly coupled systems* as systems in which each component or part of the system linked tightly to many other components of the system; therefore, a change in one component rapidly affected the status of the other system components.

According to normal accident theory, tightly coupled complex systems experience accidents that cannot be foreseen or prevented (Amaldi et al., 2007; Dulac et al., 2004; Perrow, 1999). Perrow called these *system accidents*. When a complex system experiences independent failures, the failure events can interact in unpredictable ways unknown to the designers and operators of the system (Reason, 2000). If the system is also tightly coupled, control of the cumulative effects of system failures before operators can understand the situation and implement appropriate corrective actions is difficult (Dupre & Le Coze, 2007). In such systems, apparent trivial incidents occur unpredictably and with potentially severe consequences (Johnston et al., 2006; Reason, 2000; Shappell & Wiegmann, 2006). The apparent trivial incident occurrences formed sequences of events termed *active failures* (Johnston et al., 2006; Reason, 2000; Shappell & Wiegmann, 2006). Active failures are those failures that have an immediate adverse impact and, if coupled with the latent organizational failures, provide an opportunity for catastrophic accidents, according to Reason's (2000) accident causation model.

Although Perrow (1999) made an important contribution in identifying these two risk-increasing system characteristics, Dulac et al. (2004) argued that Perrow's Normal Accident Theory provided only an engineering solution for increased redundancy in the system and advocated human procedures as the only method to increase safety. Increased redundancy introduced increased complexity and encouraged risk taking. These characteristics rendered accidents more likely (Perrow, 1999).

High Reliability Organizations

High Reliability Organizations (HRO) dominated the aviation industry (Roberts 1990, cited in Dulac et al., 2004). Roberts (as cited in Dulac et al., 2004), identified high reliability organizations as a subset of hazardous organizations with a record of high safety over long periods. According to Roberts (as cited in Dulac et al., 2004), if the number of times an organization could fail equated to the order of tens of thousands of times that the organization did not fail, the organization offered high reliability.

If the definition is accurate, there cannot be low reliability organizations in aviation (Patankar & Taylor, 2006). Simply stated, all aviation organizations have potential for catastrophic accidents during every flight operation. However, accidents are rare compared to the number of flight operations within the industry; thus, accidents are not normal occurrences, are not expected, and are not accepted (National Transportation Safety Board [NTSB], 2009; Patankar & Taylor, 2006). Any organization that did not have at least this type and level of safety record as a high reliability organization would cease operations immediately (Patankar & Taylor, 2006). United States accident data statistics for 2005 indicated 1,670 general aviation accidents, totaling 7.2 accidents per 100,000 flight hours (NTSB, 2009). Statistical listings of Federal Aviation Regulation Part 135 accidents are under General Aviation Accidents because the National Transportation Safety Board (NTSB) accident data collection and statistical database classifies FAR Part 135 accidents under the general aviation category (NTSB, 2009).

At the functional level of complex systems, operations occur while being influenced by a number of external entities, such as regulatory procedures, automated machine functions, and human performance, motivated by organizational goals of safety and efficiency (Dupre & Le Coze, 2007). Therefore, an approach addressing improvement of the system function should target those critical entities as a whole by first analyzing their complex interactions (Mohaghegh, 2007). While this holistic or systemic approach gained more recognition in human factor analytical exercises, the transition to design solutions tended to focus on correcting and modifying the variability of human beings (Dulac et al., 2004). The human modification approach or behavior-based safety approach indicated some successes in reducing accidents. However, behavior-based safety targets a class of problems that do not necessarily extend to normal incidents and accidents originating from Normal Accident Theory (Dulac et al., 2004; Mohaghegh, 2007; Mitchell et al., 2003b; Perrow, 1999).

Within the set of hazardous organizations, some have operated nearly error free for very long periods of time (Roberts, 1990). Roberts's definition of a High Reliability Organization uses the term accidents and not errors. According to Reason's (2000) Accident Causation Model, all organizations in dangerous industries operate with errors, but not all errors lead to catastrophic accidents. Reason postulated that latent failures wait to trigger active failures. Therefore, defenses in depth normally prevent the windows of opportunities for active failures to interact with latent failures to cause accidents (Reason, 2000; Shappell & Wiegmann, 2006).

On a global basis, the development and operation of hazardous technologies such as increasingly complex air traffic control systems are on the rise (Roberts, 1990). Roberts argued that current management systems and strategies in these complex systems were insufficient to manage the ever larger and more complex systems. Roberts noted the *Bhopal*, *Challenger*, and *Chernobyl* accidents as evidence that failures in management systems contributed to these rare, but catastrophic, events; however, Roberts did not cite management of a safety system as a means to improve safety performance. Roberts suggested that High Reliability Organizations enviable safety record or performance to date indicated reactive safety attempts to prevent future accidents through multiple layered redundant or backup systems at the operational level. This method of managing safety through redundancy, termed defenses in depth, introduces complexity in the organization in which the human interface must react (Reason, 2000; Shappell & Wiegmann, 2006). Safety management through redundancy requires more complex designs of management systems and control functions, introducing the potential to design into the management system latent failures (Reason, 2000; Shappell & Wiegmann, 2006).

High reliability organization research countered Perrow's hypothesis by suggesting that some complex and tightly coupled systems operate with few accidents (Dulac et al., 2004; Dupre & Le Coze, 2007). Most high reliability organization research has been on low complexity and loosely coupled systems, such as the Air Traffic Control system, where operations of the system have tight controls and are segregated, which would tend to support Perrow's theory (Mohaghegh, 2007). However, both normal accident theory and high reliability organization theory oversimplify aviation accidents (Helmreich & Merritt, 2005; Johnston et al., 2006).

The basis of both theories is on the technical operation components of the organization or system (Helmreich & Merritt, 2005; Johnston et al., 2006). Neither normal accident theory nor HRO theory adequately addresses the complexity of the organizational structure and organizational cultural impact on the system's operation (Helmreich & Merritt, 2005; Patankar & Taylor, 2006). Although the HRO theory argument may have flaws with respect to claims that the systems are tightly coupled and complex, the proposed methods and techniques for improving safety to lower risk through standards, system safety, and traditional safety approaches need consideration (Helmreich & Merritt, 2005; Johnston et al., 2006; Mohaghegh, 2007; Patankar & Taylor, 2006; Reason, 2000). Most complex systems, particularly technological and social systems do not meet the definition of low reliability (Helmreich & Merritt, 2005; Johnston et al., 2006; Mohaghegh, 2007; Patankar & Taylor, 2006; Reason, 2000). System safety concepts are widely accepted as an effective approach to reduce risk by identifying potential hazards, providing mitigation strategies, and assessing the outcome in relation to an operational system (Lu, Wetmore, & Przetak, 2006).

According to Dulac et al. (2004) and Dupre and Le Coze (2007), the concept of safety culture arose in the aftermath of the Chernobyl disaster. Safety culture resulted in new methods of conceptualizing processes of risk handling and management in organizational and other contexts (Helmreich & Merritt, 2005; Johnston et al., 2006; Mohaghegh, 2007; Pantakar & Taylor, 2006; Reason, 2000). Safety culture is a global characterization of the common behavioral preconditions to disasters and accidents in high risk socio-technical systems, such as aviation (Helmreich & Merritt, 2005; Johnston et al., 2006; Mohaghegh, 2007; Pantakar & Taylor, 2006; Reason, 2000). A key concept in Reason's Organizational Accident Causation Models recommends a systems approach to management resulting in increased safety performance, human factors in accident investigation, and SMS research (Helmreich & Merritt, 2005; Johnston et al., 2006; Mohaghegh, 2007; Patankar & Taylor, 2006; Reason, 2000; Shappell & Wiegmann, 2006).

Accident Causation Model

Advances in aviation safety management science and accident causation evolved in several steps (see Figure 2). Heinrich gained credit for developing the basis for modern accident causation models in 1932 by attributing occupational injuries to organizational and cultural influences (Helmreich & Merritt, 2005; Johnston et al., 2006).

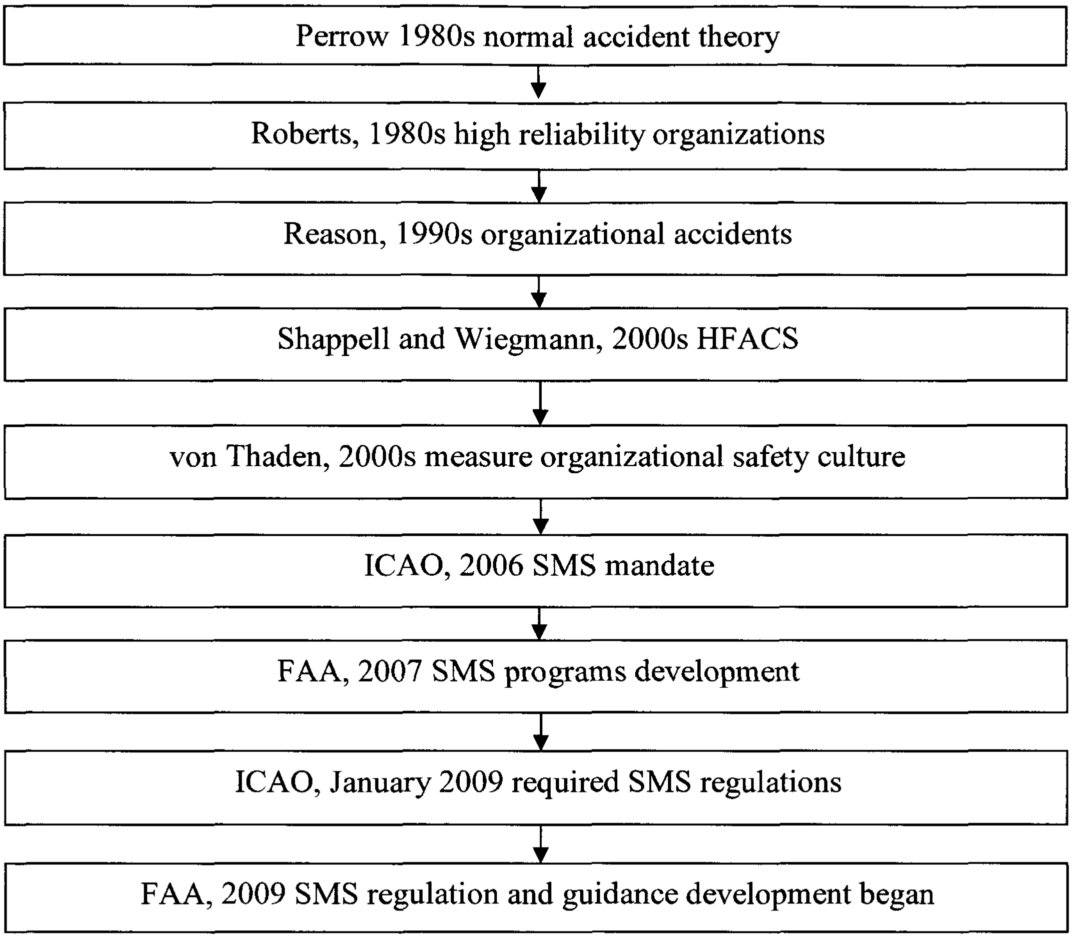

Figure 2. Historical timeline of major safety management advances.

Reason's (2000) model of accident causation developed from the concept of organizational accidents. Reason defined organizational accidents as comparatively rare, but catastrophic events that occur within complex modern technologies such as nuclear power plants, commercial aviation, and other industries. Reason's epidemiological accident causation model builds on the hypothesis of normal accident theory proposed by Perrow (1999), meets the definition of high reliability organizations defined by Roberts (1990), and furthers the work of Heinrich as cited in Reason (Helmreich & Merritt, 2005; Johnston et al., 2006).

Reason (2000) identified three approaches to safety management. In the person model, errors were a result of psychological factors, such as forgetfulness, poor motivation, carelessness, lack of knowledge or skills, inexperience, and culpable recklessness. Reason noted that the safety department normally policed safety and motivation to improve safety performance, which included such tactics as *fear appeal*. According to Reason, injury statistics, fatalities, lost-time injuries, and medical treatment cases were measures of safety performance.

Reason's engineering model originated in reliability engineering, ergonomics, risk management, and human reliability assessment. The engineering model postulated that safety could be *engineered* into the system and quantified as precisely as possible. Risk exposure normally measured safety performance, expressed in probabilistic terms. The engineering model focused on the human-machine interface performance of front-line operators, influenced by the operating environment or characteristics of the workplace (Reason, 2000; Reason & Hobbs, 2003).

As opposed to the person and engineering models, Reason's organizational model viewed errors as consequences rather than causes. Thus, errors were symptoms indicating the presence of latent conditions within the organizational system. Reason's organizational model emphasized proactive measures of safety, and the need for continuous improvement of system processes. In addition, Reason argued that the engineering model was similar to Total Quality Management (TQM), while the organizational model deliberately blurred the distinction between safety and quality related factors. Thus, the organizational model was an extension of the engineering model.

Organizational accidents have multiple causes involving many people operating at different levels within an organization (Reason, 2000). Reason observed that organizational accidents were a product of recent times, more specifically, a product of technological advancements that altered the traditional relationship between systems and the human interface. Reason's causation model offered the idea of defenses in depth, theorizing that technological advancement changed the way in which humans interacted with the system (Dulac et al., 2004; Dupree & Le Coze, 2007; Helmreich & Merritt, 2005; Johnston et al., 2006; Mitchell et al., 2003c; Mohaghegh, 2007; Reason, 2000; Shappell & Wiegmann, 2006). Reason's theory of defenses in depth was an adaptation of redundancy within a system defined in high reliability organizations (Dulac et al., 2004; Harris & Morley, 2006; Patankar & Taylor, 2006).

Reason's accident causation model used the term organizational accidents to demonstrate failures of socio-technical systems, such as aviation, by working backwards from an accident (Harris & Morley, 2006; Reason, 2000). Harris and Morley (2006) postulated that Reason's accident causation model worked only within the boundary definition of the system in which the organization existed; in other words, the organization did not function in a vacuum, but experienced environmental influences. Organizational accidents do not end at the organization, but the larger system within which the organization operates influences organizational accidents (Harris & Morley, 2006).

Operating in *the system* can extend beyond the organization as evidenced by such investigations as the Air Ontario accident at Dryden Lake in 1989. In that accident, the larger air transportation system and regulations significantly influenced the organization, and the larger system contributed to the accident causation (Harris & Morley, 2006). Helmreich and Merritt (2005) stated that technology removed the pilot from being physically and directly involved in business production, hence in immediate contact with local hazards. The newer role for pilots was as planners, managers, maintainers, and supervisory controllers of largely automated systems. Therefore, systems are more complex, supporting Perrow's (1999) argument for Normal Accident Theory. One of the consequences of defenses in depth or redundancy is that, as the systems become more complex, the systems become more remote to the people that manage and operate them (Dulac et al., 2004; Dupree & Le Coze, 2007; Helmreich & Merritt, 2005).

Human controllers in many such systems have become increasingly remote, both physically and intellectually, from the production components of the systems they control (Helmreich & Merritt, 2005). This remoteness can develop latent conditions, which result from strategic planning and decisions concerning the operation of the organization that influence the operating environment and the operators within the system (Helmreich & Merritt, 2005; Reason, 2000). Reason's causation model described latent conditions as holes or weaknesses in the defenses or controls within the system, which, when combined with an active failure, could create an accident trajectory. In the theory, accidents were consequences of latent conditions designed into the organizational model (Reason, 2000).

The decisions and strategic planning made by governments, regulators, manufacturers, designers, and organizational managers spread throughout the organization, shaping a distinctive organizational culture and creating error-producing factors within individual workplaces (Helmreich & Merritt, 2005; Johnston et al., 2006; Patankar & Taylor, 2006; Reason, 2000; Shappell & Wiegmann, 2006). The consequences of these activities spread throughout the organization and appear likely to foster or propagate unsafe acts (Helmreich & Merritt, 2005; Johnston et al., 2006; Patankar & Taylor, 2006; Reason, 2000; Shappell & Wiegmann, 2006). Contributing factors can include undue time pressure, inadequate staffing, inadequate tools and equipment, insufficient training, poor safety culture, and unworkable or poor procedures (Helmreich & Merritt, 2005; Johnston, et al., 2006; Patankar & Taylor, 2006; Reason 2000; Shappell & Wiegmann, 2006). Within the workplace, local factors and natural human tendencies to produce errors and violations are termed unsafe acts (Helmreich & Merritt, 2005; Johnston et al., 2006; Patankar & Taylor, 2006; Reason, 2000; Shappell & Wiegmann, 2006). Individuals and teams at the operational level, or the direct human to system interface, can commit unsafe acts (Helmreich & Merritt, 2005; Johnston et al., 2006; Patankar & Taylor, 2006; Reason, 2000; Shappell & Wiegmann, 2006).

Organizational Culture

National cultures reveal shared values; organizational cultures take shape mainly through shared practices (Helmreich & Merritt, 2005; Reason, 2000). A safety culture develops from persistent and successful application of practical measures (Helmreich & Merritt, 2005; Reason, 2000). Comprised of a number of interacting elements and methods of actions, thinking, and managing, safety cultures enhance safety as their natural by-product (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). Traditionally, the term culture applies more to nationalities than to organizations (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). However, the term *organizational culture* became part of management language in the 1980s (Wren, 2005). Helmreich and Merrit (2005) proposed a working definition of safety culture as the shared values of a homogenous group of people about what is important and their beliefs in how things work that interact with an organization's structures and control systems to produce behavioral norms or the way things function within the organization.

Helmreich and Merrit (2005) proposed conflicting descriptions for their definition of organizational safety culture. The first assigned shared practices as a factor in the development of organizational culture; the second included beliefs as a factor in the development of the organizational safety culture. Shared practices develop through written policies and procedures as a function of formal SMS implementation (Dekker, 2006; FAA, 2009a; ICAO, 2008; Reason, 2000). Reason noted that a SMS provided the administrative structures to develop shared safety practices in a prescriptive and normative manner (Reason, 2000). Dekker (2006) added that the repetitive application of shared practices established organizational safety culture.

Braithwaite (2009) emphasized organizational safety culture as a component of a SMS in aviation operations. The researcher observed that facilitation of a SMS depended on the shared beliefs and attitudes, or culture, of the organization if the organization's SMS were to be effective. Further, Braithwaite treated the influence of the safety culture on effectiveness and the reason for SMS implementation because of safety culture as identical. The role of the organization's safety culture as the cause of incidents and accidents is difficult to define. The Royal Commission's investigation into the 1979 Mount Erebus disaster was pivotal in changing the methods of accident investigations involving complex socio-technical systems because the commission placed greater emphasis on investigating the associated organizational and cultural factors (Braithwaite, 2009).

The reports of the 1979 Mount Erebus and the 1989 Dryden, Ontario accidents launched the first investigations in aviation that identified a breakdown of safety culture as a contributing factor (Braithwaite, 2009; Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). The official accident reports discussed not only the influences of the corporate culture of the airline involved in shaping flight crew performance, but also the influence of the social context within which the accident took place in shaping organizational performance (Braithwaite, 2009; Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). The organizational behaviorist approach suggested that fixing or improving the safety culture could reduce the potential for the same type of accident in the future (Braithwaite, 2009; Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). Hofstede (as cited in Reason, 2000) argued the organization's safety culture could improve because it reflected a collective value system of the organization. Hofstede further stated that the organization's safety culture change was manageable, and that shared practices depended on the organization's structure and systems. Hofstede argued that the organization influences change of shared practices through changing the organization's systems, thereby changing the organization's culture. Further Hofstede did not propose changing the organization's systems to improve safety through changing the organization's safety culture (Reason, 2000).

Because the accident investigations occurred post-accident, they failed to provide a method for identifying a failing safety culture prior to an accident (Braithwaite, 2009; Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). A rating scale review of the different instruments developed to measure safety culture did not identify indicators or thresholds of organizational safety culture, which could determine failure.

There was also no proof that organizations with a lower rated score were less safe or more at risk of having an accident than were organizations with a higher rated level of organizational safety culture (Mitchell et al., 2003a, 2003c; Shappell & Weigmann, 2006; von Thaden & Gibbons, 2008). Post-event or reactive analysis has *hind-sight bias* related to aviation accidents, where the benefit derives from looking back at what should have been done, but fails to account for the circumstances as they occurred to those involved (Dekker, 2006; Marx, 2009).

National, corporate, and professional cultures are significant determinants of the processes underlying the aviation systems' performance (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). Before attempting any safety endeavor, it is essential to understand a balanced safety perspective and decide where safety fits within the cultural beliefs of a given organization (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). Such cultural beliefs define the organization's operational space, the outer boundaries established by the national and professional culture, and the inner boundaries established by the corporate culture of the particular organization (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000).

To be effective, safety endeavors should be consistent with and not counter to the shared beliefs of the receiving group (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). To implement a sustainable SMS, the professional and organizational culture must be understood (Helmreich & Merritt, 2005). The values and demonstrated commitment of senior management regarding safety directly influence the safety culture (Helmreich & Merritt, 2005; Johnston et al., 2006; Mitchell et al., 2002a; Mohaghegh, 2007; Reason, 2000; Shappell & Wiegmann, 2006). Mitchell et al. (2003c) identified the characteristic of organizational commitment as a variable of positive organizational safety culture. The independent variables measured in Mitchell's survey demonstrated that senior management commitment to safety approximated the variables described as requirements to establish a SMS (ALPA, 2006; FAA, 2006a; ICAO, 2005; Reason, 2000). A prerequisite for appropriate learning is a safety information system that identifies not just the proximal active failures, but also the latent failures and their parent organizational pathogens (Johnston et al., 2006). Simply stated, for an effective SMS, management and regulatory agencies must accept the concept of organizational influence and shared responsibility for incidents and accidents.

Shappell and Wiegmann (2006) researched human factors in aviation accident causation and prevention strategies, furthering the work of Reason (2000), Perrow (1999), and Heinrich (as cited in Geller, 2000) (see Figure 2), by identifying organizational influences on the structure and operations of the organization. Shappell and Wiegmann (2006) provided support for Reason's organizational accident causation model theory indicating that most accidents result from latent failures, influences by the organization, and active triggering events failures (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000; Shappell & Wiegmann, 2006). The organizational accident causation model posited the culture of the organization determined or established by senior management' design flaws in the system or organization, and the way in which the human interface interacts with the flawed system could trigger accidents. Thus, the accidents were the fault of the system and not of the individual (Dekker, 2006; Johnston et al., 2006; Reason, 2000; Shappell & Wiegmann, 2006).

Shappell and Wiegmann (2006) argued that management of the system through management of the organizational culture influenced the organization's safety performance and way in which individuals committed errors that triggered accidents. Based on a previous review of safety culture and safety climate research, Mitchell et al. (2003a) identified five global components of safety culture, including organizational commitment, management involvement, employee empowerment, accountability, and reporting systems. The five global components of organizational safety culture identified by Shappell and Wiegmann (2006) listed some of the same components that Weinstein (1996) identified as quality management principles applicable to developing a SMS. Weinstein's (1996) research differed from the organizational behaviorists in viewing development of the organization's safety culture as a by-product of implementing a SMS. Shappell and Wiegmann (2006) developed an 86-item, 7-point Likert scale survey administered to pilots at a regional FAR part 135 scheduled air carrier to identify organizational cultural factors and to measure overall airline performance in relation to organizational safety factors. The research was a documented effort to assess safety culture within the aviation industry.

Harris and Morley (2006) reported that accident causation modeling and research evolved into the fourth stage identified by Mitchell et al. (2002a), known as the Organizational Culture Period. The organizational culture period recognized that operators of any kind performed as part of a coordinated team embedded within one or many cultures (Harris & Morley, 2006). Harris and Morley emphasized the organizational safety culture approach as opposed to the systems management approach argued by other researchers, such as Rollenhagen and Wahlstrom (2007) and Williams

(2008). Harris and Morley's (2006) culture-based research focused on organizational processes, which they considered more qualitative and interpretative than a scientific or systems management approach, making measuring safety performance by organizational safety culture difficult.

Harris and Morley (2006) offered a model of organizational safety culture called the Ripple Model. The Ripple Model proposed safety culture as a sub-culture of organizational culture, which was a sub-culture of industry culture, which was a sub-culture of national culture. The Ripple Model reflected Hofstede's conceptualization, (as cited in Harris & Morley, 2006) of culture as an onion with many skins. The researchers noted that organizational culture was multifaceted and an individual or organization could simultaneously belong to many cultures or sub-cultures with conflicting values. Safety culture was inseparable from other cultures, and any model of organizational safety culture must extend beyond the organization (Harris & Morley, 2006). Harris and Morley referenced the safety culture research of Helmreich and Merritt (2005), but omitted the sub-culture of professional culture that extended beyond the boundaries of the organization. In fact, Harris and Morley contradicted the extension of the Ripple Model beyond the organization and stated that, while there was commonality in the characteristics indicative of an effective safety culture, all factors were internal to the organization.

On the other hand, Harris and Morley (2006) noted elements outside of an organization affect safety culture and behavior. Harris and Morley (2006) suggested that, if all factors of safety culture were internal to the organization, safety culture could influence the organization's safety performance in much the same way as external factors could. The difference was in the degree of influence.

Another conceptual element of the Ripple Model was termed *influences*, which described the components that made up a SMS, similar to that modeled by the systems management approach (ALPA, 2006; Amaldi et al., 2007; Dulac et al., 2004; Dupre & Le Coze, 2007; Gibbons et al., 2007; Harris & Morley, 2006; Helmreich & Merritt, 2005; HSE, 2005; ICAO, 2005; Jackson, 2008; Johnston et al., 2006; Loebbaka, 2008; Mohaghegh, 2007; Reason, 2000; Shappell & Wiegmann, 2006; Stephens, 2000). The third conceptual element of the Ripple Model was *actions*, which related to organizational safety culture as behavior-based safety actions (Harris & Morley, 2006). The development of the Ripple Model suggested that Harris and Morley (2006) considered SMS a component of the organization's safety culture.

Establishing an organizational safety culture does not guarantee zero accidents, but may reduce the risk of having an accident (Braithwaite, 2009; Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). The organizational culture of conducting business according to an established management system of policies, processes, and procedures reduces exposure to risk and improves safety performance (Braithwaite, 2009; Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). Braithwaite (2009) argued that mandating implementation of a SMS would not guarantee a sound safety culture and without a safety culture, there could be no improved safety performance. Braithwaite listed several options for safety promotion and elements of the systems management approach including publication of safety data, communication, training, and procedures to influence the safety culture. The organizational behaviorist approach, in defining an organization with a flexible safety culture, employed the same functions defined as risk management in the systems management approach (Braithwaite, 2009; Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000).

At the time of this study, organizational modeling research in the areas of HROs, NAT, and organizational accident causation assigned organizational safety culture ownership and creator responsibility to senior management (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000; Reason & Hobbs, 2003: Shappell & Wiegmann, 2006). The organization's safety culture, influenced by senior management, suggested implementation of a SMS as the correct way to increase safety performance and safety. Thus, the organizational safety culture would directly affect the level of SMS implementation, either positively or negatively (Schein, 1984).

Safety Management

Management science applies scientific methods and principles to management decision making and problem solving in quality management systems (D. Smith, personal communication, February 19, 2009; Wren, 2005). Management science uses quantitative, mathematical, and statistical techniques (Wren, 2005). The term can denote scientific management, which has origins in the work of Taylor, Gantt, and the Gilbreths (Wren, 2005). This concept can apply to the management of safety because safety management is a science (D. Smith, personal communication, February 19, 2009). The phenomenon of SMS evolved from the engineering disciplines and the concept of systems safety (ALPA, 2006; Amaldi et al., 2007; Dulac et al., 2004; Dupre & Le Coze, 2007; Gibbons et al., 2007; HSE, 2005; Helmreich & Merritt, 2005; ICAO, 2005; Jackson, 2008; Johnston et al., 2006; Loebbaka, 2008; Mohaghegh, 2007; Reason, 2000;

Shappell & Wiegmann, 2006; Stephens, 2000; Turcsanyi & Malik, 2002; Weinstein, 1996).

Present views of SMS in the nuclear power industry can be traced to three different sources, referenced in research on the aviation and medical industries (Rollenhagen & Wahlstrom, 2007). First, quality systems underwent considerable development during the 20th century; second was the Three Mile Island accident, which provided understanding of the role of instructions in nuclear operation; and third, the Chernobyl accident, which produced interest in safety culture (Rollenhagen & Wahlstrom, 2007). The present view of SMS are reflected in regulatory documents that no longer separate safety and quality management systems, and suggest research in management systems and safety management (Rollenhagen & Wahlstrom, 2007). Rollenhagen and Wahlstrom argued for the integration of safety culture as a concept within the SMS by emphasizing more attention to the management systems when considering the safety influences of human and organizational factors. In addition, the researchers reported managing the safety system was more critical than managing the safety culture in highly complex socio-technical industries.

Rollenhagen and Wahlstrom (2007) postulated that management systems profoundly influenced work practices and safety performance. Thus, researchers should consider requirements that defined safety management systems. Rollenhagen and Wahlstrom argued that a systematic assessment of the requirements for SMS had not taken place, but rather the development of present guidance was an emergent path where opinions and beliefs provided guidance in decision making. Rollenhagen and Wahlstrom identified general requirements in four areas that should apply to functioning SMS: (a) documented, regularly reviewed, and updated when necessary; (b) understood, acceptable, and used in daily operations; (c) include all important operations and functions, and have internal consistency; and (d) have a graded approach to safety by management. These requirements for SMS are consistent with the advisory circulars published by the FAA, and the framework developed by the ICAO (ALPA, 2006; FAA, 2006a, 2009a; ICAO, 2005). Rollenhagen and Wahlstrom (2007) also identified the training of senior and lower level managers in safety management as paramount for successful SMS, and noted the training in safety management of the type and depth required was unavailable.

In a traditional operating company, flight safety activity means inspections of certain flight actions based on the results of specific planned controls (Turcsanyi & Malik, 2002; Weinstein, 1996). An important result of research on high reliability organizations, normal accident theory, human factors, and organizational accidents was that dangerous industries, such as aviation, could develop SMS to manage safety problems for effectiveness, thus increasing safety performance (ALPA, 2006; FAA, 2006a, 2009a, 2009c; ICAO, 2005; Shappell & Wiegmann, 2006; Turcsanyi & Malik, 2002; Weinstein, 1996). Professional management of accidents and incidents in complex socio-technical industries, such as aviation, should be with a SMS (Turcsanyi & Malik, 2002).

In systems safety, the primary focus is on hardware or equipment safety (Shappell & Wiegmann, 2006; Stephens, 2000). The techniques of scientific management that applied to aircraft manufacturing and aviation accidents due to equipment failures are now relatively rare events, which appears to support the high reliability organization theories (NTSB, 2009; Shappell & Wiegmann, 2006; Stephens, 2000). Scientific management techniques evolved into the idea of SMS (Amaldi et al., 2007; Helmreich & Merritt, 2005; Lazidou, 2008; Mohaghegh, 2007; Johnston et al., 2006; Reason, 2000).

The aviation industry and regulatory agencies have applied the concept of managing safety (ALPA, 2006; FAA, 2006a, 2009a; ICAO, 2005). Annex 6 of Part II of the convention of The ICAO (2008) mandated that, to operate internationally, all signature States must draft regulations that commercial air operators have an implemented SMS, verified by the States national aviation authority by 1 January 2009 (ICAO, 2008). At the time of this study: however, only Singapore and Canada had implemented SMS regulations (D. Arendt, personal communication, March 3 and 4, 2009). Numerous definitions of SMS exist, causing the FAA to issue an advisory circular delineating SMS for aviation (FAA, 2006a; FAA, 2009a).

One of the listed component parts of a SMS is a positive organizational safety culture (ALPA, 2006; FAA, 2006a, 2009a; ICAO, 2005; Reason, 2000). A systematic organizational approach to safety can replace piecemeal approaches to safety management (ALPA, 2006; FAA, 2006a, 2009a). Johnston et al. (2006) used case studies to verify that organizational approaches to safety management improved organizational safety performance and efficiency, applying Reason's model of organizational accident causation to the flight deck, aviation maintenance, and air traffic control.

Reason's organizational accident causation model asserted that the negative consequence of top-level decisions, such as inadequate budgets, deficient planning, under staffing, commercial, and operational time pressures, were transmitted along various departmental and organizational pathways to the different workplaces (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). Thus, management decisions and strategic planning created the local conditions that engendered commission of unsafe acts (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). Although there may be many unsafe acts, only a few penetrate established defenses in enough depth to contribute to accidents (Helmreich & Merritt, 2005). Cultural factors take a long time to develop and are slow to change; however, their influence is widespread and pervasive, disseminated throughout the organization in various ways, affecting the attitudes and behavior of the workforce (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000).

In 2009, the FAA (2009b) began development of regulatory requirements and guidance on implementing SMS in the U.S. aviation industry. Federal Aviation Administration order 1110.152, issued on February 17, 2009, established a SMS Aviation Rulemaking Committee (ARC) (FAA, 2009b), and issued Advisory Circular AC120-92 in 2006 (FAA, 2006a), revised in 2009 to align with ICAO documents. The advisory circular offers FAA guidance on the component parts that must be in place to have an SMS (D. Arendt, personal communication, March 3 and 4, 2009).

As of 2009, the FAA had no method of evaluation to determine whether organizations had implemented a SMS to meet the ICAO requirements (D. Arendt, personal communication, March 3 and 4, 2009). An organizational safety culture was one of the required component parts of a SMS (ICAO, 2005). However, there was no established aviation industry standard to measure the level of SMS implementation nor to determine if an organizational safety culture existed (ALPA, 2006; FAA, 2006a, 2008c, 2009a; ICAO, 2005). Rather, the FAA methodology was to develop a checklist, which did not consider the largest influencing factor of a management system, the organizational safety culture (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2006b, 2008b, 2009a; Helmreich & Merritt, 2005; Johnston et al., 2006; Mitchell et al., 2003b; ICAO, 2005). Thus, the checklist method could determine only the level of SMS implementation based on a list of parts or artifacts, and not on the interactions of or human interfaces with the system (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a; Helmreich & Merritt, 2005; ICAO, 2005; Johnston et al., 2006; Mitchell et al., 2003b).

Only a SMS could offer professional management of accidents and incidents in complex socio-technical industries such as aviation (Flannery, 2001; Turcsanyi & Malik, 2002). As technology and organizational systems become more complex and more tightly coupled, the industry must develop new methods for improving safety and managing systems (Jermier, 2004). Traditional safety programs oriented toward compliance or the technical requirements of safety failed to produce any significant improvement in safety performance (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Turcsanyi & Malik, 2002; von Thaden & Gibbons, 2008).

Weinstein (1996) theorized that safety program effectiveness had ceased and that technical requirements mandated by regulations, industry standards, and guidelines had little support in the absence of an effective SMS and culture. Weinstein identified other failings of traditional safety programs, such as the lack of integration throughout the organization. Instead, safety, relegated to a safety professional, allowed managers and employees to abdicate responsibility. Weinstein proposed a model wherein quality management concepts and methods were applied to the field of safety management and noted that , through more empathetic methods, the basic concepts that promoted quality management success also produced safety management success. Weinstein observed quality management included a philosophy, a process, and a set of techniques that could yield customer satisfaction and continuous improvement. The researcher added safety management could improve safety performance using some of the same basic quality management principles (Weinstein, 1996).

The FAA (2009c) appended a set of technical requirements to advisory circular AC 120-92 for processes considered essential in developing and implementing an effective, comprehensive SMS for U.S. aviation service providers. The SMS framework suggested that, the FAA should apply basic quality management principles and techniques to safety management (FAA, 2009c) as in the case cited by Weinstein (1996). The SMS framework outlined in the FAA advisory circular AC120-92 included four levels or phases of an effective SMS, planning, reactive, predictive, and continuous improvement (FAA, 2009c; ICAO, 2008). The structure of the SMS framework reflected the key issues of safety concepts and characteristics, technical requirements, safety structures, and performance objectives the FAA recommended incorporating into effective SMS (FAA, 2009c). Figure 3 illustrates the conceptual framework adaptation model of quality management principles and techniques to SMS by aviation regulatory agencies globally (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a; FAA, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Turcsanyi & Malik, 2002; Weinstein, 1996).

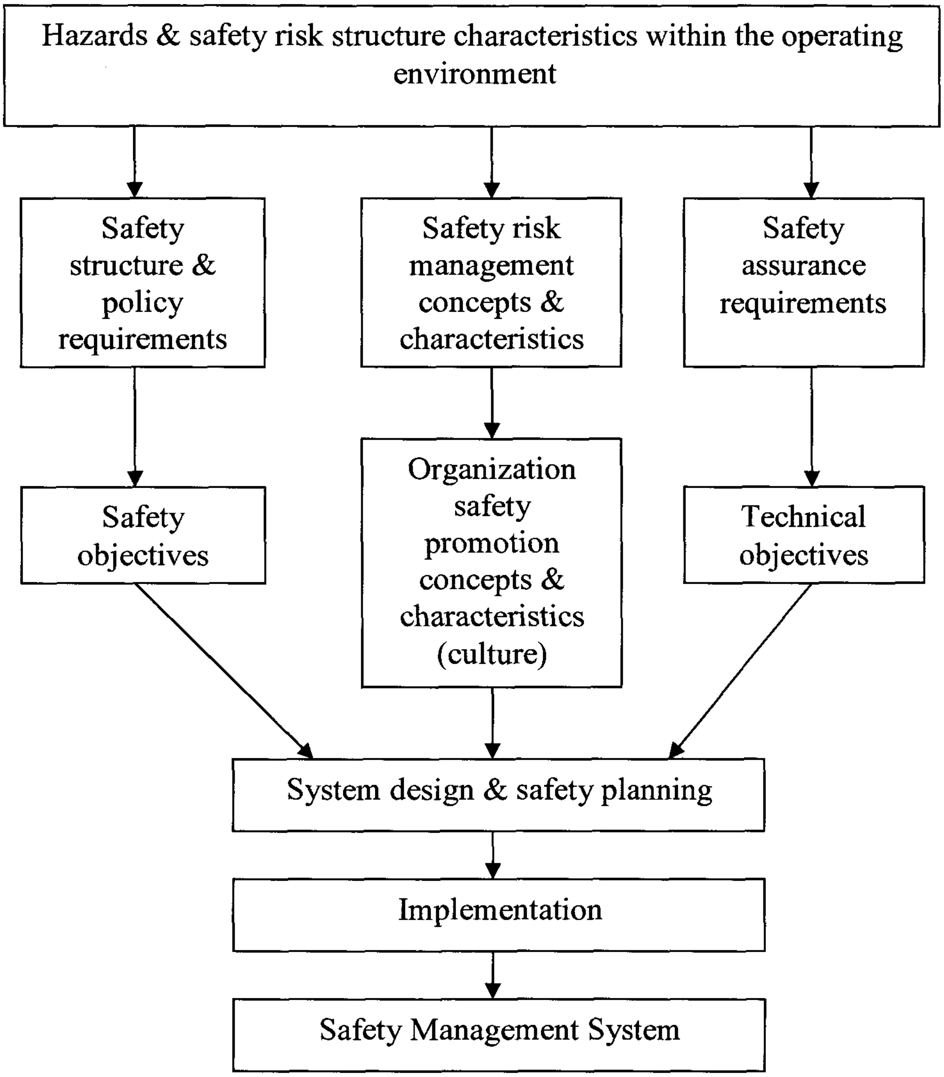

Figure 3. SMS conceptual framework model.

The concept of system safety first applied to manufacturing and production in the missile industry in the 1940s (Vincoli, 2006). The impetus for system designers and engineers to design safety into their products stemmed from the novel technology of missiles, which eliminated older methods of after-the-fact designs for safety (Vincoli, 2006). The older reactive safety methods were adequate until aircraft and their systems became more complex with increased speeds and maneuvering capabilities coupled with the likelihood of catastrophic results due to possible system failures or subtle interfaces (Dulac et al., 2004; Dupree & Le Coze, 2007; Helmreich & Merritt, 2005; Reason, 2000; Stephens, 2000; Vincoli, 2006). Factors such as these served as the catalyst for systems engineering, which evolved into the concept of systems safety and, eventually, into SMS (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Stephens, 2000; Turcsanyi & Malik, 2002; Vincoli, 2006; Weinstein, 1996).

No operation can completely guarantee complete safety without any accidents (ALPA, 2006; Dekker, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Marx, 2009; Mitchell et al., 2003b; Reason, 2000; Stephens, 2000; Turcsanyi & Malik, 2002; Vincoli, 2006; Weinstein, 1996). One stated goal for SMS is to reduce risk exposure to an acceptable level through improving safety performance (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b). The primary focus of systems safety is to prevent the loss of the system only; whereas, the focus of SMS is on improving safety performance across all levels of the organization (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Stephens, 2000; Turcsanyi & Malik, 2002; Vincoli, 2006; Weinstein, 1996).

The subtle differences between strict systems safety and SMS often appear confusing (Reason, 2000; Stephens, 2000; Vincoli, 2006). Many of the same tools and techniques that meet the technical requirements evolved from work in the systems engineering discipline (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Stephens, 2000; Turcsanyi & Malik, 2002; Vincoli, 2006; Weinstein, 1996). The literature noted the same basic technical requirements of risk assessment, hazard identification, management commitment, awareness, and safety promotion for both systems engineering safety and SMS requirements (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Stephens, 2000; Turcsanyi & Malik, 2002; Vincoli, 2006; Weinstein, 1996). The technical safety requirements of the safety engineering approach align with the technical objective and SMS technical requirements depicted in Figure 3.

One aspect of the systems engineering approach distinctly different from the SMS or organizational safety culture approach is the lack of reference to any direct involvement of the organization's safety culture (Stephens, 2000; Vincoli, 2006). Although systems engineering mentions human factors, the only discussion is on the ways in which humans cause errors within the system, and devising means to design human errors out of the system (Reason, 2000; Stephens, 2000; Vincoli, 2006). Noting all safety management models could influence overall safety management programs, Reason (2000) offered three approaches to safety management: (a) the person model, (b) the engineering model, and (c) the organizational model. Reason argued that all three safety management models influenced the overall safety management program. The direction of the person model is towards reducing individual injuries; the engineering model focuses on the human-machine interface and system reliability; and the organizational model looks at the integrity of the organization's system, processes, and system factors (Reason, 2000).

Systems engineering safety is an integral part of any organization. Safety programs can improve by incorporating the process of system safety (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Stephens, 2000; Turcsanyi & Malik, 2002; Vincoli, 2006; Weinstein, 1996). Systems safety engineers argued that a properly implemented system safety effort effectively applied appropriate scientific engineering techniques and principles to identify, then to eliminate or control, risk of exposure to systems hazards (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Stephens, 2000; Turcsanyi & Malik, 2002; Vincoli, 2006; Weinstein, 1996).

At the time of this study, there was no universally accepted list of SMS principles and concepts; each proponent offered varied definitions of SMS and the components or elements involved (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Turcsanyi & Malik, 2002; Weinstein, 1996). The structural characteristics of aviation hazards and risks within the operating environment influence safety management concepts and characteristics, safety management requirements and safety structures, and the technical requirements needed for the design, planning, and implementation of an effective SMS (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Turcsanyi & Malik, 2002; Weinstein, 1996).

The FAA's (2009b) AC 120-92 identified four components of a SMS, including safety policy and objectives, safety risk management, safety assurance, and safety promotion. The service provider should promote growth of a positive safety culture as described under the safety promotion component (FAA, 2009c). The design expectations of the safety promotion component was for senior management to promote the growth of a positive safety culture through (a) publication of senior management's stated commitment to safety; (b) visible demonstration of senior management's commitment to a SMS and communication of safety responsibilities; (c) allocation of resources to implement and maintain a SMS; and (d) clear and regular communication of safety policies, goals, objectives, and performance standards to all personnel (FAA, 2009c). The FAA's SMS framework supports the safety management approach and underscores development of the safety culture as an element, or sub-component, of the SMS (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Turcsanyi & Malik, 2002; Weinstein, 1996). As such, safety culture as an element of SMS contradicts the organizational behaviorist approach because the theory considers SMS a natural consequence of organizational safety culture. In other words, the organization's safety culture promotes the development and implementation of a SMS because the organization determines the need for a SMS instead of having one imposed by regulatory authorities (Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000; Shappell & Wiegmann, 2006).

To transition to a systems process requires organizations to implement SMS (Lu et al., 2006). Because the management of the organization determines the processes and procedures through decision making, the impact of the organization's culture may influence the success or failure of implementing a SMS (Eurocontrol, 2006; Helmreich & Merritt, 2005; Johnston et al., 2006; Reason, 2000). The relationship between the organizational safety culture and SMS implementation success or failure should be investigated, measured, and researched (Helmreich & Merritt, 2005). Five key concepts and characteristics of SMS identified in organizational behaviorists and systems management literature included (a) systems management of safety requires and influences promotion of the organizational safety culture to improve safety performance through improved management systems; (b) organizational safety culture influences and impacts the development and implementation of the SMS; (c) management and individual accountability, responsibility, and authority are fundamental to effective safety management; (d) critical processes must be measured in order for management decisions to be data driven by facts; and (e) safety risk management and safety assurance form the key processes of SMS (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Shappell &

Wiegmann, 2006; Turcsanyi & Malik, 2002; Weinstein, 1996). Adoption of the systems management approach to safety, wherein the safety culture is a sub-component within SMS, can be summarized by comparing the FAA SMS framework to established quality management concepts, tools, and techniques (see Tables 1 and 2) (FAA, 2009c; Weinstein, 1996).

Built on basic system safety and quality management principles, safety management systems are formal top-down business approaches to managing risk (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Shappell & Wiegmann, 2006; Turcsanyi & Malik, 2002; Vincoli, 2006; von Thaden & Gibbons, 2008; Weinstein, 1996). Each organization's SMS requires customization to create the safety culture of SMS (ALPA, 2006; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Johnston et al., 2006; Mitchell et al., 2003b; Shappell & Wiegmann, 2006; Vincoli, 2006; von Thaden & Gibbons, 2008). Safety management and quality management systems both require planning, performance monitoring, communication, and the participation of all employees (ALPA, 2006; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Johnston et al., 2006; Mitchell et al., 2003b; Shappell & Wiegmann, 2006; Vincoli, 2006).

Table 1

Safety Management (SM) versus Quality Management (QM) Concepts

Safety	Quality
Product/service safety risk focus	Product customer service focus
Management commitment and organization	Leadership commitment
Company safety culture	People involvement/company culture
Process approach	Process approach
Systems approach to safety management	Systems approach to quality management
Continual safety system improvement	Continual product quality improvement
Data driven management decisions	Fact base decision making
Safety integration of service providers	Mutually beneficial supplier relationships

Table 2

Tools and Techniques, Safety Management versus Quality Management

Safety	Quality
Safety risk management	Statistical process control
Preventive and corrective action	Structured problem solving
Safety assurance	Continuous improvement
Safety policy and procedures	Quality management
Safety promotion	Quality planning

Safety management systems recognize that human and organizational errors can never be eliminated, but a safety oriented culture can reduce risks and improve safety (ALPA, 2006; Dekker, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Marx, 2009; Mitchell et al., 2003b; Reason, 2000; Shappell & Wiegmann, 2006; Turcsanyi & Malik, 2002; Weinstein, 1996). Implementing a SMS dictates a cultural change in the organization, wherein safety of operations becomes the objective (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Shappell & Wiegmann, 2006; Turcsanyi & Malik, 2002; Weinstein, 1996). These statements appear contradictory in nature. However, if the purpose of a SMS is to develop a safety culture to improve safety, measuring only system requirements and technical requirements for implementation does not measure the organization's safety culture or the stated purpose of an SMS (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Shappell & Wiegmann, 2006; Turcsanyi & Malik, 2002; Weinstein, 1996).

Summary

The aviation industry is a complex socio-technical industry (Mitchell et al., 2002b; Perrow, 1999). Aviation also meets the definition of a high reliability industry, operating in an increasingly complex technological, political, sociological, and economic environment (Helmreich & Merritt, 2005). Accidents in aviation are rare and aviation has seen safety increase to the point where aircraft are seldom the cause (Helmreich & Merritt, 2005; Johnston et al., 2006; NTSB, 2009; Patankar & Taylor, 2006; Reason, 2000).

Organizational studies in the context of scientific management began with Weber, Taylor, Gant, and the Gilbreths in the late 19th century (Wren, 2005). Organizational behavior and culture started in the late 1940s (Hollenbeck & Wagner, 2005; Wren, 2005), operating on micro, meso, and macro levels (Schein, 1984). Because aviation accidents are such rare events, directly relating measures of safety culture to the reduction or prevention of accidents has been difficult (Helmreich & Merritt, 2005; Johnston et al., 2006; Patankar & Taylor, 2006; Mohaghegh, 2007).

The organizational behaviorists approach depicts the structure of the technical requirements of an SMS model (see Figure 2) as natural consequences of the organization's culture; thus, measuring the cultural behaviors of the organization indicates successful implementation of a SMS (Helmreich & Merritt, 2005; Hollenbeck & Wagner, 2005; Johnston et al., 2006; Mitchell et al., 2002b, 2003b; NTSB, 2009; Patankar & Taylor, 2006; Perrow, 1999; Reason, 2000; Shappell & Wiegmann, 2006; Wren, 2005).

Within the systems management approach, the organization's safety culture is a natural consequence of the structure and requirements (see Figure 2). Measurement of the structure and technical requirements indicates successful implementation of an SMS (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Shappell & Wiegmann, 2006; Turcsanyi & Malik, 2002; Weinstein, 1996).

The organizational approach of developing a positive safety culture influenced development of modern safety theories, system safety, and safety management theories and systems unregulated by the FAA (Helmreich & Merritt, 2005; Hollenbeck & Wagner, 2005; Johnston et al., 2006; Mitchell et al., 2002b, 2003b; NTSB, 2009; Patankar & Taylor, 2006; Perrow, 1999; Reason, 2000; Shappell & Wiegmann, 2006; Wren, 2005). At the time of this study, the international aviation community and the FAA were drafting regulations to implement a SMS. One requirement was to develop a positive safety culture through management commitment and safety promotion without tools, methods, and techniques to measure safety culture (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Shappell & Wiegmann, 2006; Turcsanyi & Malik, 2002; Weinstein, 1996). Draft regulations required measurable and verifiable implementation of SMS in accordance with the technical objectives depicted in Figure 2, there was no measure or verification of a positive organizational safety culture (Helmreich & Merritt, 2005; Hollenbeck & Wagner, 2005; Johnston et al., 2006; Mitchell et al., 2002b, 2003b; NTSB, 2009; Patankar & Taylor, 2006; Perrow, 1999; Reason, 2000; Shappell & Wiegmann, 2006; Wren, 2005). Prescriptive regulations to implement a measurable SMS based on technical aspects without measuring a key requirement of developing a safety culture would note only the application of the technical aspects of a SMS (ALPA, 2006; Dulac et al., 2004; Dupree & Le Coze, 2007; Eurocontrol, 2006; FAA, 2006a, 2009a, 2009c; Helmreich & Merritt, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2003b; Reason, 2000; Shappell & Wiegmann, 2006; Turcsanyi & Malik, 2002; Weinstein, 1996).

The existence of a safety culture without measuring the relationship between the level of the safety culture and the management system does not provide information on whether a system is in place to manage the organization's safety (Helmreich & Merritt, 2005; Hollenbeck & Wagner, 2005; Johnston et al., 2006; Mitchell et al., 2002b, 2003b; NTSB, 2009; Patankar & Taylor, 2006; Perrow, 1999; Reason, 2000; Shappell & Wiegmann, 2006; Wren, 2005). Just because everyone in an organization may want to be safe and a management system is in place does not measure safety performance (Helmreich & Merritt, 2005; Hollenbeck & Wagner, 2005; Johnston et al., 2006; Mitchell et al., 2002b, 2003b; NTSB, 2009; Patankar & Taylor, 2006; Perrow, 1999; Reason, 2000; Shappell & Wiegmann, 2006; Wren, 2005). Empirically measuring the relationship between the level of organizational safety culture and SMS implementation can illustrate whether the primarily emergent research and application of organizational safety culture influences the decision of an organization to implement a SMS. Empirical measurement can also determine whether the successful implementation of a prescriptive SMS influences the organization's safety culture and performance (ALPA, 2006; Dulac et al., 2004; Eurocontrol, 2006; FAA, 2006a, 2009a; Helmreich & Merritt, 2005; Hollenbeck & Wagner, 2005; ICAO, 2005; Jermier, 2004; Johnston et al., 2006; Mitchell et al., 2002b, 2003b; NTSB, 2009; Patankar & Taylor, 2006; Perrow, 1999; Reason, 2000; Shappell & Wiegmann, 2006; Turcsanyi & Malik, 2002; Weinstein, 1996).

Chapter 3: Research Method

This chapter establishes methodology by revisiting the statement of the problem, the purpose of the study, the research questions, and identifying the hypotheses. The chapter reviews the research design, identifies the independent and dependent variables, and discusses the process of designing and implementing the survey instrument. In addition, it offers information on the sampling frame for participants and a flowchart of the implementation research process. The remaining sections address data processing, limitations and delimitations of the methodology, ethical assurances, and a summary.

Restatement of the Problem and Purpose

The specific problem addressed was that the FAA cannot measure the level of SMS implementation based on the level of safety culture, or measure the level of safety culture based on the level of SMS implementation because there is no established relationship. The measures conflict and the FAA assigns causation to both in written literature (FAA, 2008c). At the time of this study, there were no FAA requirements to assess and confirm SMS implementation for air carriers (FAA, 2008c). As an ICAO member State, the United States committed to comply with ICAO safety standards (FAA, 2008b); however, the number of FAA officially accepted or approved SMS programs for commercial air operators in the United States was zero as of January 1, 2009 (FAA, 2008c).

The result creates operational risk for the United States commercial aviation industry and prohibits international operations between ICAO member States (ICAO, 2008). At the time of this study, there were 1,724 fixed wing turbine aircraft registered

FAR Part 135 air carrier operators in the United States (FAA, 2009b), which had not met the ICAO mandate (FAA, 2009c).

Positive safety culture depends on successful SMS implementation (FAA, 2006b, 2008a, 2009a; ICAO, 2008). Organizational culture influences safety management systems (Mitchell et al., 2002b; Shappell & Wiegmann, 2006). Implementation of a SMS is a constituent part of a positive safety culture (Mitchell et al., 2003a; Shappell & Wiegmann, 2006). Although sufficient research defined the characteristics that measured positive organizational safety cultures, more research is necessary to investigate the relationship between positive organizational safety culture and successful implementation of SMS in air carriers (Mitchell et al., 2003c; von Thaden & Gibbons, 2008). The FAA has no method to measure safety culture; therefore, one cannot validate SMS implementation if the key objective is to develop a positive safety culture as a component of SMS implementation (FAA, 2006b, 2008c, 2009c).

Systems theory provides a consistent framework for classifying and evaluating the SMS and provides a scholarly method of evaluation (Walonick, 1993). The set of interacting components that make up the system define the boundaries of the system (Walonick, 1993). The rise of systems theory in the 1970s forced scientists to view organizations as open systems that interacted with their environment (Walonick, 1993).

The purpose of this quantitative correlational study was to examine the relationship between the level of organizational safety culture and the level of SMS implementation in four FAR Part 135 air carriers. A survey administered to participants thorough Internet delivery determined whether there was a correlation between the level of SMS implementation and the level of organizational safety culture (FAA, 2006b, 2008c; Mitchell et al., 2003c). Measuring the correlation between the dependent variable of SMS implementation and the independent variables of organizational safety culture, management commitment, and safety promotion indicated an organization's ability to implement a verifiable SMS program (FAA, 2006b, 2008c, 2009a, 2009b, 2009c; ICAO 2005; Mitchell et al., 2003c; Shappell & Wiegmann, 2006; von Thaden, 2008; Xaiver, 2005).

Restatement of the Research Questions

The research questions used to examine the relationship between successful implementation of SMS and the level of organizational safety culture included:

Q1. To what extent does organizational safety culture relate to SMS implementation?

Q2. To what extent does management's commitment to safety relate to SMS implementation?

Q3. To what extent does safety promotion relate to SMS implementation?

Restatement of the Hypotheses

$H1_0$. There is no significant correlation between organizational safety culture and SMS implementation.

$H1_a$. There is a significant correlation between the organizational safety culture and SMS implementation.

$H2_0$. There is no significant correlation between management's commitment to safety and SMS implementation.

$H2_a$. There is a significant correlation between management's commitment to safety and SMS implementation.

$H3_0$. There is no significant correlation between safety promotion and SMS implementation.

$H3_a$. There is a significant correlation between safety promotion and SMS implementation.

Research Methods and Design

A quantitative correlational design offered the best approach to investigate various possible correlations between two or more variables (Hunter & Erin, 2008; Norusis, 2006; Yin, 2009). Service Provisioning System Software (SPSS) calculated the means and standard deviations of the dimensions for the dependent variable, SMS implementation, and each of the independent variables, organizational safety culture, management commitment to safety, and safety promotion (Hunter & Erin, 2008; Norusis, 2006; Yin, 2009). The K-S Lilliefor test for normality tested the assumption of normality (Norusis, 2006). Because results indicated normal data distribution, parametric tests were appropriate (Norusis, 2006), thus the analytical tool used to test the hypotheses was a one-way Analysis of Variance (ANOVA) (Norusis, 2006; Yin, 2009). The one-way ANOVA was appropriate because the study examined the correlation between the level of SMS implementation and the level of organizational safety culture. The quantitative research method used close-ended survey questions and statistical analysis of collected data with the intent to generalize from a sample to a population (Babbie, as cited in Creswell, 2003).

The study used quantitative, descriptive, and correlative statistical methods to gather and examine data analytically. Measures of the data's central tendency and dispersion created numerical and tabular distributions. The independent variables consisted of organizational safety culture, management's commitment to safety, and safety promotion. The dependent variable was SMS implementation in the four FAR Part 135 air carriers. During the course of examining the two primary issues in the research questions, the study explored SMS implementation and safety culture. In this quantitative research study, the level of organizational safety culture was the independent variable and the level of SMS implementation was the dependent variable. The primary goal of this study was to reveal relationships between the independent and dependent variables.

In the first research question, the study examined the correlation between organizational safety culture and SMS implementation in four FAR Part 135 air carriers. The second question queried a correlation between management commitment to safety and SMS implementation. In the third question, the study noted the correlation between safety promotion and SMS implementation. The independent and dependent variables for the study are in Table 3 with the demonstrated linkage between research questions and variables.

Table 3

Identification of Independent and Dependent Variables

	Variables	
Questions	Characteristics	Type
Q1/H1	Organizational safety culture (ordinal)	Independent variable
	SMS implementation (ordinal)	Dependent variable
Q2/H2	Management's commitment to safety (ordinal)	Independent variable
	SMS implementation (ordinal)	Dependent variable
Q3/H3	Safety promotion (ordinal)	Independent variable
	SMS implementation (ordinal)	Dependent variable

Note. Q1, Q2, and Q3 = research questions; H1, H2, and H3 = hypotheses

Participants

The sample population consisted of 4,295 pilots in four FAR Part 135 on-demand air carriers identified as participating in the FAA Safety Team SMS Pilot Project operating fixed wing turbojet aircraft. At the time of this study, there were 1,724 certificated FAR Part 135 air carriers operating fixed wing turbojet aircraft in the United States (D. Arendt, personal communications, March 3 and 4, 2009; FAA, 2009b). This population is part of a larger stratified population (FAA, 2009b), including helicopter operators, air ambulance operators, turbo-prop, and turbojet operators (FAA, 2009b). Simple random sampling was the common design used to select a group of subjects or *a sample* for study from a larger group or the *population* (Hunter & Erin, 2008; Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Individual selection was random and each member of the population had equal opportunity of being included in the sample (Norusis, 2006; Yin, 2009). This sampling technique was a priori; the researcher developed a sampling frame according to a mathematical procedure, and located the population selected for inclusion in the sample (Hunter & Erin, 2008; Trochim & Donnelly, 2007; Yin, 2009). Simple random sampling guaranteed that the sample represented the population (Yin, 2009). Random sampling ensured that statistical conclusions were valid (Norusis, 2006; Yin, 2009). Non-probability convenience sampling with the four FAR Part 135 air carriers aided participant selection (Trochim & Donnelly, 2007).

Sample size. Cohen (1992) found small, medium, and large population effect sizes for correlational analysis as 0.10, 0.30, and 0.50, respectively. Cohen concluded the import of sample sizes of 41, 125, and 1,163 for correlational studies with small, medium, and large effect sizes to achieve a statistical power of 0.80 at the 0.05 confidence level. Medium effect size was the smallest effect important to detect; a smaller effect would not be substantially significant and this effect size was reasonable (Cohen, 1992; Faul et al., 2007; Norusis, 2006; Yin, 2009). Therefore, a required minimum sample size of 125 would achieve 0.80 statistical power (Cohen, 1992). The Wilcoxon-Mann-Whitney two-tailed test in SPSS software calculated an a priori sample size of 368 for this study, where the assumed effect size was medium=.3, alpha=.05, power=0.8, allocation ratio=1 (Norusis, 2006; Yin, 2009). Statistical power analysis software, G Power, validated the sample size requirement (Faul et al., 2007). A two-tailed test used G Power 3.0.10 with an alpha 0.05, medium effect size 0.3, and 0.80 power to validate that a minimum of 368 respondents were sufficient for the study (Faul et al., 2007). A test with a power greater than 0.8 would be statistically powerful and considered the accepted convention (Cohen, 1992; Norusis, 2006; Yin, 2009). To detect a medium difference between two independent sample means, d=.3 at alpha=.05, required a sample size of 368.

Sampling procedures. The study employed a quantitative correlational 5-point Likert-type survey. Using post positivism, the survey could assess knowledge through measuring and testing specific variables to analyze statistical significance and to examine the relationship between organizational safety culture and SMS implementation (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Data derived from a developed survey instrument that measured attitudes, and analyzed collected information using statistical procedures and hypotheses testing (Yin, 2009). The survey method of data collection is a common method to assess safety critical factors in high risk organizations (Mitchell et al., 2003c). Survey methods allowed access to a large distribution and broad cross section of the population; respondents remained anonymous, allowing quick turnaround and researcher neutrality as an outside party without bias (Yin, 2009).

The non-probability convenience sample (Trochim & Donnelly, 2007) participated in an Internet-based survey protocol, known commercially as SurveyMonkey (SurveyMonkey, 2009). Probability sampling methods were not logistically feasible with this population due to commercial pilots constantly in transit from one duty location to the next. The primary duty location of commercial pilots is inside an aircraft. Non-probability convenience sampling using an Internet-based protocol permitted the participants to respond at a time convenient to their schedule (Trochim & Donnelly, 2007). Non-probability convenience sampling permitted the data collection phase to proceed rapidly by collecting data from pilots available to participate (Trochim & Donnelly, 2007). The four participating companies in the FAA pilot project sent an email to all crewmembers informing them of the survey, asking them to participate, and providing a link to the Internet survey. Participants accessed the Internet-based survey instrument through the Survey Monkey protocol.

Materials/Instruments

The study used a questionnaire to examine the hypotheses (Appendix A). The Safety Culture and Safety Management Systems Survey (SCSMSS) employed a database of items from the Commercial Aviation Safety Survey (CASS) (Mitchell et al., 2003c), and the FAA AC120-92 (FAA, 2009a) for each of the independent variables associated with the dependent variable. The SMS implementation section of the questionnaire did not use components of other instruments because no quantitative studies of SMS implementation existed that could verify the relationship between the level of organizational safety culture and the level of SMS implementation. Therefore, examining that relationship required a new questionnaire for this study.

Validity. Appendix B shows the set of 44 potential scale items entered into a survey type format using a scale of non-essential, essential but requires revisions, and essential (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). In field testing the survey instrument, four subject matter experts provided feedback regarding the items, including measurement of the dimensions of the dependent variable, and the appropriateness to include in a survey of air carrier employees (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Computation of the inter correlations was between all pairs of items with removal of items with low correlation using the total summed scale across all items (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Redundant items were deleted and remaining items reworded to ensure alignment with aviation terms. Based on feedback from the subject matter experts, revisions were made, and the remaining items entered into a survey format to include a 5-point Likert scale, resulting in a final survey instrument (see Appendix A) (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009) Figure 4 illustrates the process.

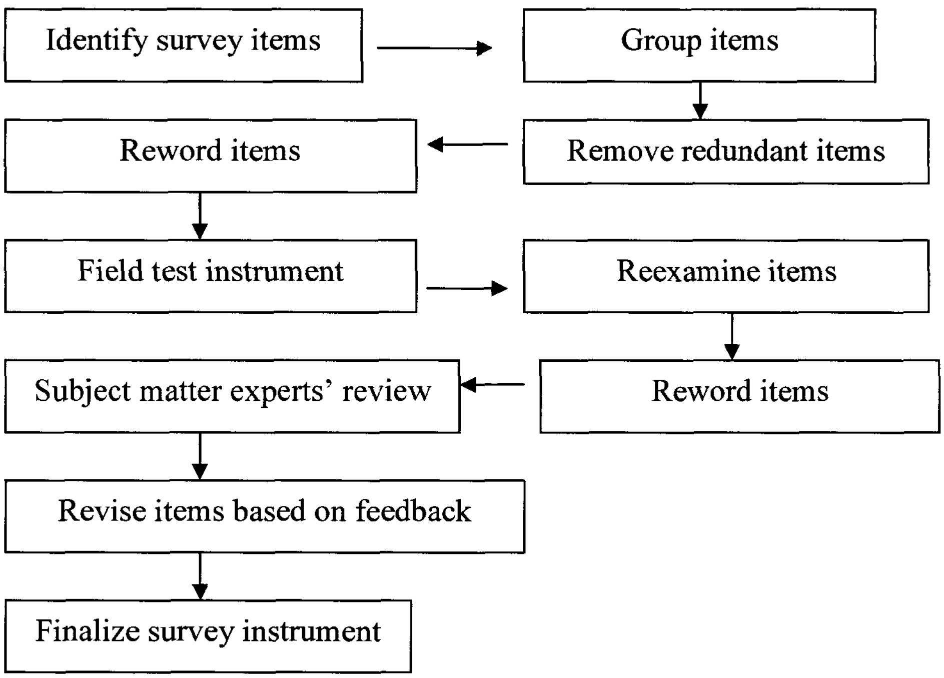

Figure 4. Process for development of SCSMSS.

The ability of the survey questionnaire items to measure the dimensions of organizational safety culture and SMS implementation related to air carriers determined the validity of the survey question. Item validity reflected the relevance of the survey instrument items to measurement of the intended dependent variable (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Items 1, 6, 7, 8, and 9 on the survey instrument measured the organizational safety culture construct. Inter correlations analysis determined convergent validity and that the five items related to the organizational safety culture construct. Items 13, 14, 15, 16, and 17 on the survey instrument measured the safety promotion construct. Inter correlations analysis determined convergent validity and that the five items related to the safety promotion construct. Items 10, 11, 12, and 13 on the survey instrument measured the SMS implementation construct. Inter correlations analysis determined convergent validity and that the four items related to the SMS implementation construct. Items 1, 2, 3, 4, and 5 on the survey instrument measured management commitment to the safety construct. Inter correlations analysis determined convergent validity and that the five items related to management commitment to the safety construct.

The sample participated in an Internet-based Likert-type style instrument through which the respondents selected one of a series of choices along a continuum from *strongly agree* to *strongly disagree*. Questions not answered complied with standard survey methodology, which dictated elimination (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Content validity was the degree to which the test measured the intended population and required both item validity and sampling validity (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Summated rating scales are most useful in social and behavioral research (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Summated rating scales are easier to develop and yield about the same information as the more laboriously constructed equal appearing interval scale. The primary advantage of a summated scale is that greater variance is obtainable. The disadvantage, as with all scales, is the vulnerability of the variance to biased response sets, e.g., the over-rater or the under-rater (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009).

Sampling validity shows how well the test or survey sampled the total population being tested (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). To determine whether the survey represented the population, a priori power analysis estimated an appropriate sample size needed to achieve adequate power (Cohen, 1992; Faul et al., 2007; Yin, 2009). The power of a statistical test is the probability that the test will reject a false null hypothesis, avoiding Type II errors. As the power of a test increases, the probability of a type II error decreases (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009).

Reliability. The degree to which the test or survey instrument consistently measures what it intends to measure is reliability (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). The estimate of reliability was numerical as a reliability coefficient obtained by correlation. A high reliability coefficient indicates high internal reliability (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Guttman-Cronbach alpha coefficients tested the scale reliability of the five scales for organizational safety culture and four scales for SMS implementation (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). An Internet-based 5-point Likert-type questionnaire surveyed individuals, allowing selection of one of a series of choices along a continuum from strongly agree (5) to strongly disagree (1) with a neutral option of neither agree nor disagree (3). Questions not answered complied with standard survey methodology, which dictated elimination (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Each survey instrument has positive and negative factors, such as time, cost, and need for specialized personnel, among others. The survey approach is one of the most commonly used methods to assess safety critical factors of high risk organizations (Mitchell et al., 2003c; Yin, 2009; Zikmund, 2003).

Formerly, no consensus was evident on the exact number of indicators that reflect an organization's SMS implementation level. Numerous organizational indicators exist with estimates ranging from 3 to as many as 8 (ALPA, 2006; FAA, 2006a; ICAO, 2005). Inconsistencies and frequent idiosyncratic labeling of these indicators make it difficult to reconcile the range of organizational indicators identified in research (Mohaghegh, 2007). Analysis of various reports revealed four global components or indicators of SMS implementation used by regulatory agencies. The four general indicators of an implemented SMS are policy, safety risk management, safety assurance, and safety promotion (ALPA, 2006; FAA, 2006a; ICAO, 2005).

Operational Definition of Variables

Safety management system implementation. The operational definition of the dependent variable SMS implementation was an effective SMS that supports and encourages full participation by everyone in the organization, and incorporates safety policy, safety risk management, safety assurance, and safety promotion (ALPA, 2006; FAA, 2006a, 2009a; Helmreich & Merritt, 2005; ICAO, 2005, 2008; Reason, 2000). Survey questions 10, 11, 12, and 13 measured SMS implementation. Safety management system survey data are ordinal scale (Trochim & Donnelly, 2007). The examination of a significant relationship between SMS implementation, safety promotion, organizational safety culture, and management commitment to safety was through a one-way ANOVA because the data were parametric (Norusis, 2006; Yin, 2009).

Safety promotion. The operational definition of the independent variable safety promotion was management's commitment to safety through communication of safety policy, training, and reporting (ALPA, 2006; FAA, 2006a, 2009a; Helmreich & Merritt, 2005; ICAO, 2005, 2008; Reason, 2000). Survey questions 13, 14, 15, 16, and 17 measured safety promotion. Safety promotion survey data are ordinal scale (Trochim & Donnelly, 2007). A significant relationship between safety promotion and SMS implementation was through a one-way ANOVA because data were parametric (Norusis, 2006; Yin, 2009).

Organizational safety culture. The operational definition of the independent variable organizational safety culture includes organizations that promote a positive safety culture through publication and demonstration of executive level management commitment to safety with clear and regular communication of safety policy, goals, objectives, standards, and performance responsibilities for all personnel (ALPA, 2006; FAA, 2006a; ICAO, 2005; Mitchell et al., 2003c). Survey questions 1, 6, 7, 8, and 9 measure organizational safety culture. Organizational safety culture survey data are ordinal scale (Trochim & Donnelly, 2007). A significant relationship between organizational safety culture and SMS implementation was through a one-way ANOVA because data were parametric (Norusis, 2006; Yin, 2009).

Management commitment. The operational definition of the independent variable management commitment was the ability of the organization's senior management to demonstrate a sustained positive attitude toward safety and the provision of resources to implement safety activities, evaluation of safety, and accountability of safety activities (Dedobbeleer & Beland, cited in Mitchell et al., 2003c). Survey questions 1, 2, 3, 4, and 5 measured management commitment to safety. Management commitment to safety survey data are ordinal scale (Trochim & Donnelly, 2007). A significant relationship between management commitment and SMS implementation was through a one-way ANOVA because data were parametric (Norusis, 2006; Yin, 2009).

Data Collection, Processing, and Analysis

Data collection was through an Internet-based survey website, Survey Monkey (SurveyMonkey, 2009). Data collection through an Internet-based survey method offered confidentiality because participants provided no names or other identifying information and the data were not available to the respondents' organizations (Norusis, 2006; Yin, 2009). Responses with missing data were not included in study results analysis following standard survey methodology (Norusis, 2006; Yin, 2009). Figure 5 depicts the process and procedures flowchart for administering the SCSMSS, data collection, and analysis steps.

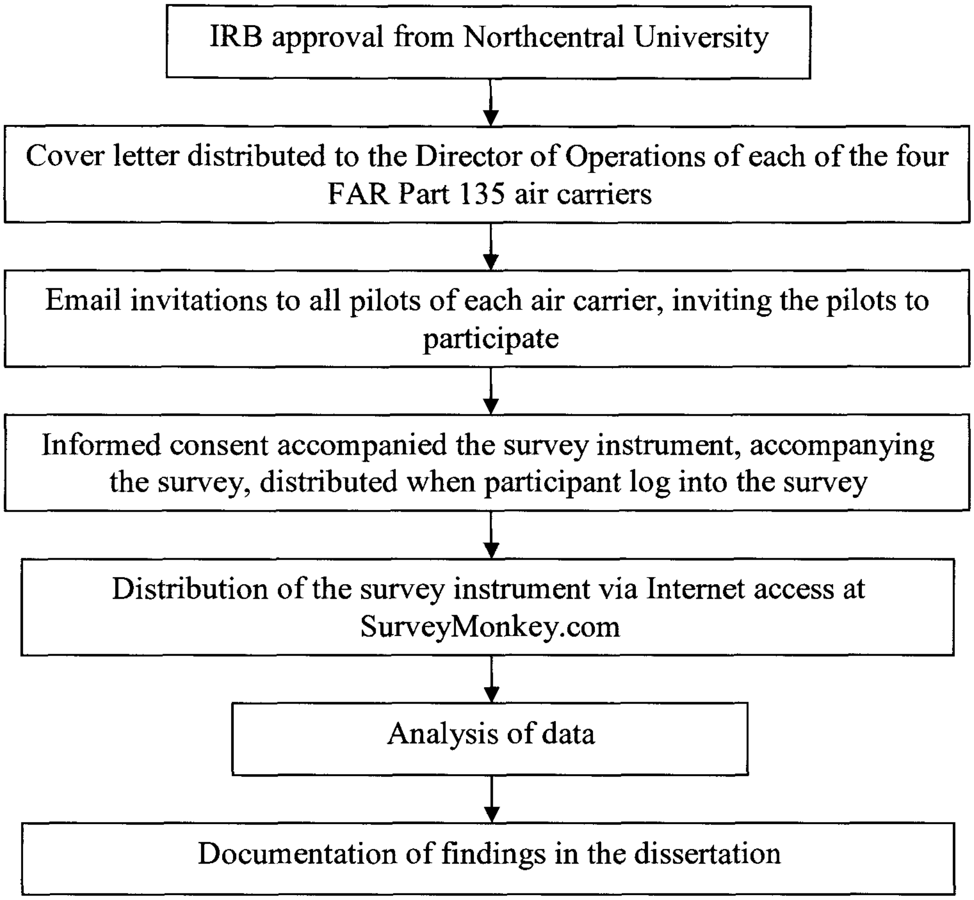

Figure 5. The process for the implementation of the instrument.

Data analysis. A survey instrument that assessed the factors that made up the independent variable organizational safety culture, and the dependent variable, SMS implementation, required correlational analysis (Norusis, 2006; Yin, 2009). The one-way Analysis of Variance (ANOVA) tested the significance of the relationship between the independent variables, safety promotion, management commitment, organizational safety culture, and the dependent variable, SMS implementation (Norusis, 2006; Yin, 2009). The K-S Lilliefor test for normality tested the assumption of normality (Norusis, 2006). Because the data had normal distribution, they underwent parametric tests (Norusis, 2006). Canonical correlation determined the degree of association between the independent variable of organizational safety culture and the dependent variable SMS implementation (Norusis, 2006; Yin, 2009).

Statistics using SPSS software calculated the means and standard deviations of the independent variables safety promotion, management commitment, organizational safety culture, and for the dependent variable SMS implementation (Norusis, 2006; Yin, 2009). A Kolmogorov-Smirnoff formal statistical test determined whether the distribution of data differed significantly from a Gaussian distribution (Norusis, 2006; Yin, 2009).

Methodological Assumptions, Limitations, and Delimitations

The methodological assumptions used for the study depended on several key assumptions (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). The first assumption was that, by using a sample of the data set of variables and displaying the information in analytical tools, such as SPSS software, the study could extract meaningful information (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Another assumption was that the subjects would respond accurately to the survey questions (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Finally, subjects were under no influence to answer one way or the other to any survey question (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009).

Assumptions. The basis for selecting a Likert-type survey was on the premise that it is impossible for one question to explain a concept as difficult as organizational safety culture or SMS implementation; therefore, any attempt to determine an organization's safety culture or SMS implementation on the basis of a single question was meaningless (Helmreich & Merritt, 2005; Mitchell et al., 2003c; Mohaghegh, 2007).

However, the use of summated data from a series of questions that measure similar factors could explain organizational safety culture and SMS implementation (Helmreich & Merritt, 2005; Mitchell et al., 2003c; Mohaghegh, 2007). The Likert-type or summated rating scales contained a set of items approximately equal in value loading (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). The subjects responded with varying degrees of intensity on a scale ranging between the extremes strongly agree and strongly disagree (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). After summation and averaging, the scores of the position responses of each of the separate scales yielded individual scores (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009).

Limitations. The data for the study derived from various locations of one air carrier industry sector (FAR Part 135); therefore, data may reflect the organizational safety culture and SMS implementation levels of only the FAR Part 135 industry sector, and may not be generalizable to all areas of aviation (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). However, the methodology is repeatable and may be applicable to almost any organization in the aviation industry setting (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009).

Not all FAR Part 135 air carrier operators in the population were large organizations. A number of these organizations had fewer than ten personnel and could not provide a large enough sample size to detect significant differences unless there was a census of the organization. The study should provide directions quantifying the organizational safety culture and SMS implementation relationship.

Quantitative analysis often appears to give precise answers to research questions. In the current study, the answers provided were only approximations, although possibly the best obtainable, to the questions of real interest (Hunter & Erin, 2008; Quade, 1970). For complex questions, computers and mathematical models cannot treat all aspects of a problem, thus requiring researchers to use more than analysis to make a correct decision or subjective judgment about the data results (Hunter & Erin, 2008; Quade, 1970). For example, a researcher may determine whether a variance has significance.

Delimitations. Delimitations included time because organizational culture and SMS is an ever evolving process. The data generated from the study may not apply to individual organizations over a long period; however, the process established a methodology for organizations to analyze the safety culture and sustained SMS of the organization and should allow for adjustments (Helmreich & Merritt, 2005; Mitchell et al., 2003c; Mohaghegh, 2007; Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009).

Ethical Assurances

Survey questionnaire. The study used a single Internet-based survey instrument with an abbreviated CASS (Mitchell et al., 2003c) and FAA guidance of SMS doctrine (FAA, 2009a). The survey contained an informed consent form and a letter to reinforce that results would develop only aggregate statistical data and that individual information would be anonymous and not offered to third parties (Trochim & Donnelly, 2007). Northcentral University IRB approved the study prior to any research.

Consent to participate. Trochim and Donnelly (2007) emphasized that researchers had an obligation to respect the rights of study participants by ensuring that they clearly understand the purpose of the study, potential risks, and benefits to them; that study participants had guarantees of anonymity and confidentiality; and that the study participants had the right to withdraw their participation at anytime (Trochim &

Donnelly, 2007; Yin, 2009). Participants were free to accept or reject a request for participation (Yin, 2009). The survey front material clearly stated that participation was voluntary and without risk of retribution if participants declined.

Honesty with professional colleagues. Ethical responsibility extended beyond the accounting of data collection and analysis as stated in the problem and purpose statements to the actual writing of a final factual research report (Trochim & Donnelly, 2007; Yin, 2009). The research report did not use biased language or words against persons because of race, gender, sexual orientation, disability, or age (Trochim & Donnelly, 2007; Yin, 2009).

Summary

The drafting of regulations mandating SMS implementation in aviation by the ICAO (ICAO, 2008) and national aviation agencies require the national aviation agencies to measure SMS implementation. At the time of this study, there were no FAA requirements for air carriers to assess and confirm SMS implementation, nor to comply with the ICAO mandate requiring member States to meet SMS implementation (FAA, 2009a; ICAO, 2008). Member States to the ICAO convention can refuse to allow commercial air operations to air carriers that do not have an implemented SMS verified by the air carrier's National Aviation Authority (FAA, 2009a; ICAO, 2008).

Regulatory agencies mandating SMS implementation postulated that an implemented SMS caused the organization's safety culture (von Thaden & Gibbons, 2008). Organizational behaviorists postulated that the safety culture caused SMS implementation (FAA, 2009a; ICAO; 2008; Shappell & Wiegmann, 2006). The basis of both arguments was on emergent theories, and not on empirical studies. There was no established empirical relationship between SMS implementation and safety culture. Safety management system literature would benefit from additional examination of the relationship between the postulated components of a SMS (ALPA, 2006; FAA, 2006a, 2009a; Gibbons et al., 2007; Helmreich & Merritt, 2005; Mitchell et al., 2003c; Patankar & Taylor, 2006; Shappell & Wiegmann, 2006)..

The purpose of this proposed quantitative correlational research study was to determine the relationship, if any, between the level of organizational safety culture and the level of SMS implementation. An Internet-based survey questionnaire from the previously developed abbreviated CASS instrument and questions based up the FAA's SMS framework AC120-92 was the basis for the study (FAA, 2009a; Mitchell et al., 2003c). The sample population consisted of 4,295 pilots in four FAR Part 135 on-demand air carriers identified as participating in the FAA Safety Team, SMS Pilot Project. Non-probability convenience sampling and an Internet-based survey protocol offered the minimum 368 responses required (Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009).

At the time of this study, there was no established regulatory aviation industry standard to measure SMS implementation or to determine if an organizational safety culture existed (ALPA, 2006; FAA, 2006a, 2008c, 2009a; Gibbons et al., 2007; Helmreich & Merritt, 2005; Mitchell et al., 2003c; Patankar & Taylor, 2006; Shappell & Wiegmann, 2006). One of the listed component parts of a SMS is an organizational safety culture (ALPA, 2006; FAA, 2006a, 2008c, 2009a; ICAO, 2005, 2008; Reason, 2000). National, corporate, and professional cultures are significant determinants of the processes underlying the aviation systems' performance (Helmreich & Merritt, 2005;

Johnston et al., 2006; Reason, 2000). Safety management systems are a logical and systematic way to integrate and manage system safety concepts and regulatory requirements throughout an organization (ICAO, 2008; Reason, 2000).

Organizational culture influences safety management systems, either positively or negatively (Mitchell et al., 2002b; Schein, 1984; Shappell & Wiegmann, 2006). Although extensive research defined the characteristics that measured and indicated organizational safety culture levels within various industries, including aviation, more research could investigate the relationship between implementation of SMS and organizational safety culture in air carriers (ALPA, 2006; FAA, 2006a, 2009a; Gibbons et al., 2007; Helmreich & Merritt, 2005; Mitchell et al., 2003c; Patankar & Taylor, 2006; Shappell & Wiegmann, 2006).

Safety management systems require a safety oriented organizational culture supported by senior management commitment and involvement, monitoring, and evaluation of safety (FAA, 2006a, 2009a; Helmreich & Merritt, 2005; ICAO, 2005; Johnston et al., 2006; Mitchell et al., 2003c; Reason, 2000; Shappell & Wiegmann, 2006). Organizational culture can contribute to accidents (Helmreich & Merritt, 2005; Mitchell et al., 2002b). By replicating this study in different types of air operations and contexts, the results could be helpful in developing a model of SMS to implement in an organizational culture context (Dulac et al., 2004).

At the time of this study, there was limited empirical research to establish a relationship between the level of organizational safety culture, and the level of SMS implementation (FAA, 2006a, 2009a; Helmreich & Merritt, 2005; ICAO, 2005; Johnston et al., 2006; Mitchell et al., 2003c; Reason, 2000; Shappell & Wiegmann, 2006).

Organizational behaviorists postulated that a SMS was the result of a positive organizational safety culture (FAA, 2006a, 2009a; Helmreich & Merritt, 2005; ICAO, 2005; Johnston et al., 2006; Mitchell et al., 2003c; Reason, 2000; Shappell & Wiegmann, 2006). Simply stated, the organizational culture caused the development of a SMS. The FAA required implementation of a SMS and managements' commitment to and promotion of safety within the organizational culture as required elements of a SMS (FAA, 2006a, 2009a; ICAO, 2005).

At the time of this study, the FAA was drafting regulatory requirements to implement SMS (FAA, 2006a, 2009a; ICAO, 2005). However, prescribing a rule or rules to require a SMS or any other system cannot guarantee development of a positive organizational safety culture (FAA, 2006a, 2009a; Helmreich & Merritt, 2005; ICAO, 2005; Johnston et al., 2006; Mitchell et al., 2003c; Reason, 2000; Shappell & Wiegmann, 2006). An organization can implement programs to comply with a regulation, and not have an associated culture to go with the program (Helmreich & Merritt, 2005; Johnston et al., 2006; Mitchell et al., 2003c; Reason, 2000; Shappell & Wiegmann, 2006).

Correlations between sets of variables apply only to linear relationships and do not impute cause (Feng, 2006; Hunter & Erin, 2008; Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Causation determination between organizational safety culture and SMS implementation will require repeated empirical research after establishing a base line relationship (Feng, 2006; Hunter & Erin, 2008; Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009).

Chapter 4: Findings

The purpose of this quantitative correlational study was to examine the relationship between the level of organizational safety culture and the level of SMS implementation in four FAR Part 135 air carriers (FAA, 2006b, 2008c; Mitchell et al., 2003c). The study used an Internet-based questionnaire to determine if correlation existed between the level of organizational safety culture and the level of SMS implementation (FAA, 2006b, 2008c; Mitchell et al., 2003c). The specific problem addressed was that the FAA cannot measure the level of SMS implementation based on the level of organizational safety culture, or measure the level of organizational safety culture based on the level of SMS implementation because there is no established relationship between the level of SMS implementation and the level of organizational safety culture.

This chapter presents the study findings, including the descriptive statistics of means, standard deviations, variance, minimum, maximum, and ranges. Results offer scale reliability and item validity for each variable scale. Organization is around the research questions and supporting hypotheses. Using additional analyses, data presented went beyond the scope of the original research questions. The conceptual framework of the study controlled interpretation of the findings.

Results

Four thousand two hundred and ninety five Safety Culture and Safety Management System Surveys (SCSMSS) went to pilots in four FAR Part 135 air carrier operators by email invitation. A link to the Internet-based survey was in the email invitation with a letter from senior safety representatives of the organizations. The first page of the Internet-based survey contained an explanation of the purpose of the survey, assuring anonymity and confidentiality. Participation was completely voluntary, and respondents received no compensation.

Of the 4,295 surveys distributed, 528 (12.3%) were returned. Not all responses to the survey were usable due to incomplete answers, thus eliminating 124 responses (23.5%). This resulted in 404 (9.4%) of the distributed surveys included in the analysis.

Scale reliability. Guttman-Cronbach alpha coefficients derived from the data for the safety culture scale, management commitment scale, safety promotion scale, and SMS implementation scale are in Table 4. Reliability coefficients of .80 or higher were considered good and indicated the data within each scale variable had relatively high internal consistency. The alpha for all four scales indicated adequate reliability, meeting or exceeding, generally accepted standards.

Table 4

Reliability Scales

Scale	#of items	alpha
Organizational Safety Culture (SC)	5	0.864
Safety Management System (SMS)	4	0.936
Management Commitment (MC)	5	0.920
Safety Promotion (SP)	5	0.947

The mean score of questions 1, 6, 7, 8, and 9 on the SCSMSS questionnaire computed the composite score for the organizational safety culture variable. Values ranged from 1 (strongly disagree) to 5 (strongly agree). The inter correlations were computed between all pairs of items making up the safety culture variable. Item validity calculated from data indicated that the survey items were relevant to the measurement of the safety culture variable. The safety culture variable scale inter correlations results depicted in Table 5 indicated relatively high correlation of the items within the safety culture variable scale. Thus, the safety culture variable scale items were relevant to measurement of the level of safety culture.

Table 5

Safety Culture Variable Scale Inter Correlation

	Q1	Q6	Q7	Q8	Q9
Q1					
Q6	.367				
Q7	.729	.400			
Q8	.643	.425	.796		
Q9	.491	.680	.564	.629	-

Note. All coefficients are significant at $p< .01$.

The mean score of questions 10 through 13 of the SCSMSS questionnaire computed the composite score for the SMS implementation variable. Values ranged from 1 (strongly disagree) to 5 (strongly agree). The inter correlations were between all pairs of items making up the SMS implementation variable. Item validity calculated from data indicated that the survey items were relevant to the measurement of the SMS implementation variable. The SMS implementation variable scale inter correlations results, depicted in Table 6, indicated relatively high correlation between the items within the scale. Thus, the SMS implementation variable scale items were relevant to measurement of SMS implementation.

Table 6

SMS Implementation Variable Scale Inter Correlation

	Q10	Q11	Q12	Q13
Q10				
Q11	.780			
Q12	.786	.832		
Q13	.821	.727	.823	

Note. All coefficients are significant at $p < .01$.

The mean score of questions 1 through 5 of the SCSMSS questionnaire computed the composite score for the management commitment to safety variable. Values ranged from 1 (strongly disagree) to 5 (strongly agree). The inter correlations were between all pairs of items making up the management commitment to safety variable. Item validity calculated from data indicated that the survey items were relevant to the measurement of the management commitment to safety variable. The management commitment to safety variable scale inter-correlations results depicted in Table 7 indicated relatively high correlation between the items within the management commitment to safety variable scale. Thus, the management commitment to safety variable scale items were relevant to measurement of management commitment to safety.

Table 7

Management Commitment to Safety Variable Scale Inter Correlation

	Q1	Q2	Q3	Q4	Q5
Q1					
Q2	.733				
Q3	.692	.775			
Q4	.713	.720	.711		
Q5	.705	.741	.689	.509	

Note. All coefficients are significant at $p < .01$.

The mean score of questions 13 through 17 of the SCSMSS questionnaire computed the composite score for the safety promotion variable. Values ranged from 1 (strongly disagree) to 5 (strongly agree). The inter correlations were between all pairs of items making up the safety promotion variable. Item validity calculated from data indicated that the survey items were relevant to the measurement of the safety promotion variable. The safety promotion variable scale inter correlation results depicted in Table 8 indicate relatively high correlation of the items within the safety promotion variable scale. Thus, the safety promotion variable scale items were relevant to measurement of safety promotion.

Table 8

Safety Promotion Variable Scale Inter Correlation

	Q13	Q14	Q15	Q16	Q17
Q13					
Q14	.757				
Q15	.809	.790			
Q16	.799	.854	.903		
Q17	.743	.809	.774	.823	

Note. All coefficients are significant at $p < .01$.

Means for each variable scale appear in Figure 6. Responses were on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) with 3 (neither agree nor disagree). The possible range of values for each variable scale was 1(indicating an extremely negative view of the dimension) to 5 (indicating an extremely positive view of the dimension). A scale score of 3 reflected neutrality (neither agreeing nor disagreeing with any item). Results indicated that all four variables means rated above 3 on the scale indicated by the horizontal line in Figure 6. Scores were positive when above the line and negative when below the line.

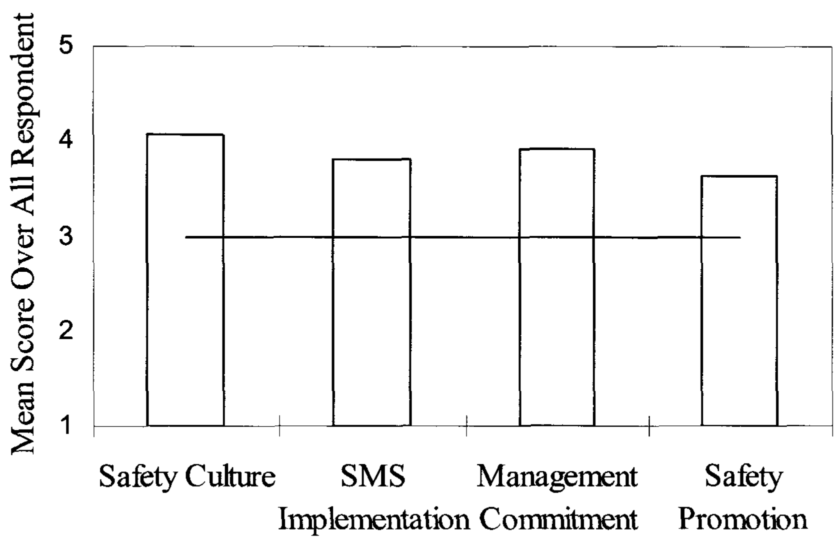

Figure 6. Mean scores on the four variable scales. The horizontal line indicates the scale midpoint of 3. Scores are positive above this line and negative below.

Data normality. The K-S Lilliefor test assessed the assumption of data normality for each variable scale. Results in Table 9 for each variable scale indicated that the data were normally distributed and one-way ANOVA parametric tests were appropriate for the study.

Table 9

Variable Scales Data Normality Test

		SC	MC	SP	SMS
N		404	404	404	404
Normal Parameters[a,b]	Mean	4.081	3.914	3.632	3.809
	Std. Dev.	.7501	.8611	.8934	.9292
Most Extreme					
Differences	Absolute	.247	.120	.192	.255
	Positive	.110	.103	.093	.100
	Negative	-.247	-.120	-.192	-.255
Kolmogorov-Smirnov Z		4.955	2.419	3.861	5.121
Asymp. Sig (2-tailed)		.000	.000	.000	.000

Note: a. Test distribution is normal; b. Calculated from data.

Calculating the means, standard deviations, range, and variances determined performance scores for each of the four variable scales. Descriptive statistics for each variable scale appear in Table 10. The mean score on all four variable scales was above the neutral point, indicating that respondents held a generally positive opinion of the level of organizational safety culture and the SMS implementation as well as the level of the moderating variables, safety promotion, and management commitment to safety (Table 10). Variability within the scales suggested that not all respondents viewed the level of safety culture, level of SMS implementation, management commitment to safety, and safety promotion in the same way. Some respondents indicated a very positive view of the performance on the variable scales, while other respondents indicated a negative view on some aspects of the variable scales. No variable scale received a perfect score from any respondent (i.e., endorsing the appropriate strongly agree/disagree alternative for all items in the variable scales), and no variable scale item received a completely positive score from all respondents. No individual respondent indicated all negative scores for all four variable scales.

Table 10

Variable Scales Descriptive Statistics

	Mean	Std. Dev.	Var.	Min	Max	Range
Safety Culture	4.081	.7501	.563	1.80	5.00	3.20
Management Commitment	3.914	.8611	.740	1.80	5.00	3.20
Safety Promotion	3.632	.8934	.798	1.20	5.00	3.80
SMS Implementation	3.809	.9292	.863	1.25	5.00	3.75

Research questions. Bivariate correlations measured the relationship between the dependent variable SMS implementation and the three independent variables, level of organizational safety culture, level of management commitment to safety, and the level of safety promotion. All tests were two-tailed and assumed an alpha significance level of .05. Following is a presentation of the findings for the research questions used to examine the relationships between the variables.

Research question Q1. The following is a restatement of Research Question Q1, together with associated null and alternative hypotheses.

Q1. To what extent does organizational safety culture relate to SMS implementation?

$H1_0$. There is no significant correlation between organizational safety culture and SMS implementation.

$H1_a$. There is a significant correlation between organizational safety culture and SMS implementation.

Participants completing the survey numbered 404. Bivariate correlations measured the relationship between the level of organizational safety culture and the level of SMS implementation. The relationship between the level of organizational safety culture and the level of SMS implementation was positive and significant, $r(404) = .86$, $p < .001$. The one-way analysis of variance between the level of organizational safety culture and the level of SMS implementation revealed a significant effect of the level of organizational safety culture on SMS implementation, $F(15, 388) = 98.423$, $p < .001$, $MS_{error} = 0.122$, $\alpha = .05$. The null hypothesis $H1_0$ was rejected. Table 11 displays the One-Way Analyses of Variance correlation summary data for the relationship between the level of organizational safety culture and the level of SMS implementation. Table 12 displays the Pearson's correlation coefficients for the relationship between the level of organizational safety culture and the level of SMS implementation.

Table 11

Summary One-way ANOVA for the Effects of Safety Culture, Management Commitment, and Safety Promotion on SMS Implementation

Variable	df	MS	F	*p*
Safety culture	15	11.972	98.423	< .001
Management commitment	15	9.873	25.551	< .001
Safety promotion	15	20.379	494.625	< .001

Table 12

Correlations of SMS Implementation with Independent Variables

	N	r	Significance
Safety culture	404	.86***	<.001
Management commitment	404	.64***	<.001
Safety promotion	404	.95***	<.001

*** $p < .001$.

Research question Q2. The following is a restatement of Research Question Q2, together with associated null and alternative hypotheses.

Q2. To what extent does management's commitment to safety relate to SMS implementation?

$H2_0$. There is no significant correlation between management's commitment to safety and SMS implementation.

$H2_a$. There is a significant correlation between management's commitment to safety and SMS implementation.

Bivariate correlations measured the relationship between the level of management's commitment to safety and the level of SMS implementation. The relationship between the level of management's commitment to safety and the level of SMS implementation was positive and significant, $r(404) = .64, p < .001$. The one-way analysis of variance between the level of management's commitment to safety and the level of SMS implementation revealed a significant effect of the level of management's commitment to safety on the level of SMS implementation, $F(15, 388) = 25.551, p < .001$, $MS_{error} = 0.386$, $\alpha = .05$. Thus, the null hypothesis $H2_0$ was rejected. Table 11 displays the one-way ANOVA correlation summary data for the relationship between the level of management's commitment and the level of SMS implementation. Table 12 displays the Pearson's correlation coefficients for the relationship between the level of management's commitment to safety and the level of SMS implementation.

Research question Q3. The following is a restatement of Research Question Q3, together with associated null and alternative hypotheses.

Q3. To what extent does safety promotion relate to SMS implementation?

$H3_0$. There is no significant correlation between safety promotion and SMS implementation.

$H3_a$. There is a significant correlation between safety promotion and SMS implementation.

Bivariate correlations measured the relationship between the level of safety promotion and the level of SMS implementation. The relationship between the level of safety promotion and the level of SMS implementation was positive and significant, $r(404) = .95, p < .001$. The one-way ANOVA between the level of safety promotion and the level of SMS implementation revealed a significant effect of the level of safety promotion on the level of SMS implementation, $F(15, 388) = 494.625, p < .001$, $MS_{error} = 0.041$, $\alpha = .05$. Therefore, the null hypothesis $H3_0$ was rejected. Table 11 displays the one-way ANOVA correlation summary data for the relationship between safety promotion and the level of SMS implementation. Table 12 displays the Pearson's correlation coefficients for the relationship between the level of safety promotion and the level of SMS implementation.

Additional analysis. The data gathered for this study afforded opportunities for additional analysis beyond the scope of the three research questions. There were correlations between the level of organizational safety culture and the variables, management's commitment to safety and safety promotion. Relationships were significant and positive between the level of organizational safety culture and management's commitment to safety, r(404) = .69**, $p < .001$. The one-way ANOVA between the level of organizational safety culture and the level of management's commitment to safety revealed a significant effect of the level of management's commitment to safety on the level of organizational safety culture, $F(16, 387) = 90.106$, $p < .001$, $MS_{error} = 0.163$, $\alpha = .05$. Table 13 displays the correlations between the level of organizational safety culture and the variables management's commitment to safety and safety promotion.

Table 13

Correlation of Safety Culture with other Independent Variables

	n	r	Significance
Management commitment	404	.69**	<.001
Safety promotion	404	.69**	<.001

*** $p < .01$.

There were correlations between the level of organizational safety culture and the variable safety promotion. Relationships were significant and positive between the level of organizational safety culture and safety promotion, r(404) = .69**, $p < .001$. The one-way ANOVA between the level of organizational safety culture and the level of safety promotion revealed a significant effect of the level of safety promotion on the level of organizational safety culture, $F(16, 387) = 16.853, p < .001, MS_{error} = 0.134, \alpha = .05$. Table 13 displays the correlations between the level of organizational safety culture and the variables management's commitment to safety and safety promotion.

The survey included a demographic section to provide additional information about the respondents (see Table 14). Most of the respondents (80%) were male, while only 20% were female. The majority of respondents (73%) held the position of Captain and (27%) were First Officers. The reported range for years of employment with the highest frequency (65%) was the 7 to 15 year employment range. They noted their total number of flight hours; however, the responses appeared to round numbers to the nearest thousands. Therefore, reliability of this variable element data was suspect and thus eliminated from analysis.

Table 14

Demographics Data

	Gender		Title		Years	
	Male	Female	Captain	First Officer	1-6	7-15
N	323	81	294	110	140	264

The safety culture variable had the highest mean score of 4.081 and the smallest variance around the mean of .56. The safety culture variable had a median score of 4.4 and the most responses at the cut point with 137. The safety culture variable and the management commitment variable had the smallest range of scores at 3.20. The safety culture variable had the lowest number of responses above the cut point with 98. Table

15 depicts the study participants perception of safety behavior within their organizations varied the least.

Table 15.

Central Tendency Statistics

	Mean	Median	At	Above	Below	Coefficient of Variation
Safety culture	4.081	4.4	137	98	167	18.38
Management commitment	3.914	4.0	29	197	178	22.00
Safety promotion	3.632	4.0	70	145	189	25.58
SMS implementation	3.809	4.0	91	181	132	23.45

The management commitment variable had the second largest mean score of 3.914 and the second largest variance around the mean of .74. The management commitment variable had a median of 4.0 and the lowest number of responses at the cut point with 29. The management commitment variable had the same small range of scores as the safety culture variable at 3.20. The management commitment variable had the largest number of responses above the cut point at 197. Table 15 depicts the study participants perception of the level of management commitment to safety varied more than the level of safety culture.

The safety promotion variable had the lowest mean score of 3.632 and the second largest variance around the mean of .79. The safety promotion variable had a median score of 4.0 and the third largest number of responses at the cut point with 70. The safety promotion variable had the largest range of scores at 3.80 and the third largest number of response above the cut point at 145. Table 15 depicts the study participants perception of the level of safety promotion varied more than the level of safety culture.

The SMS implementation variable had the third largest mean score of 3.809 and the largest variance around the mean of .86. The SMS implementation variable had a median score of 4.0 and the second largest number of responses at the cut point with 91. The SMS implementation variable had the second largest range of scores at 3.75. The SMS implementation variable had the second largest number of responses above the cut point at 181. Table 15 depicts the study participants perception of the level of SMS implementation varied more than the level of safety culture.

The coefficient of variation for the safety culture variable is 18%. For the management commitment variable, the coefficient of variation is 22%. For the safety promotion variable, the coefficient of variation is 25%. For the SMS implementation variable, the coefficient variation is 23%. Compared to their means, the level SMS implementation, management commitment, and safety promotion varies more than the level of safety culture.

Evaluation of Findings

Although researchers measured the level of organizational safety culture and postulated through emergent theory, the level of SMS implementation through management's commitment to safety and safety promotion as a result of the organization's safety culture (FAA, 2006b, 2009a; ICAO, 2008; Mitchell et al., 2002b, 2003a; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008), the relationship between the level of organizational safety culture and the level of SMS implementation has no documentation. The FAA's requirement to implement a SMS (FAA, 2009a;

ICAO, 2008) and the argument that implementation of a SMS causes the development of a positive safety culture through management's commitment to safety and safety promotion has no supporting research. Therefore, the results of this study illustrate the need for a positive level of organizational safety culture to implement a SMS successfully through the identified constituent components of management's commitment to safety and safety promotion.

Findings in the current study confirmed the relationship between the level of organizational safety culture and the level of SMS implementation. In addition, results reinforced the applicability of management's commitment to safety and safety promotion as constituent components of both the level of organizational safety culture and the level of SMS implementation (FAA, 2006b, 2009a; ICAO, 2008; Mitchell et al., 2002b, 2003a; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Researchers (Gibbons et al., 2007; Wiegmann et al., 2003; von Thaden & Gibbons, 2008) showed that management's commitment to safety and safety promotion was relatively highly correlated to safety culture. Von Thaden and Gibbons (2008) reported that organizations with an implemented SMS had identifiable organizational safety cultures and the constituent components of management commitment and safety promotion. The results of this study support the findings reported by von Thaden and Gibbons (2008).

Although these aspects were identifiable and measurable, there was no empirical evidence to support causation of SMS implementation through safety culture or causation of safety culture through implementation of a SMS. The measurement of SMS implementation using one parameter is not supported by the results of this study. The positive and significant relationship between all variables indicates that measuring successful SMS implementation requires measuring all variables.

The implementation of a SMS is a constituent part of a positive organizational safety culture (FAA, 2006b, 2009a; ICAO, 2008; Mitchell et al., 2003a; Shappell & Wiegmann, 2006). Results of this study showed that the constituent variables of management's commitment to safety and safety promotion are as correlated to implementing a SMS as they are to the level of the organization's safety culture (FAA, 2006b, 2009a; ICAO, 2008; Mitchell et al., 2002b, 2003a; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008).

A system's engineering approach to SMS implementation is expected by the FAA, evidenced by the FAA's definition of SMS as a top down business like approach to managing safety (FAA, 2009a). This study indicates that implementing an SMS is a deliberate organizational change (Lofquist, 2008) where the organizational culture influences the effectiveness of implementing and managing change to the organizations management system. The results indicate that all of the variables exist at differing levels from organization to organization, and an organization whose culture involved the entire organization in deliberate SMS implementation, reduces organizational resistance to the change and creates higher levels of commitment by employees towards implementing an SMS (Lofquist, 2008). The results suggest no direct causation, but that each variable influences the development of the other variables, positively or negatively. Results indicated that the systems engineering approach and the organizational behaviorist approach coexist at the same time and are not easily separable (Lofquist, 2008). The results of this study indicated a strong positive relationship, where implementing an SMS using a systems engineering approach influences rather than causes the organizations safety culture to be positive (Hollnagel, et all, 2006; Lofquist, 2008).

Management commitment to SMS efforts influences safety culture, SMS organization, and safety promotion (Hollnagel et al., 2006; von Thaden & Gibbons, 2008). The current study supports the system theory concept, that processes are determined by the interaction of conditions present in the total system (von Bertalanffy, 1952 as cited by Hollnagel et al., 2006). Proactive assessment of an organization's SMS relies on some form of management audit and organizational cultural assessment (Hollnagel et al., 2006; von Thaden & Gibbons, 2008). Lofquist (2008) postulated that individual perceptions of management's commitment to safety and safety climate have strong influences on the relationship and attitude towards change and perceptions of safety.

The current approach to SMS research has been to decompose the system into interacting parts, describing the interaction of the component parts at a lower level of organization (Hollnagel, Woods, & Leveson, 2006). The results of the current study indicated a positive and significant relationship between the interacting parts of the system, suggesting that measurement of a single variable will not produce an adequate understanding of the system as a whole (Hollnagel et al., 2006; von Thaden & Gibbons, 2008).

The research data neither explained nor eliminated other possible interpretations associated with the level of organizational safety culture. More research in needed related to the aspects of influence theories on the organizations safety culture levels as a result of implementing a SMS. Current research in the area of safety culture measures the perceptions of safety culture of the participants. Little research or analysis has been conducted on whether the measures actually only measure the participants self perception.

The study results indicated that the participants perceived they behave or perform safely. More research is needed to determine if the participant responses indicated self perception of safety or attitudes of normal behavior towards safety (Hollnagel, Nemeth, & Dekker, 2008). Results from participants across 4 organizations produced the narrowest range of positive responses potentially indicating that pilots may simply believe they fly safely, like many drivers believe they drive safely. The results of this study indicate that measuring only a single variable will not provide enough information to determine successful SMS implementation. It is argued that all variables must be measured to determine the level of SMS implementation.

Summary

The study examined the relationship between the level of organizational safety culture and the level of SMS implementation in 404 FAR Part 135 pilots in four air carrier organizations participating in the FAA Safety Team SMS pilot project by means of the Internet. The SCSMSS provided data. Significant correlations existed between the level of organizational safety culture and the level of SMS implementation, $F(15, 388) = 98.423, p < .001$. The mean scores for both the level of organizational safety culture (4.081) and the level of SMS implementation (3.809) were above the medium value of 3, indicating the respondents viewed both variables as positive. Results indicated that the relationship between the level of organizational safety culture and the level of SMS implementation was significant and positive. In addition, significant correlations were apparent between the level of management's commitment to safety and the level of SMS implementation, $F(15, 388) = 25.551, p < .001$. The mean score of the management's commitment to safety variable (3.914) was positive and above the medium value of 3. The results indicated that the relationship between the level of management's commitment to safety and the level of SMS implementation was significant and positive. Significant correlations existed between the level of safety promotion and the level of SMS implementation, $F(15, 388) = 494.625, p < .001$. The mean score of the safety promotion variable (3.632) was positive and above the medium value of 3. Results indicated the relationship between the level of safety promotion and the level of SMS implementation was significant and positive. Significant correlations also existed between the moderating variables of management commitment to safety, safety promotion and the level of organizational safety culture following additional analysis not included in the original research design. Management's commitment to safety and safety promotion were important for the development of a positive organizational safety culture as well as for the successful implementation of a SMS. The measurement of a single variable does not provide adequate understanding of the SMS. Determination of successful SMS implementation requires measuring all interacting variables. The systems engineering approach uses systems theory and engineering methodology to manage hazards through identification, elimination, and control through analysis, design, and management procedures (Hollnagel, et al., 2008). Implementation of SMS in high risk industries are deliberate organizational changes, particularly from a business perspective within the socio-technical high risk aviation industry (Lofquist, 2008).

Chapter 5: Implications, Recommendations, and Conclusions

The research problem was that the FAA cannot measure the level of SMS implementation based on the level of safety culture or measure the level of safety culture based on the level of SMS implementation because there is no established relationship between the level of SMS implementation and the level of organizational safety culture. Both measures conflict and the FAA literature assigns causation to both (FAA, 2008c). At the time of this study, there were no FAA requirements to assess or confirm SMS implementation for air carriers (FAA, 2008c). As an ICAO member State, the United States has committed to comply with ICAO safety standards (FAA, 2008b). However, the number of accepted or approved SMS programs for commercial air operators in the United States by the FAA was zero as of January 1, 2009 (FAA, 2008c). This could produce an operational risk to the United States commercial aviation industry as the inability to operate internationally between ICAO member States (ICAO, 2008). At the time of this study, there were 1,724 fixed wing turbine aircraft registered FAR Part 135 air carrier operators in the United States (FAA, 2009b) operating under the FARs, which had not met the ICAO mandate (FAA, 2009c).

The purpose of this quantitative correlational study was to examine the relationship between the level of organizational safety culture and the level of SMS implementation in four FAR Part 135 air carriers using a questionnaire to determine a correlation between the level of SMS implementation and the level of organizational safety culture. The study was non-experimental in design. Participants included 404 pilots from four FAR Part 135 air carrier operators selected through non-probability convenience sampling. Participants completed the SCSMSS, an Internet-based survey, measuring levels of organizational safety culture, SMS implementation, management's commitment to safety, and safety promotion.

The study had several limitations. The survey was electronic with emailed invitations to participate distributed through the safety departments of the organizations. Participants may have concerns that responses were traceable and that employer retribution would result. These factors could produce less than honest responses. With recent economic conditions, participants may have reluctance to express unfavorable responses about their organization. For this reason, there may be bias toward more positive response, rather than indications of honest opinions. To address this limitation, a statement at the beginning of the survey assured participants that no identifying information was necessary, either for the participant or the employer. There were no login or identification requirements.

The non-probability convenience sampling method was a limitation identified in the study. Respondents were from one industry sector of aviation and may not represent the whole aviation industry. Additionally, participation in the study was voluntary; therefore, self-selecting bias may have affected the results (Yin, 2009; Zikmund, 2003).

The generalization of the findings was somewhat limited by the size and nature of the sample. Only pilots participated in the study and completed the survey. Therefore, no conclusions regarding the level of organizational safety culture and SMS implementation among other groups of employees, such as maintenance personnel and administrative staff, were available. In addition, the response rate was relatively low with only 12% of pilots in the selected population participating although response exceeded the minimum required number of respondents of 368. This raised the question of whether the respondents constituted an adequate representative sample of the pilot population. Bias does occur in voluntary survey research when individuals who differ in some way relevant to the survey respond at different rates. For example, pilots with negative views may have been more motivated to respond than pilots with more positive views. While it is not possible definitively to determine whether bias was present without surveying non-respondents, it does not appear that bias was evident to any significant degree in the study. Scores for all four variable scales varied across the alternative choice range from strongly agree to strongly disagree, including both positive and negative scores (see Figure 6 and Table 10) and did not deviate appreciably from a normal distribution (see Table 9). It seems reasonable to conclude that the survey respondents represented the overall spectrum of pilots' attitudes toward organizational safety culture and SMS implementation.

The majority of respondents for this study (*N*=323 of 404) were male. In contrast, only 81 respondents were female. As pilots working in the aviation industry are predominately male, the results may indicate a male perspective more than a female perspective. The majority of respondents for this study (*N*=294 of 404) were Captains. In contrast, only 110 respondents were First Officers. The results may indicate a senior pilot perspective more than a less experienced pilot perspective. Compared to their means, the level SMS implementation, management commitment, and safety promotion varies more that the level of safety culture.

To ensure following ethical guidelines and offering participants protection, the Institutional Review Board of Northcentral University approved the study before any data collection. The informed consent statement noted responses to the survey would be for data analysis only. The respondents had to acknowledge the informed consent statement at the beginning of the survey prior to participating. The survey required no login, password, or user identification and no employee or employer identities could be determined from the collected data.

This chapter includes the implications from the findings, reviews each hypothesis, and presents recommendations based on the findings.

Implications

Researchers found that improving the human interface of safety performance required a change in the safety culture of an organization (von Thaden & Gibbons, 2008). The stated purpose of regulatory mandated implementation of SMS is to improve safety by improving safety performance (FAA, 2006a, 2009a; ICAO, 2005, 2008; von Thaden & Gibbons, 2008). Implementing a formal SMS is a deliberate change to the organizational system of safety management (Lofquist, 2008). Several factors affecting organizational safety culture and SMS implementation are management's commitment to safety and management's promotion of safety (FAA, 2008c, 2009a; Mitchell et al., 2002b; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Loftquist (2008) postulated that management commitment to safety and safety promotion through implementing an SMS influenced the behavior within the organization to accept the change to the organizations system, rather than causing the system change.

Organizational behaviorists postulated that the organizational safety culture influenced the development of the organization's SMS as a constituent part of the safety culture through management's commitment to safety and management's promotion of safety (Mitchell et al., 2002b; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Systems theorists and regulatory agencies postulated that organizational safety cultures were the result of an implemented SMS, through management's commitment to safety and the promotion of safety (FAA, 2006b, 2009a; ICAO, 2008).

Heinrich's original work (as cited in Geller, 2000) provided the foundation for research and study by organizational psychologists and scientific management researchers. Heinrich postulated that most accidents resulted from unsafe acts and unsafe conditions suggesting safety performance was more than the behavior of the individual, rather it referred to the behavior of the organization (Reason, 2000; Shappell & Wiegmann, 2006). Heinrich's theories suggested that preventing fatal accidents did not depend solely on systems engineering methods to manage safety performance (Geller, 2000; Manuele, 2002). Two basic theories for managing safety evolved. The organizational safety behaviorist approach and the system engineering approach. Management science applies scientific methods to management decision making (Wren, 2005). Systems safety engineers argue that a properly implemented system safety effort effectively applies scientific and engineering techniques to identify, then eliminate or control, risk of exposure to system hazards (Amaldi et al., 2007; Dekker, 2006; Helmreich & Merritt, 2005; Mohaghegh, 2007; Johnston et al., 2006; Reason, 2000).

The findings of this study showed that the level of organizational safety culture and level of SMS implementation are related, and that management's commitment to safety and safety promotion related to organizational safety culture and SMS implementation (Mitchell et al., 2002b; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008).

The first research question for this study was as follows:

Q1. To what extent does organizational safety culture relate to SMS implementation?

Although there was no significant correlation between organizational safety culture and SMS implementation hypothesized, results indicated that the relationship was positive and significant. Higher levels of organizational safety culture associated with higher success in implementing a SMS, and greater success in implementing a SMS associated with higher levels of organizational safety behavior or culture. Poor safety behaviors or culture in an organization associated with an incomplete or less functional SMS, and poorly implemented SMS associated with poorer organizational safety cultures. Management commitment levels to implementing a SMS and the promotion of safety within the SMS affected the level of the safety behavior or culture with the organization and success or failure of implementing a SMS.

The second research question for this study was as follows:

Q2. To what extent does management's commitment to safety relate to SMS implementation?

Although there was no significant correlation between management commitment to safety and SMS implementation hypothesized, results indicated that the relationship was positive and significant. Higher levels of management commitment to safety associated with higher success in implementing SMS. Lower levels of management commitment to safety associated with an incomplete or less functional SMS. Management commitment to safety affected the levels of safety behavior or culture within the organization and success or failure of implementing a SMS (Mitchell et al., 2002b; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008).

The third research question of this study was as follows:

Q3. To what extent does safety promotion relate to SMS implementation?

Although there was no significant correlation between safety promotion and SMS implementation hypothesized, results indicated that the relationship was positive and significant. Higher levels of safety promotion associated with higher success in implementing SMS. Lower levels of safety promotion associated with an incomplete or less functional SMS. The level of promotion of safety affected the level of safety behavior or culture within the organization and success or failure of implementing a SMS (Mitchell et al., 2002b; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008).

Results of the study's descriptive mean scores across the four variable scales were positive, which appeared to support previous research (Gibbons et al., 2007; Helmreich & Merritt, 2005; Johnston et al., 2006; Mitchell et al., 2002a). Successful SMS implementation related to the level of organizational safety culture; organizations with a more positive safety culture implement a sustainable SMS more often than do organizations without a positive organizational safety culture. The mean score of safety culture as highest with SMS implementation scoring third may indicate earlier research suggesting that the level of the organizational safety culture influenced the level of SMS implementation was correct (Braithwaite, 2009; Lazidou, 2008; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008).

The safety culture of the organization directly influences the level of SMS implementation. If the organization's management is not 100% committed to implementing an SMS, including allocating resources, the SMS will attain only a certain level of maturity and progress only to the level that the organization is willing to fund. A determining characteristic of an organizational safety culture includes behavior, in other words, what people do about safety. What management does not do is also a behavioral aspect of the organization's safety culture. Thus, the moderating variable management commitment may be the significant influence on both SMS implementation and development of a positive organizational safety culture. This raises the question of whether management commitment to safety and implementing SMS is a result of the organization's safety culture or senior management's personal safety culture (Reason, 2000).

Research hypothesized that organizational safety culture shaped through shared practices (Helmreich & Merritt, 2005; Reason, 2000). This study showed that both organizational safety culture and SMS implementation positively related. The scientific management approach of managing safety through documented processes and procedures develops the shared practices within the organization (Helmreich & Merritt, 2005; Reason, 2000: Rollenhagen & Whalstrom, 2007). The shared practices developed through the SMS application also developed the organization's safety culture. Because the relationship could be negative or positive between the level of organizational safety culture and SMS implementation, the level of management commitment to implementing an SMS and the level of safety promotion of SMS implementation may influence the level of maturity of the SMS and the level of organizational safety culture (Helmreich & Merritt, 2005; Reason, 2000; Rollenhagen & Whalstrom, 2007; von Thaden & Gibbons, 2008).

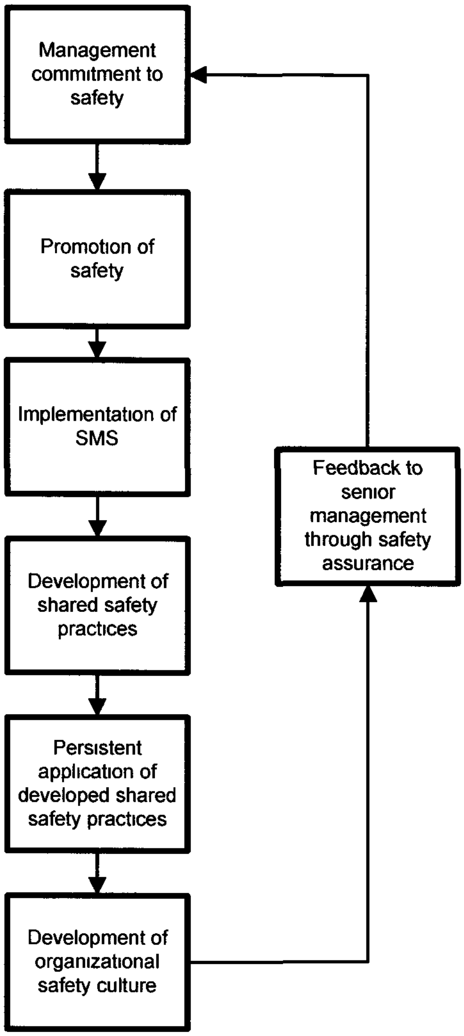

Figure 7. Safety culture and SMS development process.

Recommendations

Research of air carrier organizations showed that organizational safety culture influences implementation of SMS (von Thaden & Gibbons, 2008). With the mandated requirement for air carriers to implement a measurable SMS (FAA, 2009a; ICAO, 2008), organizations can use the results of this study to identify and analyze organizational cultural and management behaviors to implement SMS.

The results highlight the need for organizations to examine the areas of management commitment, safety promotion, and organizational safety culture to understand SMS implementation within the organization. Therefore, by understanding and developing management's commitment to safety and safety promotion, organizations can better equip to develop positive organizational safety cultures and successfully implement SMS. Organizations would benefit from understanding that the level of organizational safety culture and the level of SMS implementation relate, although the direction of causality for this relationship is not definitive. More research is required in the fields of influence theories and social dissonance theories related to development of organizational safety cultures. With this understanding, organizations can use safety behaviors or culture to improve effectiveness in implementing SMS. Therefore, a recommendation for organizational practice is to design a standardized measure or survey to implement on a recurring basis to develop consistent levels of safety culture and SMS implementation.

Another recommendation is organizations should understand that the level of management commitment to safety relates to the level of SMS implementation and to the level of organizational safety culture. This relationship makes management's commitment to safety important in successfully implementing a SMS and developing a positive organizational safety culture. Because the study showed that management commitment to safety related to SMS implementation, managers should commit to and support safety initiatives and programs. A third recommendation is that management commitment to safety and safety promotion be accomplished through establishing clear safety policies, procedures, programs, and performance measurement of managers' adherence to established criteria, commonly referred to as shared practices. The development of shared practices, persistently applied, influences the development of the organization's safety culture (Dekker, 2006; Reason, 2000).

A documented formal system for managing safety that requires management's commitment to the criteria could positively influence the organization's safety culture (Lofquist, 2008; von Thaden & Gibbons, 2008). The positive influence on safety behaviors could improve the organization's safety culture or safety behaviors to adhere to and participate in the organization's safety system (Lofquist, 2008; von Thaden & Gibbons, 2008). Finally, organizations should understand the relationships between the promotion of safety and SMS implementation and organizational safety culture. Organizations should ensure communication of promotion of safety initiatives and safety programs to the organization through regular meetings and other media, such as newsletters.

There are five recommendations for future research. First, future studies should include samples for other operational departments of air carriers to determine whether the relationships between organizational safety culture, management commitment to safety, safety promotion, and SMS implementation exist within the entire organization. Second, future studies should segregate air carrier organizations into groups as potential moderating variables. Future research studies could include larger numbers of females because the sub-sample of females in this study was relatively small. The promotion of safety is another area for examination with respect to organizational safety culture and SMS implementation to understand how safety promotion affects organizational safety culture and SMS implementation. Future research could measure the way in which management's commitment to safety affects organizational safety culture development and SMS implementation. The research should include influence theories and social dissonance theories on the development of the organizations safety culture and successful SMS implementation. Finally, empirical data or measures should be available to determine whether the implementation of a SMS reduces exposure to risk, prevents accidents, or improves safety performance.

Conclusions

The results of this study indicated a relationship between the level of organizational safety culture and the level of SMS implementation in the four FAR Part 135 organizations pilot employee groups. Further indications are that the relationship was significant, $F(15, 388) = 98.423$, $p < .001$ and positive with mean scores of 4.081 and 3.809. Although indicating no direction of causation, the results support both the organizational behaviorists' and the systems management theorists' assertions that a relationship exists between the level of organizational safety culture and the level of SMS implementation (FAA, 2006b, 2009a; ICAO, 2008; Mitchell et al., 2002b, 2003a; Shappell & Wiegmann, 2006; von Thaden & Gibbons, 2008). Although the results of this study indicated that organizational safety culture, management commitment to safety, and safety promotion positively and significantly related to SMS implementation, the direction of causality was not definitive and indicated that influence theory rather than causation developed the organizations safety culture leading to acceptance of the changes to the organizations management system. Correlations between the relationship of the organizational safety culture level and the SMS implementation level can have graphic representation; causation determination will require repeated empirical research the established baseline (Feng, 2006; Norusis, 2006; Trochim & Donnelly, 2007; Yin, 2009). Further research may determine a definitive direction of causation.

Additional analysis results of this study indicated that the moderating variables, promotion of safety and management commitment to safety, affects the development of positive organizational safety culture and successful implementation of SMS (Braithwaite, 2009; Helmreich & Merrit, 2005; Johnston et al., 2006; Reason, 2000; Schein, 1984; von Thaden & Gibbons, 2008). Findings regarding organizational safety culture, management commitment to safety, safety promotion, and SMS implementation showed that all four components link (see Figure 8).

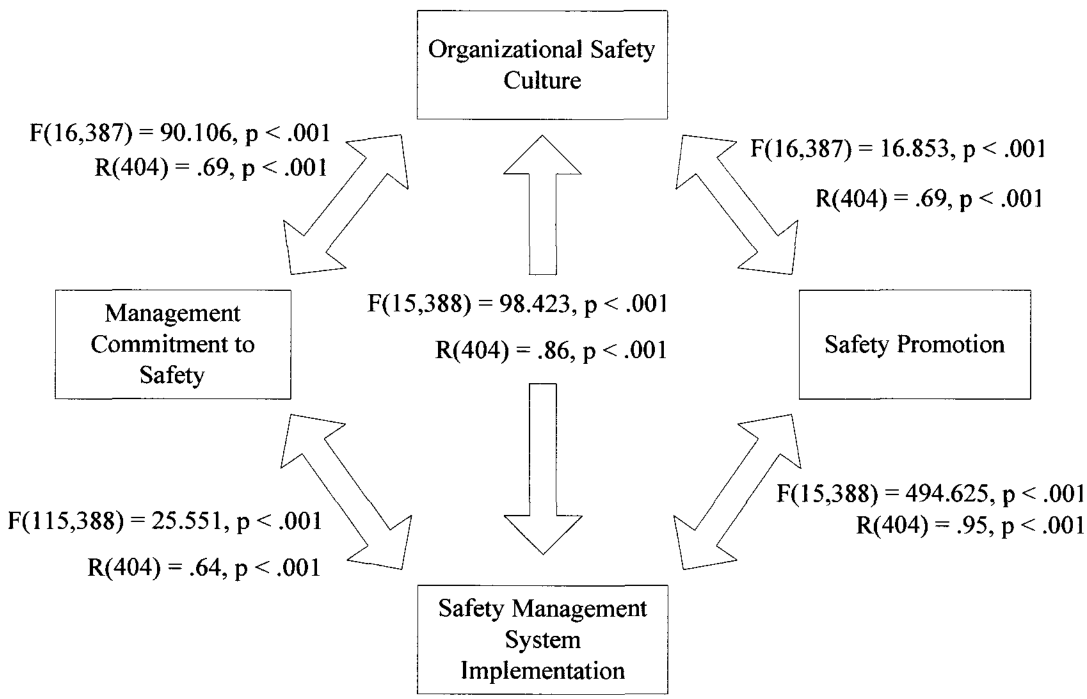

Figure 8. Correlation between organizational safety culture, management commitment to safety, safety promotion, and SMS implementation.

Results of this study suggest that the organizational behavioral approach and the scientific systems management approach improve safety performance, thereby reducing the risk of having accidents. The results of this study illustrate the need for a positive organizational safety culture to implement a SMS, and the need for a positive SMS to develop a positive organizational safety culture through the identified moderating variables of management commitment to safety and safety promotion (Braithwaite, 2009; Helmreich & Merrit, 2005; Johnston et al., 2006; Lofquist, 2008; Reason, 2000; Schein, 1984; von Thaden & Gibbons, 2008).

Senior management's personal safety culture influences management's commitment to the promotion of safety and the effort expended in implementing a SMS. The persistent and practical application of safety measures develop into the shared safety practices within the organization and influence the development of the level of organizational safety culture. Simply stated, the organizational culture of conducting business according to an established management system of policies, processes, and procedures reduces the exposure to risk and improves safety performance (Braithwaite, 2009; Helmreich & Merrit, 2005; Johnston et al., 2006; Reason, 2000; Schein, 1984; von Thaden & Gibbons, 2008). Indications are that no single measure adequately reflects successful SMS implementation, and that all variables must be measured to determine successful SMS implementation. Future research could examine the role of the moderating variables have on influencing the successful implementation of SMS from a systems engineering application.

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Appendixes

Appendix A:

Safety Culture and Safety Management System Survey

Safety Culture and Safety Management System Survey

1. Informed Consent to Participate

Thank you for taking the time to participate in this survey. Your participation in this study is strictly voluntary, you are not required to participate. You may stop participating in this study at anytime you choose. The purpose of this survey is to examine the relationship between organizational safety culture and safety management system implementation in FAR Part 135 flight operations. This survey measures your opinions about safety culture and safety management, and does not require any physical or face to face interaction between yourself and the researcher. This is a confidential survey, and nondisclosure of your identity will be strictly enforced. Your identify will remain anonymous throughout the study,in that even the researcher will not know your identity. By participating in this study, you agree that the researcher may use the non-identified aggregate data for the purpose of examining the relationship between organizational safety culture and safety management system implementation. Thank you for your participation.

Safety Culture and Safety Management System Survey

2. Demographics Section

1. What is your Gender?

- Male
- Female

2. What is your title?

- Captian
- First Officer

3. How many years have you been with your current organization?

- < 1 year
- > 1 year but < 5 years
- > 5 years but < 10 years
- > 10 years

4. What is your total flight time in hours?

- > 200 but < 1,500
- > 1,500 but < 3,000
- > 3,000 but < 5,000
- < 5,000 but < 10,000
- > 10,000

Safety Culture and Safety Management System Survey

3. Survey Questions Section

1. Management willing invests people and financial resources to reduce identified safety risks in flight operations.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

2. My organization looks for opportunitites to prevent accidents and incidents.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

3. Following safety procedures is an expectation consistently enforced within my organization.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

4. Management is committed to equipping aircraft with adequate technologies and equipment.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

5. Management in my organization views regulatory violations seriously, even when the violations do not result in any apparent damage.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

6. Upper, Senior level management is personally involved in or aware of safety activities.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

7. Pilot performance is evaluated for safety and professionalism using clear and documented standards.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

Safety Culture and Safety Management System Survey

8. I am authorized and expected to stop, cease, or prevent unsafe flight operations.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

9. Pilots willingly report information regarding safety violations, marginal aviator performance, or other unsafe behavior.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

10. This organization's safety policy reflects management's commitment to implementing procedures and processes for establishing and meeting safety objectives that are measureable and attainable, promoting a culture of safety.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

11. My organization uses safety risk management to verify adequate control of identified risks.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

12. My organization uses safety risk management to assess safety system design, and identify potential risks.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

13. My organization continually assesses the need of new risk conrols due to changes in the operational environment.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

14. My organization continually assess the need to eliminate or modigy risk controls that are ineffective due to chagnes in the operational environment.

Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree

Safety Culture and Safety Management System Survey

15. At my organization, all levels of management actively promote, and provide the leadership to ensure a positive safety culture.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

16. At my organization sharing of safety information to develop lessons learned is supported at all levels of management.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

17. My organizaton routinely shares information related to corrective actions, and the results of management reviews.

- Strrongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Appendix B:

Safety Culture and Safety Management System Survey Questions

Safety Culture and Safety Management Systems Questionnaire

McNeely **Page 1** **10/4/2009**

The purpose of this survey is to develop appropriate questions about positive organizational safety culture, and safety management system implementation, to be used in a survey of FAR Part 135 pilots, for research studies. Please review the questions. The purpose is to determine if the question relates to the operational definition, and is an acceptable question to ask. Please indicate the appropriateness of the questions, by placing a check mark in the box next to the question. If the question needs refined, or an alternative question is more appropriate, I would like to know this. Please write any alternative, or refinements in the space below the questions. Please do not hesitate to provide constructive criticism, as this only makes the questions better.

Thank you in advance for your time.

		In regards to a study of Organizational Commitment and Safety Culture skills and knowledge, how would you rate this question?		
No.	**Question**	**Nonessential**	**Essential but requires revision**	**Essential**
1.	Management willing invests money and effort to improve safety in flight operations.			
2.	My organization does all it can to prevent accidents and incidents.			
3.	Following safety procedures is an expectation consistently enforced within my organization.			
4.	Management is committed to equipping aircraft with the latest up-to-date technologies and equipment.			
5.	Management in my organization views regulatory violations very seriously, even when the violations do not result in any apparent damage.			
		In regards to a study of Management Involvement and Safety Culture skills and knowledge, how would you rate this question?		
No.	**Question**	**Nonessential**	**Essential but requires revision**	**Essential**
6.	Upper level management gets personally involved in safety activities.			
7.	Management involvement in safety issues has a high priority in my organization.			
8.	Management stops unsafe operations or activities.			
9.	Management does not hesitate to approach pilots to discuss safety issues.			
10.	Management ensures that all pilots are responsible and accountable for safe flight operations.			
		In regards to a study of Accountability and Safety Culture skills and knowledge, how would you rate this question?		
No.	**Question**	**Nonessential**	**Essential but**	**Essential**

Safety Culture and Safety Management Systems Questionnaire

McNeely Page 2 10/4/2009

			requires revision	
11.	Management negatively evaluates pilots who behave recklessly.			
12.	Safe pilot performance is evaluated using clear standards.			
13.	Action is consistently taken against pilots who violate safety procedures and rules.			
14.	Pilots who cause accidents or incidents are held sufficiently accountable for their actions.			
15.	Being involved in an accident or incident has an adverse effect on a pilot's future with this organization.			
16.	Being involved in an accident or incident has an adverse effect on a pilot's reputation.			
		In regards to a study of Employee Empowerment and Safety Culture skills and knowledge, how would you rate this question?		
No.	Question	Nonessential	Essential but requires revision	Essential
17.	Pilots are actively involved in identifying and resolving safety concerns.			
18.	Pilots are given sufficient opportunities to make suggestions regarding safety issues.			
19.	My organization rarely questions a pilot's decision to turn around due to weather.			
20.	I am encouraged to stop flight activities that are unsafe.			
21.	Pilots look at this organization's safety record as their own and takes pride in it.			
		In regards to a study of Reporting Systems and Safety Culture skills and knowledge, how would you rate this question?		
No.	Question	Nonessential	Essential but requires revision	Essential
22.	I am familiar with the system for formally reporting safety issues in my organization.			
23.	This organization's safety program includes mechanisms to report safety deficiencies.			
24.	Pilots willingly report information regarding safety violations, marginal aviator performance, or other unsafe behavior.			
25.	Pilots can report safety discrepancies without fear of negative repercussions.			
26.	I am satisfied with the way this organization deals with safety reports.			
		In regards to a study of Safety Management Systems Policies, skills and knowledge, how would you rate this question?		
No.	Question	Nonessential	Essential but requires revision	Essential

Safety Culture and Safety Management Systems Questionnaire

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27.	This organization's senior management has established a policy communicating the organizations commitment and expectation that the organization will incorporate and continually improve safety in all aspects of the business processes, and management's expectation of high safety performance.			
28.	This organization's safety policy reflects management's commitment to implementing procedures and processes for establishing and meeting safety objectives that are measurable and attainable, and supports promotion of a culture of safety.			
29.	Senior management identifies responsibility and accountability for all employees with respect to safety performance.			
30.	This organization has a quality system consistent with the safety management system.			
31.	Senior management has established standards for acceptable behavior that affects safety.			
32.	This organization has established and maintains a plan for response to accidents and serous incidents.			
		In regards to a study of Safety Management Systems Risk Management, skills and knowledge, how would you rate this question?		
No.	Question	Nonessential	Essential but requires revision	Essential
33.	My organization uses safety risk management to identify and analyze hazards, and develop appropriate risk controls.			
34.	My organization uses safety risk management to assess safety system design, and to verify adequate control of risks.			
35.	Safety risk management principles and techniques are integrated in business an operational processes at my organization.			
36.	This organization has a means to identify and control hazards introduced by planned changes to the operational system.			
37.	This organization has defined acceptable levels of risk, in terms of severity and likelihood.			
38.	This organization has defined who can make safety risk acceptance decisions.			
		In regards to a study of Safety Management Systems Safety Assurance, skills and knowledge, how would you rate this question?		
No.	Question	Nonessential	Essential but requires revision	Essential
39.	My organization continually assesses operational activity to identify new hazards and to ensure risk controls achieve their intended objectives throughout the system life cycle.			
40.	My organization continually assesses the need of			

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	new risk controls, or to eliminate, or to modify risk controls that are ineffective or are no longer needed due to changes in the operational environment.			
41.	My organization continually assesses conformity with organizational safety policies and procedures			
		In regards to a study of Safety Management Systems Safety Promotion, skills and knowledge, how would you rate this question?		
No	Question	Nonessential	Essential but requires revision	Essential
42.	At my organization, all levels of management actively promote, and provide the leadership to ensure a positive safety culture.			
43.	At my organization sharing of safety information to develop lessons learned is encouraged and supported at all levels of management.			
44.	My organization routinely shares information related to corrective actions, and the results of management reviews			