THE IMPLEMENTATION OF SAFETY MANAGEMENT SYSTEMS IN MAINTENANCE OPERATIONS

A Thesis Presented to the Faculty of the
College of Basic and Applied Sciences

Middle Tennessee State University

In Partial Fulfillment
of the Requirements for the Degree

Master of Science
Aviation Administration

by

Daniel Heng Siao

May, 2015

Thesis Committee:

Dr. Wendy S. Beckman, Chair

Dr. Terry L. Hunt

I dedicate this work to my family. I thank my wife, Jennifer, my parents, Andrew and I-wen, my brother, Stephen, and my new family—Jeff, Jan, Elmer, Muriel, Michael and Jill Hooks—for their prayers, support, and love through this time. Most of all, I thank God for all the opportunities and the strength to complete this work.

"My grace is sufficient for you, for my power is made perfect in weakness.

Therefore I will boast all the more gladly of my weaknesses,

so that the power of Christ may rest upon me."

(II Corinthians 12:9, ESV)

ACKNOWLEDGEMENTS

I would like to express my deep gratitude to Dr. Wendy Beckman. I could not have asked for a better committee chair. Dr. Beckman is truly one of the best educators I have ever worked with. She has worked tirelessly above and beyond what is expected in helping me with my thesis. I would also like to express sincere gratitude to Dr. Terry Hunt, who has become my mentor and friend over the course of my time at MTSU. Dr. Hunt possesses a profound knowledge of the aviation industry, which has been very valuable. In addition, Dr. Hunt has provided me excellent advice, insight, and encouragement, but I have benefitted most from your prayers for me. Finally, I would like to express my earnest gratitude to Mr. Joe Hawkins, who, over the years, has also become a mentor and friend. Mr. Hawkins' knowledge of maintenance, balanced with his extensive practical experience in the professional field, has given me a well-rounded perspective of aviation maintenance, which is vital in aviation safety research.

I would also like to thank Mr. Stephen Gossett and Mr. Bill Allen for giving me incredible opportunities to serve as a graduate teaching assistant in the aerospace maintenance department. I am thankful to have worked with both Mr. Gossett and Mr. Allen, where I have continued to learn about aviation maintenance and maintenance education.

ABSTRACT

Literature and research for Safety Management Systems (SMS) that apply to flight operations are abundant, but there is a limited supply of SMS-related literature and research for maintenance operations. Even though the benefits of SMS are well established, it is difficult for maintenance facilities—especially small repair stations—to justify the cost. While the high cost of implementing an SMS is the putative reason for not having SMS, there could be other factors that hinder the implementation of SMS. This research sought to reveal the hindrances that prohibit successful SMS implementation. A cross-sectional survey was utilized for this study. The results from the 49 survey participants were analyzed, which revealed that there was statistical significance between the written policies of a company and its actual practices. However, this study also determined that—based on this sample—small repair stations do not lack safety policies, nor do the majority of employees working for small repair stations feel that there was a significant need for the improvement of safety policies and practices.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I — INTRODUCTION

The prestige of the aviation industry is greatly affected by safety. The flying public expects stellar safety records, and anything short of that taints the aviation industry. Thus, safety is the singular goal for every entity in the aviation industry, which consists of numerous organizations including government agencies, operators, maintenance operations, training facilities, etc. Safety is the raison d'etre of the Federal Aviation Administration (FAA), and it is emphatically stated on its website: Safety is the "foundation of everything we do" ("Safety: The Foundation," 2014, A6); in essence, regulations and a regulatory body are unnecessary, if not for safety.

While "safety" is a familiar term, the perception and definition of "safety" differs from person to person: To the traveling public it simply means reaching one's destination without getting hurt (Stolzer, Halford & Goglia, 2008). Traditionally, the aviation industry approaches safety in a reactive manner, but the industry is undergoing a paradigm shift to approach safety proactively and innovatively by utilizing Safety Management Systems (SMS).

Safety with regard to aircraft operation is highly researched and addressed; however, there is a general lack of research for aviation maintenance. The necessity of increasing aviation safety is the general tenor of FAA's Flight Plan; however, FAA's Flight Plan makes no mention of aviation maintenance. Maintenance safety is a critical component of overall aviation safety: "Safety in the air begins with quality maintenance on the ground" (Key, 2014, p. 1). Safety reporting programs that apply to pilots equally apply to maintenance technicians; however, maintenance safety seems to be a rarely discussed topic. Finding answers to why maintenance operations lack SMS may reveal hindrances. Ultimately, the hindrances must be addressed and overcome.

Literature Review

The aforementioned definition of "safety"—reaching one's destination without getting hurt—is too rudimentary (Stolzer et al., 2008). The International Civil Aviation Organization (ICAO) provides a definition for "safety" apropos for the safety practitioner: Safety is defined as "the state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management" (ICAO, 2013, p. 2-1). Stolzer et al. interprets ICAO's definition to mean "safety management," and the ability to manage safety is accomplished through SMS (2008). SMS is a system that incorporates "organizational structures, accountabilities, policies and procedures" (Stolzer et al., 2008, p. 14). Further, Stolzer et al. contends that SMS, at its core, is a risk management system, where risk is the product of severity and likelihood (2008).

SMS is the FAA's answer to move beyond the current safety system ("FAA flight plan," n.d.). In order to effectively utilize SMS, data must be widely accessible and available. Data collection, sharing, and integration are all part of the FAA's effort to promote an industry-wide standard of SMS implementation. SMS also functions to identify trends and errors that are precursors to accidents. Recognizing precursors also allows safety practitioners to understand the multitude of opportunities that exist to stop an accident ("Safety Management System," 2009).

Financial Benefits

There are also financial benefits to implementing SMS. SMS can be costly, and most organizations consider SMS a cost liability without factoring in its economic benefits (George, 2013). The cost of SMS is a valid concern for organizations. The implementation of SMS may require organizations to hire additional staff, purchase equipment and software, and provide initial and ongoing training. Cost concerns are further compounded by the lack of research regarding the economic benefits of SMS.

Proponents of SMS argue that the cost of accidents far exceeds the cost of SMS. The cost of an accident includes loss of lives, injuries, physical damage, litigation costs, and a negative public perception of safety. Therefore, instead of viewing SMS as a cost liability, SMS should be viewed as an investment. As with any investment, worth is measured by a calculated return on investment (ROI). Research and literature regarding ROI abound; however, research regarding the ROI of SMS is limited (Lercel, Steckel, Mondello, Carr & Patankar, 2011). Preliminary research indicates significant financial benefit, but long-term benefits require further study (Lercel et al., 2011). While there are examples of short-term benefits from SMS, the long-term effects remain unclear. Lu et al. (2011), cites Moncton Flight College's immediate $25,000 annual savings in insurance premiums as a result of SMS implementation. The difficulty of assessing long-term economic benefits of SMS is twofold. First, SMS is in its infancy stages with very limited financial data. Second, it is difficult to quantify cost savings if an accident never occurred (George, 2013). While both George and Lercel et al. acknowledge the cost of implementing SMS, Lercel et al. suggests using systems already in place that comply with SMS standards (2013). A total overhaul of safety systems and starting from scratch is not the implication of implementing SMS.

Components of a Successful SMS

There are four pillars of SMS: policy, safety risk management, safety assurance, and safety promotion (FAA, 2010). All four pillars must exist in order for SMS to function effectively (Stolzer, et al., 2008). In addition to the four pillars, a successful SMS is supported by a cultivated safety culture within an organization. The term "safety culture" is the sum of two ideas. Organizational culture is the "behavioral norm consisting of beliefs, attitudes, and common values of an organization" (Lu, Young, Schreckengast & Chen, 2011, p. 29). A safety culture is a culture where safety is a commonly held belief. It is a crucial foundation for SMS: "Safety culture is the engine that drives the organization towards the goal of maximum attainable operational safety regardless of any formats of resistances, obstacles, and pressures" (Lu et al., 2011, p. 29). According to the FAA's Advisory Circular (AC) 120-92A, people that comprise an organization must work toward the goal of safety—otherwise, SMS is rendered ineffective (FAA, 2010).

Establishing trust and respect within an organization between employees and management is an essential component of a safety culture. Safety culture consists of four sub-cultures: reporting culture, just culture, informed culture, and learning culture (Lu et al., 2011). In a reporting culture, employees are willing to submit safety reports regarding errors—inadvertent errors, of course. Safety reports contain the data necessary for establishing error trends and identifying precursors to accidents. Employees must be active participants in an SMS; however, management must also be fully engaged.

Management is responsible for protecting employees who submit safety reports (Lu et al., 2011). Further, it is the responsibility of management to review safety reports and implement corrective measures. It is determined that "top management is aware of only about 4% of the significant safety problems, with line managers aware of only 9% and supervisors aware of about 74%" (Lu et al., 2011). This gap suggests managements' tepid interest in safety.

A just culture does not punish employees for inadvertent and unintentional acts. The difference between acceptable and unacceptable acts should be clearly stated, and management is expected to follow-through. Unintentional errors are treated with non-punitive measures (Lu et al., 2011). Further, Stolzer, et al. suggests encouraging and rewarding employees for critical safety-related information (2008). In a just culture, employees trust the system. Reporting systems are anonymous and confidential, and the immunity policies are clearly detailed (Lu et al., 2011). Within a reporting and just culture is an informed culture, where critical information is never withheld from employees.

Finally, a learning culture cannot be established without a reporting, just, and informed culture. In a learning culture, employees are continually educated and know how to respond to different circumstances. Lu, et al. calls this a "learning and adaptive" culture (2011). Stolzer, et al. refers to this as a flexible culture where people can "adapt organizational processes when facing high temporary operations or certain kinds of danger, shifting from the conventional hierarchical mode to a flatter mode" (2008, p. 24).

Creating a safety culture in an existing organization is an arduous task. It requires a culture change, which is usually met with resistance as employees are ensconced in the existing organizational culture. The topic of organizational change is very well studied and treated in various sources: This subject is addressed in ICAO Safety Management Manual (2013), FAA AC 120-92A (2010), and Lu et al. (2011). Despite the resistance and challenges, management must be persistent in implementation efforts, which is often accomplished through phases (Lu et al., 2011).

Safety Culture

The term "safety culture" was coined following the Chernobyl disaster in 1986, where 28 workers died, 106 workers received radiation sickness, and at least 200,000 workers were exposed to elevated levels of radiation ("Backgrounder on Chernobyl," 2013). Beyond the immediate health consequences, this disaster left a trail of carnage—even though the actual health effects are lower than what was initially speculated—numbering in the tens of thousands ("Backgrounder on Chernobyl," 2013). A correlation exists—albeit a weak correlation—between the exposure to radiation and thyroid cancer. Among the children and adolescents who drank radiation-contaminated milk, 6,000 thyroid cancers have been reported; however, 99% were successfully treated, and only 15 thyroid cancer deaths were reported nearly 20 years after the disaster ("Backgrounder on Chernobyl," 2013).

It was determined in the post-accident review that the lack of safety culture led to this disaster. Furthermore, the regulatory environment in which Chernobyl operated was not conducive to the assurance of safety, and the enhancement of safety required a systemic change: "The regulatory regime was ineffective in many important areas, such as analysing [*sic*] the safety of the design and operation of plants, in requirements of training and for the introduction and promotion of safety culture, and in the enforcement of regulations" ("The Chernobyl Accident," 1992). The findings of this report implicated the Soviet Union (USSR) as a regime that desperately lacked controls to prevent a disaster of this scale, a blatant dereliction of duty. Even more inexcusable is the fact that problems similar to those leading to the Chernobyl disaster were previously recorded: Ignalina nuclear power plant in 1983 and Leningrad nuclear power plant in 1975. The observations documented design problems in both of these facilities, and if analysis was performed, the precursors would have been identified, potentially averting disaster at Chernobyl ("The Chernobyl Accident," 1992).

The Chernobyl accident highlights the necessity for cooperation inside and outside an organization, including governing authorities, company management, and line employees. The authors of the report did note that safety regulations regarding power plants existed in the USSR at the time of the accident; however, due to the lack of cooperation these regulations were not enforced ("The Chernobyl Accident," 1992). This further points to the importance of engaging in safety at all levels inside and outside an organization. The authors of this report coined the term "safety culture" to describe the cohesive effort required for safety management ("The Chernobyl Accident," 1992).

Aviation finds itself in a similar situation, where regulations exist with no consistent enforcement effort. According to Steckel, Lercel, Rieser, Kostal & Patankar (2013), one of the main problems identified by members of the aviation industry, particularly 14 CFR Part 121 (air carriers), 135 (commuter/on-demand operators), 141 (approved flight schools), and 145 (repair stations) operations, is the lack of consistency in interpreting SMS requirements and compliance options, which differ across the FAA Flight Standards District Offices (FSDO) or Certificate Management Offices. The lack of consistency in interpreting safety regulation inevitably leads to inconsistent enforcement efforts, which stymies safety culture development. Even though inconsistencies plague the entire industry, maintenance operations face a unique set of problems, which will be addressed later.

Reporting Systems

SMS begins with data collection, mainly in the form of safety reports. There are two notable safety reporting systems currently in place in the U.S.: Aviation Safety Reporting System (ASRS) and Aviation Safety Action Program (ASAP). In order to establish trends and determine precursors to accidents, safety reports are critical; however, if individuals are expected to divulge information regarding errors and mistakes, there must be protection and immunity. The landmark case of Bredice v. Doctor's Hospital in 1973 accentuated the gravity of the importance of immunity built into safety reporting systems. Through the medical malpractice case, the definition of "qualified privilege," or immunity, was strengthened (Stout, 2004). A few years later, in 1976, aviation followed and created the ASRS (Kent, 1976). Initially, the aviation community was skeptical of FAA's ability to process safety reports impartially; therefore, the FAA placated the aviation community by choosing NASA as an unbiased third party (Kent, 1976). The ASRS is a joint effort between the FAA and NASA.

The intended users of ASRS are pilots, controllers, flight attendants, and maintenance personnel (Stout, 2004). On the ASRS website, four different reporting forms are available based on job functions: general, air traffic controller (ATC), maintenance, and cabin ("Electronic report submission," n.d.). Since the inception of ASRS, it continues to be voluntary. Reporters also receive immunity under Title 14 Code of Federal Regulations (CFR) Part 91.25: "The Administrator of the FAA will not use reports submitted to NASA in any enforcement action except information concerning accidents or criminal offenses which are wholly excluded from the Program" (2014). Actions that warrant exclusion from protection include "reckless operations, criminal offenses, gross negligence, willful conduct and accidents" (Stout, 2004, "History and Development of the ASRS *[sic]*," para. 1).

The ASRS functions effectively in most cases; however, there are instances where immunity was denied. The decision to grant or deny immunity is based on the condition that the action is "inadvertent and not deliberate" (Stout, 2004). Since the definition is ambiguous, it is difficult to determine the intentionality of the reporter. The most famous case is Ferguson v. National Transportation Safety Board (NTSB), where a pilot was denied immunity based on NTSB's subjective interpretation of the "inadvertent and not deliberate" clause (Stout, 2004). Further, the application of immunity has been inconsistent (Stout, 2004). Increasing incertitude regarding immunity is further bolstered by inconsistencies and cases like Ferguson v. NTSB.

The ASAP is another safety reporting program. It is a voluntary program intended for flight crews, dispatchers, maintenance technicians, and flight attendants (Stolzer et al., 2008, p. 53). It is even touted as the most successful of all voluntary programs (Stolzer et al., 2008). The ASAP and the ASRS are similar in intention, that is to identify precursors to accidents through safety reporting (Stout, 2004). There are also differences. The ASAP was created as a joint effort between American Airlines (AA) and the FAA in 1994 (Stolzer et al., 2008). Unlike the ASRS, the ASAP is not available to everyone in the aviation industry. The ASAP is only available to air carriers or repair stations (Stolzer et al., 2008). It is an agreement between the FAA and the air carrier or repair station—in some cases labor unions are also involved (Stolzer et al., 2008). A Memorandum of Understanding (MOU) is signed by all parties, which establishes the program (Stolzer et al., 2008).

While the immunity clause for the ASRS may be opaque, the immunity clause for the ASAP is perspicuous: “The reported event must not appear to involve criminal activity, substance abuse, controlled substance, alcohol, or intended falsification” (Stout, 2004, “Immunity from Enforcement Actions,” para. 2). The ASAP has a good record of granting protection to reporters. There was only one case regarding immunity, and the case ended up favoring the pilot (Stout, 2004).

For safety reporting programs implemented at air carriers and repair station operations, management involvement is a critical component. Literature regarding safety reporting, safety culture, and organizational culture emphasize the need for top-down influence (Stolzer et al., 2008, “FAA Flight Plan,” n.d., FAA, 2010, ICAO, 2013). However, while understanding the importance of top-down influence, Lu et al. (2011) states that excessive top-down pressure has a negative overall effect. Kelly, Lercel, and Patankar add to the discussion by stating that safety climate will deteriorate if there is insufficient trust with supervisors—even if there is positive job satisfaction (2011).

Apart from the challenges faced by safety reporting programs, the ASRS and the ASAP have been very successful in general. The effectiveness of these programs relies solely on users submitting safety reports. The primary challenge, then, is trust. Because of its success, the ASRS is used as a model for the development of reporting systems in other high risk industries such as medical and nuclear (Connell, 2004). Literature for cross-industry applications of safety reporting systems are widely available, especially in the medical field.

SMS in Maintenance

Safety is the reason maintenance exists, and it is the ultimate goal for aviation maintenance technicians (AMT). According to McDonald, Corrigan, Daly, and Cromie (2000), between the years 1990 and 2000, flights increased 55%, but maintenance-related accidents increased 100% (p. 154). Louie Key, national director of Aircraft Mechanics Fraternal Association (AMFA), states, “Safety must always be our number one priority—bar none” (Key, 2014, p. 3). In the same article, in addition to Key, Lee Seham discusses the protection that is available for whistleblowers under the federal law AIR 21 (Seham, 2014, p. 7). AIR 21 was created to protect employees who report under the ASAP (Key, 2014); however, AIR 21 complaints are filed with the Occupational Safety and Health Administration (OSHA). Providing additional insight on AIR 21, Seham states that employers—in an attempt to expedite maintenance work—may instruct employees to “cut corners” (2014). Therefore, AIR 21 was enacted to protect employees who—at their employers’ request—deviate from adherence to FARs when performing maintenance (Seham, 2014). Similar literature in aviation maintenance is available on AMFA’s website.

An FAA report conducted and written by Saint Louis University provides an overview of ASAP and maintenance. The report cites a lack of awareness as a key challenge (“A practical guide,” 2009). A contributing factor to low awareness is the lack of management support. The report describes the need for trust and accountability between management and employees (“A practical guide,” 2009). Without a basic mutual understanding that is clearly written in the form of MOUs, a lack of trust will naturally exist, and while this is the foundational step for programs like ASAP, some programs still lack clear policies in written form ("A practical guide," 2009). The problem is compounded when management and labor unions use ASAP as a bargaining chip ("A practical guide," 2009). The FAA details the steps necessary to build an ASAP program.

SMS is becoming more common, and it is the goal of the FAA to promote SMS ("FAA Flight Plan," n.d.). There is an increase in ASAP participation ("A practical guide," 2009). While it is logical that organizations, especially maintenance, should embrace and implement SMS, there are barriers to the implementation of SMS in maintenance. Repair stations can be categorized based on size. Lercel and Patankar (2011) define the size of repair stations: small (under 30 employees) or medium to large (more than 30 employees). The authors have also identified an unbridgeable divide between small and medium or large repair stations (2011). Small repair stations in general do not see SMS as a benefit: "Small repair stations believe that the proposed SMS regulations will be overly burdensome, expensive, and may not improve safety" (Lercel & Patankar, 2011, p. ii). Medium and large repair stations tend to view SMS as a benefit. Lercel & Patankar (2011), congruent to Lercel et al. (2011), suggest using existing systems and resources to reduce the cost of SMS. Due to a higher accident rate in the general aviation (GA) sector, the NTSB is ardently calling for SMS implementation in the GA sector, and researchers believe this is inevitable (Lercel & Patankar, 2011, p. 29). There will be continued challenges for small repair stations because they represent over 70% of all repair stations (Lercel & Patankar, 2011).

Problems for Small Repair Stations

Small repair stations voice many legitimate concerns to the enactment of industry-wide SMS regulation, particularly a one-size-fits-all approach that will greatly affect small operations. Compliance with SMS requirements designated by ICAO is required by all member states; however, the FAA is unable to meet that requirement due to inadequate legislative support (Lercel & Patankar, 2011). Therefore, it is critically important that small repair stations support legislation enacting SMS regulations in the U.S. on par with ICAO's requirements.

Because small repair stations represent a large majority of all U.S. repair stations, small repair stations boast tremendous power. In fact, Lercel & Patankar (2011) posit that the reason SMS regulation is not enacted is because small repair stations are unwilling to support such regulation, which they deem to be a burden with little benefit. Furthermore, on December 18, 2008, the FAA explained the reason for not complying with ICAO SMS requirements. The FAA stated that U.S. rulemaking process involves thorough analysis and stakeholder input, which is the main reason for delaying SMS regulation (Steckel et al., 2013).

St. Louis University's Center for Aviation Safety Research (CASR) hosted a two-day SMS conference in 2011. Invitations were sent to Part 145 repair stations, and the focus of the conference was SMS scalability. CASR sent 2,000 invitations by mail, but the registration numbers were very low, which prompted CASR to contact 1,038 repair stations by phone (Lercel & Patankar, 2011, p. 6). The response for phone invitations were also not promising: Only forty-eight representatives of the contacted repair stations registered for the conference (Lercel & Patankar, 2011, p. 7). Additionally, out of 1,038 contacted by phone, CASR left 480 phone messages and received no response; 214 indicated no interest in SMS or too busy to attend; 106 were not familiar with SMS; 104 heard about SMS but do not fully understand SMS; 73 believe SMS regulations for small repair stations will never be enacted and showed no interest in attending (Lercel & Patankar, 2011, p. 7). In an attempt to increase registration numbers, CASR sent an additional 3,800 invitations to certificated aircraft mechanics, and four more people registered (Lercel & Patankar, 2011, p. 7). Out of the 48 total attendees, 17 represented large repair stations with over 100 employees, nine represented repair stations employing between 26 to 100, and 14 represented repair stations with under 25 employees, which, according to the authors, is not a "representative sample of the population due to the under representation of small organizations" (Lercel & Patankar, 2011, p. 7). The lackluster attitude toward SMS explains why the FAA and the industry have reached an impasse in SMS implementation.

At the conclusion of the SMS conference, the authors noted that there were several problems hindering the successful implementation of SMS at small repair stations. The salient objection to SMS implementation is cost, where small repair station operators believe SMS to be "overly burdensome" (Lercel & Patankar, 2011). Other problems include knowledge, familiarity, and benefits. On average, conference attendees working for smaller repair stations indicated a lower level of knowledge and familiarity while larger repair station employees indicated a higher level. In addition to the findings at the conference, the authors mentioned the response of those who were contacted but did not attend. Forty-one percent of people contacted by phone had little to no knowledge of SMS, and 85% of organizations employing fewer than 26 employees indicated a lack of familiarity with SMS (Lercel & Patankar, 2011, p. 12).

Another major problem is the lack of evidence supporting the benefits of SMS. This concern is shared among members of the aviation industry. Aircraft Owners and Pilots Association (AOPA) published an article questioning the benefits of SMS regulation ("Proposed Safety Management," 2009). In addition to questioning the benefits of SMS, AOPA is also raising concerns regarding the methods employed to pass this regulation: "AOPA is concerned about the proposal because it has the potential to undercut the rulemaking process by eliminating public input and cost benefit analysis" ("Proposed Safety Management," 2009). Echoing AOPA's sentiment, Lercel & Patankar (2011) stated that the FAA has not published literature detailing the actual ability of SMS to provide benefits to repair stations (p. 13). Additionally, the aircraft accident rate is extremely low, which leads opponents of SMS to argue that the actual benefit provided by SMS is miniscule. The International Air Transport Association (IATA) released a report showing the global accident rate of western-built jets to be one accident per every 2.4 million flights (IATA, 2014). Understanding the impossibility of achieving the goal of zero accidents and fatalities, opponents of SMS are satisfied with the safety of aviation. They also believe that there is no more room for significant safety improvements: "There will be no quantum leaps made no matter what system is developed or implemented" (Lercel & Patankar, 2011, p. 13).

Earning support and approval from small repair station operators are critical to the industry-wide SMS implementation effort. While a universal SMS regulation without concern for the size and scope of operations will certainly fail to garner support, research indicates that scalable solutions—a relatively nascent concept—are more acceptable to small operators. A scalable solution is a tailored approach that takes into account size, organizational complexity, and the category of aircraft serviced, which is also known as "SMS Applicability" (Lercel & Patankar, 2011).

Problems for Large Repair Stations

While not all agree on the necessity of implementing SMS in small repair stations, the majority agrees that repair stations working on transport category aircraft should be required to have SMS (Lercel & Patankar, 2011, p. 18). Since there is little question regarding the necessity of SMS in larger operations, the problem is found in the implementation process. For large repair stations, culture change is the main problem. Developing a safety culture—if not extant—is a herculean task that requires culture change. As previously stated, the development of a safety culture requires the development of sub-cultures: reporting culture, just culture, informed culture, and learning culture (Lu et al., 2011). Additionally, employees in large organizations are often entrenched in organizational cultures established over a long period of time, and the idea of culture change will be met with great resistance, especially from seasoned employees. To further complicate this problem, labor unions are often involved.

Authors Simon and Cistaro (2009) document the journey of implementing culture change at a major utility company in New Jersey: Public Service Electric and Gas Co. (PSE&G). The challenges faced by PSE&G are similar to the challenges faced by large repair stations. For the company's 6,500 employees, taking risks was the cultural norm, and that led to 32 fatalities in 27 years (Simon & Cistaro, 2009, p. 28). In an effort to enhance safety, senior management undertook the laborious task of culture change, which lasted nine years (Simon & Cistaro, 2009). Because it was critical to gain support from labor unions, PSE&G offered labor unions a share of leadership in the change process (Simon & Cistaro, 2009). The authors noted that even members of the leadership team were resistant at first, and they felt that too much time was being spent on safety (Simon & Cistaro, 2009). However, the authors concluded that the eventual nine-year journey was successful. The authors believe that effective culture change occurs from bottom up and top down simultaneously, which led to the conclusion that culture change must enlist people as champions—not just implementing programmatic formulas (2009, p. 29).

The culture change process of PSE&G also applies to aviation, and it is an appropriate model for large repair stations. Another excellent guide in culture change management, produced by the Australian Civil Aviation Safety Authority (CASA), is "SMS for Aviation—A Practical Guide: Safety Assurance," which is the fourth booklet in a series of six booklets. This booklet warns that safety change will invariably introduce safety risks elsewhere (CASA, 2012). This highlights the importance of change management, which must be methodical. After implementation, an organization must continue management efforts as overconfidence in a risk system can have a negative effect. A risk system that is too strong will lead employees to rely on the system and hold the system accountable rather than holding oneself accountable, which is detrimental to safety management efforts (Nason, 2009).

Statement of the Problem

Literature and research for SMS that applies to flight operations are abundant, but there is a limited supply of SMS related literature and research for maintenance operations. Current research indicates a need for more maintenance-related safety research. Even though the benefits of SMS are well established, it is difficult for maintenance facilities—especially small repair stations—to justify the cost.

The high cost of implementing an SMS is the putative reason for not having SMS; however, there could be other factors that hinder the implementation of SMS. Since a successful SMS requires participation from everyone in the organization, resistance from even one group within the organization could greatly hinder the implementation of SMS. Additionally, if there is a lack of trust between management and employees, the efficacy of even the most robust SMS will still be greatly curtailed. This research will attempt to reveal the hindrances that prohibit SMS implementation at aviation maintenance facilities.

Research Questions

1. What commonly accepted safety practices are reported by surveyed personnel as currently utilized in maintenance facilities and how effective are these?

2. What is the general attitude of surveyed AMTs and maintenance facility personnel toward SMS?

3. What is the level of awareness among surveyed AMTs regarding safety reporting systems?

4. What is the reported level of immunity and protection offered to surveyed employees who submit safety reports?

5. What is seen by the surveyed maintenance personnel as the greatest hindrance to SMS implementation?

CHAPTER II — METHODOLOGY

The method for this research involved the use of a survey targeting individuals working in a maintenance facility. The data collected from the survey were used to test relevant hypotheses and answer the research questions. Survey questions were designed to collect data that reflect the current attitude of AMTs toward SMS. For that reason, a cross-sectional survey was chosen. Cross-sectional surveys are effective when the intent is to provide a "snapshot" of the attitudes of the surveyed AMTs (Gay, Mills & Airasian, 2012, p. 185). Research participants received the survey via email, where a link to the survey was provided. The only requirement was that the participant worked as an aircraft technician in a maintenance facility. While FAA certification was not a requirement, participants were asked to select any FAA certificates held. The survey consisted of questions that required answers in multiple choice, multiple selection, yes or no, and Likert scale formats. This research was approved by the Middle Tennessee State University (MTSU) Institutional Review Board (IRB), protocol number 15-134 (See Appendix A).

Participants

Two organizations were originally targeted to provide the survey link to their members via email: Curt Lewis & Associates, LLC listserv and registered attendees for the 49th annual Tennessee Mid-South Aviation Maintenance Conference. After contacting both sources, only Curt Lewis & Associates, LLC was able to disseminate the research survey. Curt Lewis & Associates, LLC is a consulting firm specializing in aviation and industrial safety ("Welcome to our," n.d.). While consulting services are compensated, Curt Lewis & Associates, LLC offers two free products via email: Flight Safety

Information Newsletter (FSInfo) and Flight Safety Information Journal (FSIJ). Subscribers of these two electronic products number over 36,000 worldwide ("About us," n.d.). The newsletter, FSInfo, includes current topics on flight safety and provides summaries of flight safety related articles from newspapers, websites, and industry sources ("About us," n.d.). The journal, FSIJ, focuses on the same theme of flight safety; however, instead of summarizing newsworthy safety related information, contributions from aviation researchers make up this journal. Requirements for submitting papers to this journal can be obtained by contacting Curt Lewis & Associates, LLC ("About us," n.d.).

Even though FSInfo is a newsletter that is predominantly focused on flight safety, maintenance related articles are occasionally featured. Pilots are the expected audience for this newsletter, but anyone interested in safety—including AMTs—benefits from the information contained in FSInfo. Since AMTs can work on aircraft without possessing any mechanic certificate, the only criterion for participation was that one must work at an aviation maintenance facility. To gain additional information on the participants, a survey question asked the participants to select any applicable FAA certificates currently held. Participants selected from a list of seven choices, including "none" and "other." The choices include "mechanic-airframe," "mechanic-powerplant," "mechanic-inspection authorization," "private pilot," and "commercial pilot (and above)."

Initially, the researcher questioned the possibility of including an eighth choice for certificates—"repairman"—but, after consulting with a member of the thesis committee, this possibility was excluded. The repairman certificate is issued under Title 14 Code of Federal Regulations (14 CFR) Part 65, Subpart E. This certificate is issued by repair stations certificated under 14 CFR Part 145, certificated commercial operators, and certificated air carriers. The decision to exclude the repairman certificate as a choice was based on the following. First, the repairman certificate is issued for specific jobs within the confines of repair stations, commercial operators, or air carriers. Second, the repairman certificate is only valid for the repair station, commercial operator, or air carrier that issued the certificate. Third, the repairman certificate must be surrendered upon termination of employment. In sum, there is no standardized requirement for knowledge and practical proficiency; holders of repairman certificates may possess varying knowledge and skills. Further, it is possible to have possessed several repairman certificates with previous employers and not possess a repairman certificate at the time of this research. Having the "repairman" option would not benefit the research. Data collection commenced on December 9, 2014 and the last completed survey was received on January 6, 2015. A total of 49 responses were collected.

Instruments

A survey consisting of 18 to 20 questions was utilized. Survey questions were developed to address the research questions. Some of the survey questions in this study were modeled after a published study: "Safety Culture: Perception of Taiwan's Aviation Leaders." This research utilized a cross-sectional survey to study the attitudes and perceptions of aviation professionals in Taiwan. Although the participants in this study consisted of airport managers and government officials of Civil Aeronautics Administration (CAA) in Taiwan, the survey was designed based on FAA Advisory Circular (AC) 150/5200-37, FAA System Safety Handbook, Transport Canada's model, and ICAO Doc. 9859 (Lu et al., 2011). The survey questions utilized in the Lu study were validated in spring 2010 (Lu et al., 2011).

The survey questions for this research were modeled after Lu et al. (2011), but questions were tailored for maintenance-oriented research. The questions were initially pilot-tested by graduate teaching assistants at MTSU, primarily for clarity of wording. The questions were then presented to the maintenance faculty at MTSU, which consisted of four members. Testing the questions for content was the primary purpose, and it was at this stage when the decision was made to exclude "repairman" as a selection.

The survey questions were entered into SurveyMonkey. Several questions that shared the same Likert scale selections were grouped into one question. Participants received a minimum of 18 questions, and depending on the answers of two questions, some participants received an additional one to two questions. After the participants opened the survey, an implied informed consent statement was provided. Participants expressed consent to participate in the research by clicking the "NEXT" button, which directed participants to the first survey question.

Survey Questions Examined

The first two survey questions (see Appendix C) provide background information on the research participants. The choices for Question 1 were derived from the Lercel and Patankar (2011) study, where the researchers defined the sizes of repair stations as small (under 30 employees) and medium to large (more than 30 employees). For this study an additional category, "medium" (30 to 50 employees), was defined and created. For Question 2, the list of airman certificates and ratings were obtained from 14 CFR Part 61 and 14 CFR Part 65: certification of pilots and certification of airmen other than crewmembers, respectively.

The remaining questions were all designed to assist in answer the research questions of this study. As indicated in Chapter 1, and repeated here for ease of reference, these research questions are:

1. What commonly accepted safety practices are reported by surveyed personnel as currently utilized in maintenance facilities and how effective are these?

2. What is the general attitude of surveyed AMTs and maintenance facility personnel toward SMS?

3. What is the level of awareness among surveyed AMTs regarding safety reporting systems?

4. What is the reported level of immunity and protection offered to surveyed employees who submit safety reports?

5. What is seen by the surveyed maintenance personnel as the greatest hindrance to SMS implementation?

Survey Question 3 (see Appendix C) provides a list of safety practices. These practices are commonly found in an aviation maintenance facility. This survey question answers the first research question of this study, as it examines the commonly accepted safety practices reported by surveyed personnel. Survey Question 4 (see Appendix C) is also used to answer the first research question. Even though safety reporting systems are considered safety practices that ensure workplace safety, it is listed as a separate question because it does not actively promote safety. Additionally, a participant's level of awareness of workplace safety reporting systems answers the third research question.

Questions 5 and 6 (see Appendix C) determine a participant's familiarity and knowledge of SMS. Survey Questions 5 and 6 also answer the third research question; however, instead of using the general term "safety reporting systems," the more specific term, SMS, is used. According to ICAO, the definition of SMS is "a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures" (ICAO, 2013, xii). Based on that definition, safety reporting systems are only a component of SMS; therefore, it is not synonymous to SMS. The presence of safety reporting systems in aviation maintenance facilities is not an indication of an active SMS; on the contrary, an organization with an effective SMS will always have a safety reporting system (ICAO, 2013, 2-11). Question 5 determines how much a participant has heard about SMS. Question 6 determines the level of SMS knowledge possessed by the participants. The reason for utilizing two questions regarding SMS—rather than combining into one—was that familiarity by hearing differs from possessing actual knowledge of SMS.

Question 7 (see Appendix C) determines the current state of safety in aviation maintenance facilities. This survey question supports the first research question by testing the effectiveness of commonly accepted safety practices. The effectiveness of safety practices is determined by the average number of safety-related issues that occur within a month.

Question 8 (see Appendix C) was designed to examine the role of managers as safety advocates and promoters, which answers the fifth research question. It is the responsibility of managers to be active participants of safety enhancement, which includes the promotion of safety. When management fails or refuses to act in that capacity, they become hindrances to the successful implementation of SMS. Furthermore, responses collected from participants may indicate the level of safety awareness among management. Lu et al. (2011) cite that as management rank increases awareness of significant safety problems among management personnel decreases.

Question 9 (see Appendix C) is the combination of five separate questions that share the same response selections, and this question is treated as five separate questions: 9A, 9B, 9C, 9D, and 9E. These five questions answer the second research question by exploring the general attitude of surveyed AMTs toward SMS. By necessity, these questions and the associated answer selections are subjective. Question 9A determines the effectiveness of safety policies and procedures from the participants' perspective. This question also supports the first research question. Question 9B determines the priority of safety as an organizational goal in the workplace of surveyed AMTs. Question 9C determines the priority of safety among managerial staff. Question 9D determines the attitude of the surveyed participants toward SMS. Finally, question 9E extends the scope of question 9D by determining the participants' attitude toward cost benefits of SMS. As safety management systems may not be recognized by the title "SMS" in some maintenance facilities, Questions 9D and 9E include the term "safety policies and procedures" in addition to SMS, which implies—to a degree—a synonymous relationship between the two terms. Furthermore, Question 9E also answers the fifth research question regarding hindrances. Because it is established that cost is a deterrence for SMS implementation—especially for small operations—Question 9E provides insight on the attitude toward cost benefits of SMS from the participants' perspective.

Questions 10, 11, and 12 (see Appendix C) are related questions. Depending on the selection for Question 10, participants will either continue to Question 11 or skip to Question 12. These three questions answer the fourth and fifth research questions. Participants who select "Yes" on Question 10 will answer Question 11; likewise, participants who answered "No" on Question 10 will skip to Question 12. Participants will not answer both Questions 11 and 12, as Question 11 skips to Question 13.

Selecting "Yes" on Question 10 indicates that safety reports are submitted anonymously at the participant's workplace. The follow up question, Question 11, then determines the participant's confidence level in its actual ability to remain anonymous. Despite the actual policy of anonymity, if the system cannot be trusted by users, the system is ineffective and that is considered a hindrance to successful SMS implementation. If "No" was selected on Question 10, indicating no policies of anonymity, Question 11 is skipped and Question 12 is presented to the participant. Question 12 determines if the lack of anonymity is a deterrence, which is also considered a hindrance to successful SMS implementation.

Similarly formatted, Questions 13, 14, and 15 (see Appendix C) are also related, and these questions also answer the fourth and fifth research questions. Instead of anonymity, Question 13 examines immunity and protection for employees submitting safety reports. Participants selecting "Yes" on Question 13 will continue to Question 14, and participants selecting "No" on Question 13 will skip Question 14 and answer Question 15. Participants who indicate protection and immunity policies ("Yes" on Question 13) will then indicate their confidence in the system's actual ability to protect (Question 14). Low confidence in the system is a hindrance to successful SMS implementation. Participants indicating the lack of immunity and protection policies ("No" on Question 13) will proceed to Question 15. Question 15 determines, from the participant's perspective, whether the absence of immunity and protection policies deters people from submitting reports.

The final question, Question 16 (see Appendix C), examines the participant's attitude toward current safety policies. This answers the second research question. To some, SMS policies are considered a burden, and to others, SMS policies are beneficial. Additionally, a safety system that is too strong can actually become a safety hazard (Nason, 2009). Understanding the general attitude of the participants can serve as the much needed impetus for SMS implementation, or it can reveal hindrances. Examining the need for more or less safety policies reveals the current attitude of the industry—based on the perspective of the surveyed AMTs.

Procedures

Curt Lewis & Associates, LLC was contacted via email. A brief description of the survey and a brief biography of the researcher was included in the email (see Appendix B). The link to this research survey was published in the daily newsletter, FSInfo, for one week (December 9, 10, 11, 12, 15, 16). Most of the responses—31 in total—were received within the first three days of publishing the survey. During this time, an industry professional, who took the survey, contacted the researcher with suggestions to expand the reach of this survey. Suggestions included using groups on LinkedIn, an online professional networking service. Due to the time limit, research of LinkedIn interest groups was not conducted, and this source was not utilized.

After December 16, 2015, 44 responses were collected. In order to increase the number of participants, after receiving approval from the MTSU IRB to include an additional distribution mechanism, the Professional Aviation Maintenance Association (PAMA) was contacted with the intent of reaching its members via email. An introductory email was sent to PAMA using the general inquiries email: info@pama.org. A representative of PAMA responded with information regarding the protocol of reaching PAMA's members to conduct research: The research must be approved by PAMA's board of directors. Information forwarded to the board of directors included a brief description of the research, the name of the university, the contact information of the researcher, and the contact information of the faculty advisor. Additionally, the PAMA representative inquired of the preferred deadline for the collection of data, and the researcher provided the PAMA representative with January 5, 2015 as the deadline. The PAMA representative made an effort to "fast track" the request to the board of directors for approval to post the survey link on PAMA's website and to send the link in an email blast. Approval was not obtained by the deadline, and no further attempts were made to pursue this source for potential participants.

The last response was collected on January 6, 2015. Data were downloaded and analyzed using Microsoft Excel. Data were coded numerically before analysis was performed. An "add-in" was downloaded in Excel to enable data analysis using ANOVA. This "add-in," named "Analysis ToolPak," was created by Microsoft, and it is a free "add-in" for Excel. The "Analysis ToolPak" includes functions such as ANOVA Single Factor, ANOVA Two Factor with and without Replication, Correlation, Regression, and t-Test.

CHAPTER III — DATA ANALYSIS

Data were collected from a total of 49 survey participants. For some data analysis, participants were split into three groups based on size, which was determined by the number of AMTs employed at their respective workplace: under 30 (n = 25), 30 to 50 (n = 4), and more than 50 (n = 19) with one no response (N = 48). Some data were also analyzed by testing differences between groups based on the certificates possessed by the participants. Thirty-nine respondents possessed airframe and powerplant (A&P) certificates, and an additional 17 respondents possessed the inspection authorization (IA). Mechanics with an IA have additional privileges, chief among them the privileges to "perform an annual, or perform or supervise a progressive inspection" (U.S. DOT, 2015, FAR 65.95). Holders of IA must also possess an A&P certificate. An A&P mechanic becomes eligible to apply for an IA after two years of actively engaging in aircraft maintenance (U.S. DOT, 2015, FAR 65.91).

In addition to the mechanic certificates, 24 participants were also certificated pilots. Out of the 24 pilots, nine participants possessed a private pilot certificate, and 15 participants possessed at least a commercial pilot certificate. One more pilot certificate is available beyond the commercial certificate: Airline Transport Pilot (ATP). However, the ATP certificate—requiring 1,500 hours of total time as a pilot—was not listed as a selection for the reason that it is not a common certificate AMTs would hold (U.S. DOT, 2015, FAR 61.159).

With regard to certificates, only two of the 49 selected "none," and eight participants selected "other." Entries from the "other" selection were distinct and varied: "Senior Aviation Safety Specialist," "Aircraft Maintenance Engineers (CAN)," "Founding PRM (Person Responsible for Maintenance) under Transport Canada," "FCC General Radiotelephone Operator," "Senior Parachute Rigger," "Avionic /Electrical License," "NZCAA airframe/powerplant CASA A, B1 & C," and "Flight Engineer." The participant possessing the CASA license is licensed under a different system. According to the response, this individual was licensed by the Civil Aviation Authority of New Zealand (NZCAA), and this individual was licensed according to the standards of the Civil Aviation Safety Authority (CASA). The licenses held by this individual are similar to the A&P. The CASA category B1 license "covers aircraft structure, powerplant, mechanical and electrical systems" (CASA, 2011, p. 6). Additionally, the B1 category covers "turbine-engined aeroplanes, piston-engined aeroplanes, turbine-engined helicopters, and piston-engined helicopters [*sic*]" (CASA, 2011, p. 5).

Effectiveness of Current Safety Practices

See Figure 1 for the breakdown of current safety practices utilized to ensure and promote safety in aviation maintenance facilities reported by surveyed participants. Figure 1 presents the data in increasing order from the fewest to the greatest in terms of frequency, which differs from the order presented to the participants in the survey. The most common safety practices, present in over 70% of the surveyed participants' workplaces, are safety training, safety posters, safety checklists, and safety meetings. Though not as common, safety officers and safety newsletters were present in the majority (over 50%) of the surveyed participants' workplaces. Participants selecting the choice of "other" were asked to list additional safety practices that were not provided. The two "other" responses were "ASAP" and "written policies." Two items of safety, safety officer and safety training, were further analyzed. These two items of safety require the most resources to implement, and data analysis were performed to further determine the statistical differences between groups of various sizes (see Tables 1-2). All four participants working for the medium sized maintenance facilities indicated the presence of a safety officer, while only three of the four indicated that safety training was provided. There were more surveyed participants working for small maintenance facilities that indicated the presence of a safety officer than those working in large maintenance facilities. Likewise, more large maintenance facilities provided safety training than small maintenance facilities.

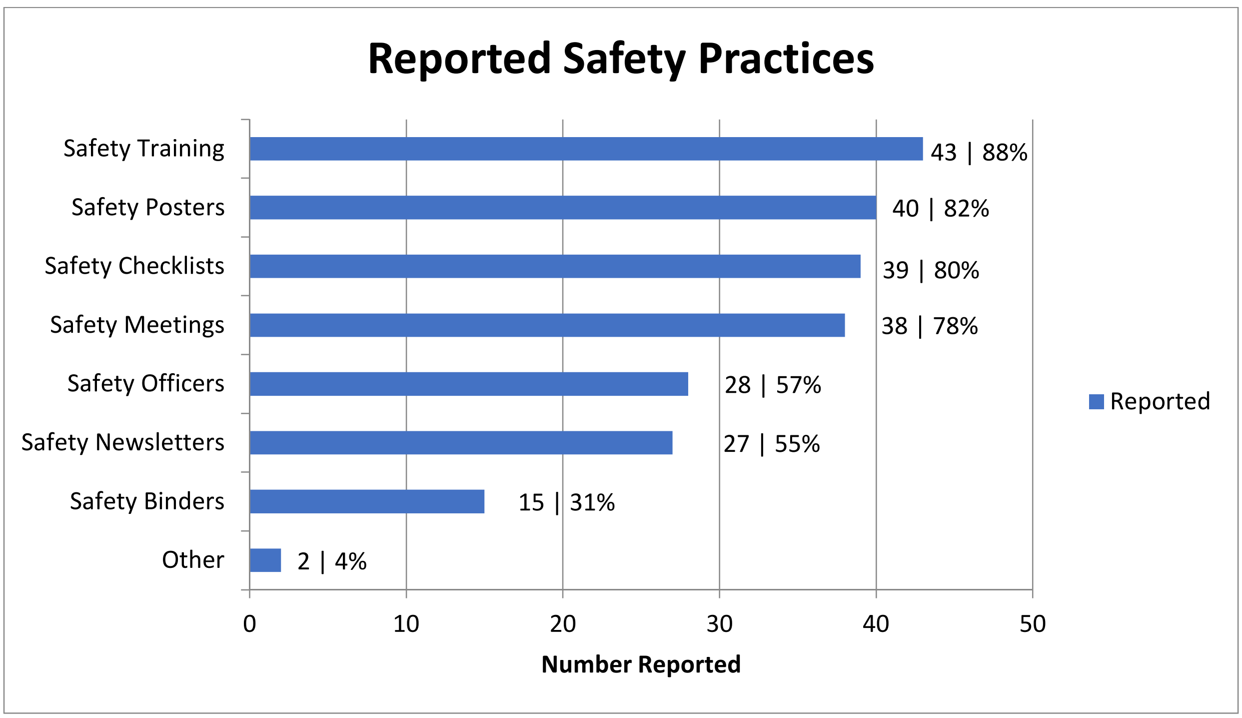

Figure 1. Reported safety practices in aviation maintenance facilities.

Table 1

Participants indicating the presence of a safety officer in their workplace.

	Under 30	30 to 50	More than 50
Reported	15	4	8
Total population	25	4	19
% of population	60%	100%	42.1%

Table 2

Participants indicating safety training provided by their employers.

	Under 30	30 to 50	More than 50
Reported	21	3	18
Total population	25	4	19
% of population	84%	75%	94.7%

Perceived effectiveness in relation to the number of safety practices

Perceived effectiveness of the safety practices listed was tested using a one-way Analysis of Variance (ANOVA). Participants' perception of the effectiveness of the given safety practices were analyzed based on the number of safety practices employed in their respective workplaces. Participants were divided into two groups for this test. Groups were determined by the number of selected safety items. Participants selecting fewer than five items were placed into Group 1 (n = 17), and participants selecting five or more items were placed into Group 2 (n = 28); there were four no responses on this question (N = 45). Participants indicated the level of agreement to Question 9A, "I believe that safety procedures and policies in my workplace are effective." Participants selected from five choices, which were ranked numerically for data analysis: 1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree. The mean for Group

1 was 3.47, and the mean for Group 2 was 3.89. The one-way ANOVA, $F(1, 43) = 2.32$ ($F_{crit} = 4.07$), $p = 0.135$, demonstrated statistically insignificant differences between the two groups at the $p < .05$ level, although the mean for Group 2 was slightly higher. The participants were further separated into seven groups based on the number of safety practices selected. There is a moderate to strong relationship when the groups were compared based on the number of safety practices and perceived effectiveness (see Figure 2).

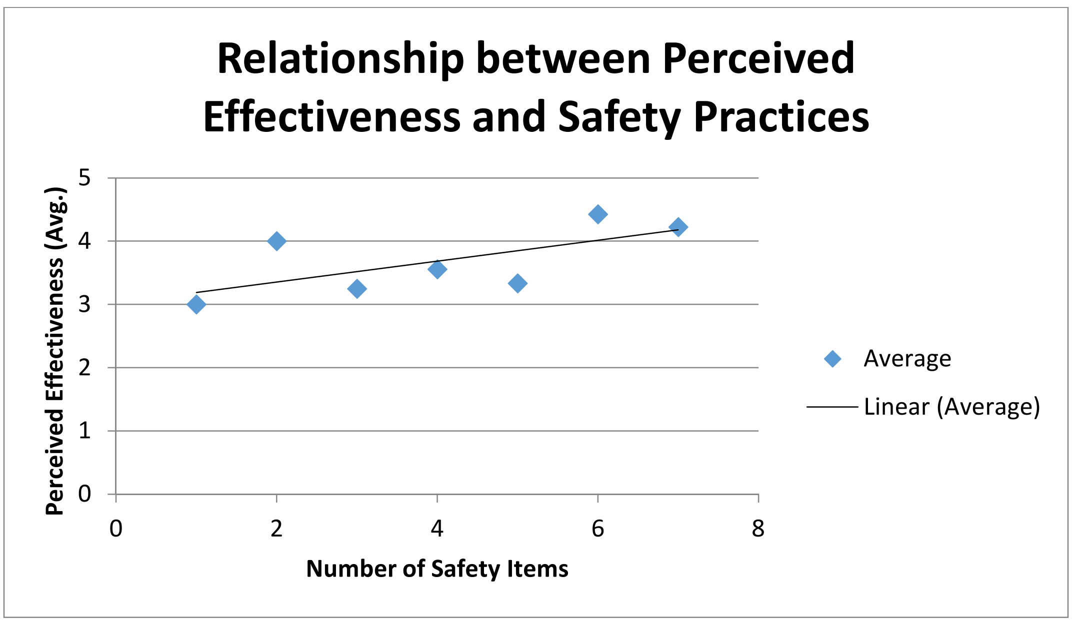

Figure 2. Relationship between perceived effectiveness and safety practices. There is a relationship between perceived effectiveness and the number of safety practices. Regression line equation: $y = 3.027 + 0.164x$; correlation coefficient: $r = 0.659$.

Perceived effectiveness in relation to organizational size

A one-way ANOVA was used to test the perceived effectiveness of participants in relation to an organization's size. Before testing the perceived effectiveness, a one-way

ANOVA was performed to determine the relationship of organizational size and the number of safety practices. Participants were divided into three groups: under 30 (*n* = 25), 30 to 50 (*n* = 4), and more than 50 (*n* = 19); there was one no response (*N* = 48). The mean for under 30 was 4.52 (*SD* = 1.87), the mean for 30 to 50 was 4.75(*SD* = 1.71), and the mean for more than 50 was 4.89 (*SD* = 1.41). There were no statistically significant differences in the number of practices and the size of an organization at the $p < .05$ level [$F(2, 45) = .27$ ($F_{crit} = 3.20$), $p = .77$].

A one-way ANOVA was then performed to determine the relationship of perceived effectiveness and the size of an organization. Participants were divided into three groups based on organizational size: under 30 (*n* = 22), 30 to 50 (*n* = 4), and more than 50 (*n* = 18). There were four no responses for the effectiveness question, and there was one no response for organizational size (*N* = 44). The mean for under 30 was 3.95 (*SD* = .90), the mean for 30 to 50 was 3.75 (*SD* = .50), and the mean for more than 50 was 3.44 (*SD* = .98). The one-way ANOVA at the $p < .05$ level, $F(2, 41) = 1.55$ (F_{crit} = 3.23), $p = .22$, demonstrated statistically insignificant differences among the three groups.

Analysis of Participants' Attitudes toward SMS

Participants' attitudes toward SMS were analyzed using three different grouping methods. The first test consisted of one group: the entire population. The second test grouped participants based on the number of AMTs working at their facility. The third test utilized two groups based on the possession of pilot certificates.

Analysis of overall attitude for the entire population

For the first test, overall attitude for all participants was determined. Results for Question 9D (*N* = 45, *M* = 4.27, *SD* = .81) and Question 9E (*N* = 45, *M* = 4.13, *SD* = .94) are displayed in Tables 3-4, respectively. In Table 3, an overwhelming majority of the 37 participants (82%) indicated that SMS would be beneficial to their company. Similarly, in Table 4, 34 participants (76%)—though slightly less than the previous table, but a majority nonetheless—indicated that SMS is worth the cost. Data from Questions 9D and 9E were then analyzed using Spearman's rank-order correlation test to determine statistical significance. The result of the Spearman's rank-order test, r_s (df) = .73, two-tailed $p = 0$, was statistically significant, which means participants who believed SMS would be beneficial also believed SMS would be worth the cost, and vice versa. To understand the current needs of safety policies in the industry, data from Question 16 was analyzed and the results ($N = 45$, $M = 3.29$, $SD = .76$) are presented in Table 5. While there the majority of participants selected "sufficient," the mean ($M = 3.29$) is between "sufficient" (3) and "needs slightly more" (4).

Table 3

Benefits of SMS to a company.

Selection	Numeric	Number of Participants
Strongly Disagree	1	0
Disagree	2	1
Neutral	3	7
Agree	4	16
Strongly Agree	5	21

Note. Results for Question 9D: "I believe Safety Management Systems (SMS)/safety policies and procedures would be beneficial to my company."

Table 4

Cost benefits of SMS to a company.

Selection	Numeric	Number of Participants
Strongly Disagree	1	0
Disagree	2	3
Neutral	3	8
Agree	4	14
Strongly Agree	5	20

Note. Results for Question 9E: "I believe SMS/safety policies and procedures are worth the cost."

Table 5

Current need of safety policies in participants' place of employment.

Selection	Numeric	Number of Participants
Needs much less	1	0
Needs slightly less	2	4
Sufficient	3	28
Needs slightly more	4	9
Needs much more	5	4

Note. Results for Question 16: "What is the current need for safety policies at your place of employment?"

Analysis of organizational size and pilot certificates

A one-way ANOVA was performed to determine the participants' attitudes toward SMS based on the number of AMTs employed by their workplace. The participants were placed into three groups: under 30 (n = 22), 30 to 50 (n = 4), and more than 50 (n = 18). The mean for under 30 was 3.18 (SD = .66), the mean for 30 to 50 was 3.25 (SD = .96), and the mean for more than 50 was 3.44 (SD = .86). Results from all three groups were between 3 ("Sufficient") and 4 ("Needs slightly more"). There were five no responses (N = 44). The one-way ANOVA, $F(2, 41) = .58$ ($F_{crit} = 3.23$), $p = .56$, demonstrated statistically insignificant differences among the facilities of various sizes at the $p < .05$ level.

A chi-square test was conducted to determine statistical differences between participants possessing a minimum of a private pilot certificate and participants who do not possess any pilot certificates. Participants were split into two groups to test for differences in the attitude toward the current needs for safety policies in their respective workplaces. The two groups are participants possessing pilot certificates ($n = 21$) and participants without pilot certificates ($n = 24$). There were four no responses ($N = 45$). The chi-square test determined no statistically significant differences between the two groups [$\chi^2 (3) = 4.69$, $p = .20$].

Analysis of Safety Awareness among Surveyed AMTs

Out of the total surveyed AMTs ($N = 49$), 47 participants are aware of a safety reporting system, and two participants were not aware of a safety reporting system at their workplace. Data analysis was conducted on survey Questions 5 and 6, and correlation was determined by Spearman's rank-order correlation test. The results for Question 5 ($M = 4.25$, $SD = 1.01$) and Question 6 ($M = 3.95$, $SD = 1.18$) are displayed in Figure 3. The Spearman's rank-order test ($r_s = .87$, two-tailed $p = 0$) determined that there is a strong relationship between the selections of Questions 5 and 6, meaning that those who have heard a lot about SMS also know a great deal about SMS, and vice versa.

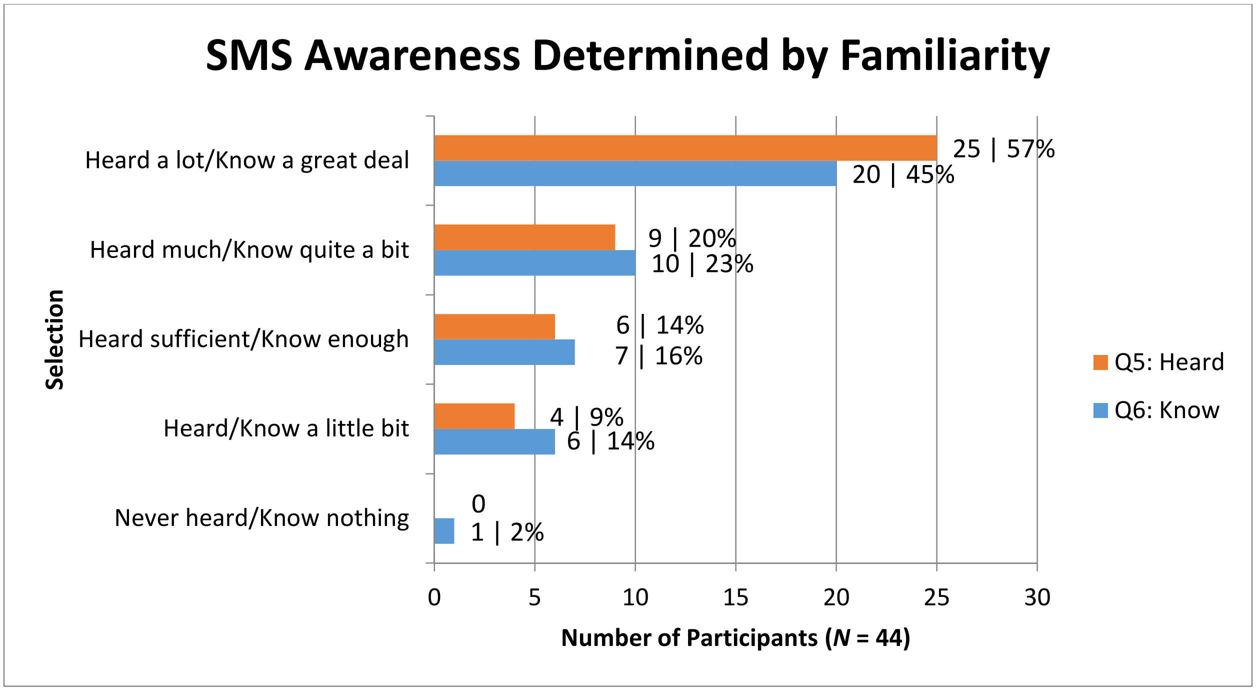

Figure 3. SMS awareness determined by familiarity. Selections for Question 5: 1 = "I have never heard of SMS," 2 = "I have heard a little bit about SMS," 3 = "I have heard a sufficient amount about SMS," 4 = "I have heard much about SMS," and 5 = "I have heard a lot about SMS." Selections for Question 6: 1 = "I know nothing about SMS," 2 = "I know a little about SMS," 3 = "I know enough about SMS," 4 = "I know quite a bit about SMS," and 5 = "I know a great deal about SMS."

Analysis of the Impact of Anonymity, Immunity, and Protection

Out of the total participants, 35 indicated that anonymity was provided for submitting safety reports, 10 indicated no policies for anonymity, and there were four no responses. Similarly, 32 participants indicated that immunity and protection were offered for submitting safety reports, 13 indicated no policies for immunity and protection, and there were four no responses. There were six participants who answered no to both anonymity and immunity/protection. To confirm the correlation between "Yes/Yes" and "No/No" pairs (based on Questions 10 and 13), a Spearman's rank-order correlation test was conducted. The results of the Spearman's rank-order test, r_s = .48, two-tailed p =

.00074, was statistically significant. Maintenance facilities offering anonymity are also more likely—statistically—to offer immunity and protection.

Anonymity was further studied among three groups: under 30 (n = 22), 30 to 50 (n = 4), and more than 50 (n = 18). There were four no responses for the anonymity question, and there was one no response for the organizational size question (N = 44); the results are presented in Table 6. Immunity and Protection policies were further studied among the three groups (previously mentioned); the results are presented in Table 7. A majority of participants indicated the existence of policies of anonymity, immunity, and protection. In general, anonymity is offered more than immunity and protection; however, the percentage spread for anonymity is greater than immunity and protection: There is a 10 percentage point spread for anonymity between small and large maintenance facilities, but there is only a four percentage point spread for immunity and protection between small and large maintenance facilities.

Table 6

Results of safety report anonymity.

	Groups		
Selection	Under 30	30 to 50	More than 50
Yes	16 (73%)	3 (75%)	15 (83%)
No	6 (27%)	1 (25%)	3 (17%)
Sum	22	4	18

Note. Percentages are expressed as the ratio within each group.

Table 7

Results of immunity and protection policies offered for safety reports.

Selection	Groups: Under 30	30 to 50	More than 50
Yes	15 (68%)	3 (75%)	13 (72%)
No	7 (32%)	1 (25%)	5 (28%)
Sum	22	4	18

Note. Percentages are expressed as the ratio within each group.

To test for statistical significant differences among the three groups, chi-square tests were used for both anonymity and immunity/protection policies. The chi-square result for differences in anonymity policy among the three groups was statistically insignificant [χ^2 (2) = .65, *p* = .72]. There were no statistically significant differences among the three groups, regardless of organizational size. The chi-square result for differences in immunity and protection policies among the three groups was also statistically insignificant [χ^2 (2) = .12, *p* = .94]. Again, there were no statistically significant differences among the three groups regardless of organization size.

Analysis of Factors Considered to be Hindrances to SMS Implementation

Organizational efforts to ensure and promote safety are tested using various methods. Data for survey Questions 9B, 9C, and 8 are displayed in Tables 8-10, respectively. There were four no responses to these three questions (*N* = 45). Table 8 depicts participants' agreement that safety is a core value of the company, which is the result of Question 9B (*M* = 4.18, *SD* = .81). A majority of the surveyed participants, 87% (39 participants), agreed that safety is a core value of the company. Table 9 depicts participants' agreement that managers see safety as a priority, which is the result of

Question 9C (*M* = 3.78, *SD* = .97). A majority of the surveyed participants, 64% (29 participants), agreed that safety is a managerial priority. Table 10 depicts the frequency that safety is discussed by supervisors and managers, which is the result of Question 8 (*M* = 3.60, *SD* = .89). A majority of the surveyed participants, 62% (28 participants), indicated that safety was discussed frequently by their supervisors or managers.

Table 8

Participants' agreement that safety is a core value of the company.

Selection	Numeric	Number of Participants
Strongly Disagree	1	1
Disagree	2	0
Neutral	3	5
Agree	4	23
Strongly Agree	5	16

Note. Results for survey Question 9B.

Table 9

Participants' agreement that safety is a managerial priority.

Selection	Numeric	Number of Participants
Strongly Disagree	1	1
Disagree	2	3
Neutral	3	12
Agree	4	18
Strongly Agree	5	11

Note. Results for survey Question 9C.

Table 10

The frequency of safety discussion by supervisors and managers.

Selection	Numeric	Number of Participants
Never	1	1
Rarely	2	4
Occasionally	3	12
Frequently	4	23
Very Frequently	5	5

Note. Results for survey Question 8.

Further analyses were conducted to determine correlation among the three responses. Individual responses to these three questions were analyzed using the Friedman test. The result of the Friedman test indicated statistical significance, χ^2 (2) = 10.08, p = 0.0065. Post hoc analysis using the Wilcoxon signed-rank test was conducted to determine statistical difference between the three groups: frequency, core value, and managerial priority. There was statistical significance between frequency and core value (Z = -3.26, p = .001). There was also statistical significance between core value and managerial priority (Z = 2.8, p = .005). However, there was no statistical significance between managerial priority and frequency (Z = .9, p = .368). Taken together, the results suggest that there is disparity between company core value and managerial actions, but managers who see safety as a priority will discuss safety more frequently.

To determine the differences between various organizational sizes, the three aforementioned questions were tested using a one-way ANOVA. There were five no responses (N = 44). The three groups are under 30 (n = 22), 30 to 50 (n = 4), and more than 50 (n = 18). The one-way ANOVA result for differences in safety as a core value of the company among three groups was statistically insignificant at the p < .05 level [F(2,

41) = .08 (F_{crit} = 3.23), p = .92]. The results for individual groups are as follows: under 30 (M = 4.18, SD = .96), 30 to 50 (M = 4, SD = 0), and more than 50 (M = 4.17, SD = .71). The one-way ANOVA result, using the same groups, for statistical differences in safety as a managerial priority among three groups was statistically insignificant at the $p < .05$ level [F(2, 41) = 1.18 (F_{crit} = 3.23), p = .32]. The results for individual groups are as follows: under 30 (M = 3.95, SD = 1.09), 30 to 50 (M = 4, SD = 0), and more than 50 (M = 3.50, SD = .92). The one-way ANOVA result, using the same groups, for differences in the frequency of safety discussion by supervisors and managers among three groups was also statistically insignificant at the $p < .05$ level [F(2, 41) = 1.48 (F_{crit} = 3.23), p = .25]. The results for individual groups are as follows: under 30 (M = 3.36, SD = 1.00), 30 to 50 (M = 3.75, SD = .92), and more than 50 (M = 3.83, SD = .71). Taken together, there were no statistically significant differences among the three groups, and safety as a core value of the company, safety as a managerial priority, and the frequency of safety discussions by supervisors and managers did not differ based on organizational size.

An additional variable, the number of safety-related issues that surveyed AMTs witness per month, was introduced and tested, and the results are presented in Table 11. A majority of the participants (58%) indicated “less than 5,” and 82% of the participants witness fewer than 11 safety-related issues in a month. The differences in the number of witnessed safety-related issues were tested among three groups, previously mentioned: under 30 (n = 22), 30 to 50 (n = 4), and more than 50 (n = 18). The results for individual groups are as follows: under 30 (M = 4.59, SD = .85), 30 to 50 (M = 4.75, SD = .50), and more than 50 (M = 3.56, SD = 1.50). The one-way ANOVA result, F(2, 41) = 4.53 (F_{crit} = 3.23), p = .02, was statistically significant among three groups at the $p < .05$ level, suggesting that one or more group pairs were significantly different. A Tukey post hoc test was conducted to determine statistically significant differences between group pairs. The results of the Tukey post hoc test revealed that the differences in the number of witnessed safety-related issues were statistically insignificant between the small-medium (p = .90) and medium-large (p = .16) group pairs. However, there were statistically significant differences between the medium-large (p = .02) group pair, which means that the number of safety-related issues witnessed by surveyed AMTs is elevated in large (more than 50) aviation maintenance facilities.

Table 11

Number of safety-related issues witnessed by participants.

Selection	Numeric	Number of Participants
Less than 5	5	26
6 to 10	4	11
11 to 15	3	3
16 to 20	2	1
20 or more	1	4

Note. Results for survey Question 7 (N = 45).

The number of witnessed safety-related issues were also tested among the three previously mentioned variables: safety as a core value of the company, safety as a managerial priority, and the frequency of safety discussions by supervisors and managers. These three variables were compared with the number of witnessed safety-related issues using the Spearman’s rank-order correlation test to determine a correlation between the number of witnessed safety-related issues and the level of safety engagement by the participants’ employers. The first test was conducted to determine the statistical significance between safety as a core value of a company and the number of witnessed safety-related issues. The result of the Wilcoxon signed-rank test was statistically insignificant [$Z = -0.324$, two-tailed $p = .749$], which means that the number of witnessed safety-related issues are not correlated to safety as a core value of a company (as one increases, the other does not necessarily increase). The second test was conducted to determine the statistical significance between safety as a managerial priority and the number of witnessed safety-related issues. The result of the Wilcoxon signed-rank test was statistically significant [$Z = -1.985$, two-tailed $p = .048$], which means that the higher safety is prioritized by managers, the lower the number of witnessed safety-related issues. Finally, the third test was conducted to determine the statistical significance between the frequency of safety discussions by supervisors and managers and the number of witnessed safety-related issues. The result of the Wilcoxon signed-rank test was statistically significant [$Z = -2.686$, two-tailed $p = .007$], meaning that more safety discussions lead to fewer witnessed incidents.

Lack of Anonymity as a Potential Hindrance

Participants indicated whether anonymity was offered for submitting safety reports (see Table 6). Participants selecting “Yes” were asked about their level of confidence in the actual ability to remain anonymous. Table 12 presents the results, which indicates that most participants were confident in their actual ability to remain anonymous. A one-way ANOVA was conducted to determine statistical difference among three groups based on organizational size. Participants were divided into three groups: under 30 ($n = 16$), 30 to 50 ($n = 3$), and more than 50 ($n = 15$). Results for the individual groups are as follows: under 30 ($M = 3.69$, $SD = 1.20$), 30 to 50 ($M = 4.33$, SD

= .58), and more than 50 (M = 3.33, SD = 1.35). The one-way ANOVA, $F(2, 31) = .91$ ($F_{crit} = 3.30$), $p = .41$, determined no statistically significant differences among the three groups at the $p < .05$ level. Participants selecting "No" were asked if this was a deterrence (see Table 13). There is no strong consensus regarding surveyed participants' attitudes toward the lack of anonymity as a deterrence.

Table 12

Confidence level of the actual ability to remain anonymous.

Selection	Numeric	Number of Participants
Not confident at all	1	2
Not very confident	2	6
Neutral	3	6
Confident	4	12
Very confident	5	9

Note. Results for survey Question 11, based on the selection of "Yes" on survey Question 10 (N = 35).

Table 13

Lack of anonymity as a deterrence for safety report submission.

Selection	Numeric	Number of Participants
Not at all	1	3
To little extent	2	1
To some extent	3	4
To a moderate extent	4	2
To a great extent	5	0

Note. Results for survey Question 12, based on the selection of "No" on survey Question 10 (N = 10).

Lack of Immunity and Protection as Potential Hindrances

Participants indicated whether immunity and protection were offered for submitting safety reports (see Table 7). Participants selecting "Yes" were asked about their level of confidence in the actual ability to offer immunity and protection. Table 14 presents the results, which indicates that most participants were confident in its actual ability to protect. A one-way ANOVA was conducted to determine statistical differences among three groups based on organizational size. Participants were divided into three groups: under 30 (n = 15), 30 to 50 (n = 3), and more than 50 (n = 13). Results for the individual groups are as follows: under 30 (M = 3.93, SD = .96), 30 to 50 (M = 4.00, SD = 1.00), and more than 50 (M = 3.46, SD = 1.13). The one-way ANOVA, $F(2, 28) = .82$ ($F_{crit} = 3.34$), $p = .45$, determined no statistically significant differences among the three groups at the $p < .05$ level. Participants selecting "No" were asked if this was a deterrence (see Table 15). In this case, the lack of immunity and protection does seem to be a deterring factor for submitting safety reports; however, there is not enough data to reach a strong consensus.

Table 14

Confidence level of the actual ability to offer immunity and protection.

Selection	Numeric	Number of Participants
Not confident at all	1	1
Not very confident	2	3
Neutral	3	6
Confident	4	14
Very confident	5	8

Note. Results for survey Question 14, based on the selection of "Yes" on survey Question 13 (N = 32).

Table 15

Lack of immunity and protection as factors of deterrence for safety reports.

Selection	Numeric	Number of Participants
Not at all	1	3
To little extent	2	2
To some extent	3	6
To a moderate extent	4	1
To a great extent	5	1

Note. Results for survey Question 15, based on the selection of “No” on survey Question 13 ($N = 13$).

Two additional tests were conducted to determine if the lack of anonymity, immunity, and protection were factors attributing to a higher number of witnessed safety-related issues. Participants’ selections of the number of witnessed safety-related issues were compared in two groups: those who answered “Yes,” and those who answered “No” to both anonymity and immunity/protection questions. For anonymity, the Mann-Whitney U test, $U = 226$, two-tailed $p = .17$, determined no statistically significant differences. For immunity and protection, the Mann-Whitney U test also determined no statistically significant differences between the two groups [$U = 257.5$, two-tailed $p = .22$]. Taken together, the lack of anonymity, immunity, and protection do not lead to a higher number of witnessed safety-related issues in an aviation maintenance facility.

CHAPTER IV — DISCUSSION AND RECOMMENDATIONS

The primary goals of the research questions were designed to determine the current level of safety awareness, the current safety practices in maintenance facilities, the general attitudes of AMTs toward SMS, and hindrances to SMS implementation. Survey questions were designed to answer these questions, which included both objective and subjective selections. This approach facilitated the analyses of both factual information and the perception of surveyed AMTs in order to answer the research questions.

Research Question 1 Analysis

The first research question asked surveyed AMTs to identify safety practices utilized in their workplace. Furthermore, surveyed AMTs indicated their perception of the effectiveness of the selected practices. The four most common safety practices reported by surveyed AMTs were safety training, safety posters, safety checklists, and safety meetings. These four safety practices were present in the over 75% of the workplaces represented by the surveyed AMTs. These four safety practices were followed by safety officers and safety newsletters, which were present in over 50% of the workplaces represented by the surveyed AMTs. The safety practice least selected was safety binders. It was found that there were no statistically significant differences in the number of safety practices among the maintenance facilities of various sizes. Participants working for maintenance facilities of all three sizes—small (under 30), medium (30 to 50), and large (more than 50)—indicated an averaged of between four and five safety practices in their workplace. Furthermore, there were no statistically significant differences in the perception of the effectiveness of safety practices among small, medium, and large maintenance facilities. The number of safety practices and its perceived effectiveness is similar among maintenance facilities of various sizes.

Out of the eight safety practices, safety training and safety officers were deemed to be safety practices that required the most resources. Since cost was listed as a main hindrance in SMS implementation, especially in smaller maintenance facilities, these two safety practices were analyzed to determine the difference among facilities of various sizes. It was found that the percentage of maintenance facilities utilizing safety training and safety officers to ensure safety among small, medium, and large facilities were similar. In fact, more participants working in small maintenance facilities indicated the presence of a safety officer than the participants working in a large maintenance facility, with a spread of 18 percentage points between small and large maintenance facilities. Although all of the participants in the medium category reported the presence of a safety officer in their workplace, the sample of four participants—where each participant represented 25% of the sample—is too small for this particular question. On the contrary, there was a higher percentage of participants working in large maintenance facilities indicating safety training than small maintenance facilities; however, the percentage point spread was smaller (10 percentage points). In this instance, the medium category was the lowest in terms of percentage.

According to the results, cost is not a hindrance to SMS implementation, even for small maintenance facilities. However, the terms “safety officers” and “safety training” were not defined for the participants. A safety officer could be a supervisor tasked with the responsibility of ensuring safety, or a safety officer could be an employee—e.g., safety manager—whose primary duty is to ensure safety. The difference in cost for previous examples is quite significant. Also, safety training could be anything from watching safety videos to formal dedicated safety training sessions conducted by safety professionals. Again, the cost difference for previous examples is significant.

In order to determine the perceived effectiveness of the listed safety practices, participants were grouped based on the quantity of reported safety practices. Employees working for facilities with more safety practices do not necessarily have an elevated perception of its effectiveness. Even though there was no statistical significance between the perceived effectiveness of facilities based on the number of safety practices, there is a moderate to strong relationship between the number of safety practices and perceived effectiveness. This means that participants who indicated the presence of seven safety practices, on average, have a higher level of perceived effectiveness than participants who indicated only one safety practice. Because the sample in each group is small—due to having seven groups—this is not an accurate indicator of the relationship between safety practices and perceived effectiveness.

According to the results, cost is not a hindrance to SMS implementation in maintenance facilities of any size. It was also determined that there is no lack of safety practices in small maintenance facilities. Additionally, safety practices utilized by the surveyed participants' maintenance facilities are effective, and there is no indication of the lack of effectiveness—based on the perception of surveyed AMTs. Based on these results, it is difficult to conclude that the implementation of more safety practices will yield a higher level of perceived effectiveness.

Research Question 2 Analysis

The second research question was designed to determine the general attitude of surveyed AMTs and maintenance facility personnel toward SMS. The general consensus among the entire surveyed population indicated a favorable attitude toward SMS. On average, surveyed participants agree that SMS would be beneficial to their respective organizations. It was also determined that the attitude of surveyed participants toward the cost of implementing SMS was favorable, and on average, surveyed participants agree that SMS is worth the cost. The analysis also suggested that participants who believe that SMS is beneficial to a company also believe that it is worth the cost. It is interesting to note that despite the fact that current safety practices are considered effective, surveyed participants, on average, indicated a need for “slightly more” safety policies.

The results from the population were also further analyzed using two grouping methods: organizational size and possession of pilot certificates. There were no statistically significant differences among the three groups, and the results for all three groups revealed that the current need for safety policies is between “sufficient” and “slightly more.” Since safety is highly emphasized during all phases of flight training, analysis was conducted to determine if there were differences between the attitudes of those with and without pilot certificates. The results revealed that a participant with a pilot certificate does not have a more favorable view of SMS than those who do not possess pilot certificates. It appears pilot training and mechanic training instilled an equal amount of safety awareness and knowledge in survey participants.

Taken together, the analyses revealed that participants have a favorable attitude toward SMS and welcome the implementation of additional safety policies. Surveyed

AMTs working in small maintenance facilities also favor the implementation of SMS and believed that it is worth the cost. Also, based on the results, it appears that pilot training did not instill a higher sense of safety for participants, meaning that mechanic training emphasizes a level of safety comparable to pilot training. In sum, organizational size and cost are not hindrances to the implementation of SMS.

Research Question 3 Analysis

The third research question was designed to determine the level of awareness among surveyed AMTs regarding safety reporting systems, which is a component of a successful SMS. There is an overwhelming majority (96 percent) of participants who were aware of a safety reporting system in their place of employment. Out of all the participants, 77 percent of surveyed AMTs indicated that they heard much or heard a lot about SMS, and 68 percent of surveyed AMTs indicated that they know quite a bit or know a great deal about SMS. There is also a strong relationship between how much one has heard and how much one knows about SMS. The awareness level of SMS among surveyed AMTs is more than sufficient—in terms of familiarity and knowledge of SMS. The results revealed that the more an employee hears about SMS the more SMS knowledge this employee possesses. The promotion of SMS is a significant factor. Providing employees with more exposure to safety-related items may increase overall safety awareness.

Research Question 4 Analysis

The fourth research question was designed to determine the level of immunity and protection offered to surveyed employees submitting safety reports. Safety reports are a critical component of SMS. Precursors to accidents can be identified by data collected from safety reports; however, the lack of anonymity, immunity, and protection may act as a deterrence. A majority of the participants indicated that reports were submitted anonymously (77 percent) and indicated that immunity and protection are offered for submitting safety reports (71 percent). There were no statistically significant differences of anonymity, immunity, and protection among maintenance facilities of various sizes. Larger maintenance facilities do not have more policies for anonymity, immunity, and protection. Another conclusion is maintenance facilities offering anonymity will also offer immunity and protection for the submission of safety reports.

Although the goal is to have policies of anonymity, immunity, and protection in every maintenance facility, results from this study reveal that there is no lack for policies of anonymity, immunity, and protection for submitting safety reports in the organizations of the survey participants. While organizations offering anonymity are also likely to offer immunity and protection, this is not always the case. On average, there is a lower percentage of participants indicating policies of immunity and protection for submitting safety reports. Surveyed AMTs may submit safety reports anonymously; however, those that submit reports anonymously may not be granted immunity and protection from the content of their reports. While the majority of participants did indicate anonymity, immunity, and protection, there is still clearly room for improvement in this area.

Research Question 5 Analysis

The fifth research question was designed to reveal the hindrances of SMS implementation. Several factors were considered as hindrances. Safety as an organizational priority is a sine qua non of a successful and mature SMS. The lack of anonymity, immunity, and protection are also potential hindrances. Further, the responses of the participants were tested against the frequency of safety-related issues that occur

Safety as an Organizational Priority

Safety as an organizational priority was tested several ways. Tests were conducted to determine if there was a correlation between safety as a core value of the company and the resultant managerial priority. While a strong majority (87%) of participants indicated that safety is a core value at their place of work, the results for safety as a managerial priority and the frequency of safety discussions differed. The results indicate that there is a disparity between the core value of a company and the actual practices of a company. When safety is a core value, it will be reflected in company policies and procedures. However, that is only one component. Policies and procedures may exist—on paper—but may not be practiced by managers. When this happens, a disparity exists between the core value and actual practice, and this disparity was evident based on the results of the research. This disparity between core value and actual practice appears to be an industry-wide problem, as this problem existed in facilities of various sizes—small, medium, and large.

This disparity was further proven with the introduction of one additional variable: the number of safety-related issues witnessed by surveyed AMTs. According to the results of this research, safety as a core value of the company did not correlate to a reduction in the number of safety-related issues in a maintenance facility. However, when it becomes a managerial priority, managers discuss safety more frequently, which results in a lower number of safety-related issues. Practically, when managers prioritize safety and discuss safety frequently, safety is improved. Further, incongruent with previous research, this research indicates that AMTs working for larger maintenance facilities witnessed more safety-related issues than AMTs working for the small and medium-sized maintenance facilities.

Lack of Anonymity, Protection, and Immunity as Hindrances

Anonymity, protection, and immunity are necessary components for the successful implementation of SMS. Thirty-five participants (77 percent) indicated that the policy of anonymity was offered in their workplace; however, only 60 percent of the 35 participants indicated that they were confident in its actual ability to protect. There is a gap between policy and actual practice. Thirty-two participants (71 percent) indicated that the policies of protection and immunity were offered in their workplace; however, 69 percent of the 32 participants were confident in its actual ability to protect. Clearly, in order to encourage safety reporting, the ideal number of workplaces offering anonymity, immunity, and protection is 100 percent, or close to it. The aforementioned disparity of core value and actual practice is seen again. The disparity between the policy of anonymity and the confidence level of employees is great: Just over half of the participants offered anonymity were confident in their actual ability to remain anonymous. This means that there is a lack of trust in the system. While the disparity between the policy of anonymity and confidence level is great, the disparity for protection and immunity is much smaller. These policies were also tested against the number of witnessed safety-related incidents. The results indicate that the lack of anonymity, immunity, and protection do not directly impact the number of safety-related issues. These policies have a statistically insignificant effect on overall safety.

Limitations of Research

The participants of this survey were subscribers to the Curt Lewis and Associates, LLC. safety newsletter. By default, people who choose to receive safety newsletters may be more inclined toward safety and have a heightened awareness of safety. Furthermore, these participants, many possessing pilot certifications, do not represent the entire aviation maintenance industry. The category of medium-sized maintenance facility was also disproportionally small, compared to the other categories. The responses of four participants in the medium-sized category were not enough to make generalizations of all medium-sized maintenance facilities. Several items in this research were also not clearly defined. For instance, the definitions of safety training and safety officers are ambiguous. While participants had the ability to skip questions—and four participants did—most questions were answered, and participants who skipped questions did not greatly affect the outcome of this research. Additionally, because of the small sample, it is not possible to make generalizations of the entire aviation maintenance industry based on this study.

Recommendations

This research found that there is no great lack of SMS in maintenance facilities. Surveyed AMTs also indicated little resistance to SMS implementation, and most AMTs welcomed the implementation of SMS. Current safety practices in surveyed participants' maintenance facilities were determined to be effective; however, the increase of safety practices correlates to higher perceived effectiveness. In addition to increasing the number of safety practices, maintenance facilities should also actively promote safety. The more employees hear about safety, the more they know about safety. Cultivating a healthy safety culture includes the active promotion of safety.

In some cases, there appears to be a disparity between the core value of the company and its actual practices. Managers should be aware of this disparity and bridge the gap between policies on paper and actual practices in the maintenance facility. However, managers who prioritize safety also discuss safety more frequently, and that results in a reduction of safety-related issues. Finally, policies of anonymity, protection, and immunity are present in roughly 70 to 80 percent of the surveyed facilities. This number should be increased. Managers in maintenance facilities should review these policies and make necessary changes to increase the confidence of their technicians in the system.

Recommendations for Future Research

While there is a correlation between the number of safety practices and the perceived effectiveness, studies should be conducted to determine if there is a threshold where perceived effectiveness begins to decrease with additional safety practices. There may be a point where safety becomes too tedious and becomes a risk. This survey indicated no resistance to SMS implementation, even for small maintenance facilities. Further study should be conducted to determine hindrances not addressed in this study. Participants of this research held a favorable view of SMS implementation and the cost associated; however, studies should be conducted to determine the attitude of managers and owners of maintenance facilities toward the cost of SMS.

Future studies utilizing a similar survey should reduce the ambiguity of several survey questions. The role of a safety officer and the meaning of safety training should be clearly defined. This will help researchers gauge more accurately the cost associated with these two safety practices. Safety-related issues witnessed by AMTs should also be clarified. Further, a scalable system should be developed to properly address the number of witnessed safety-related issues in maintenance facilities of various sizes. This research found that the overall number of safety-related issues is higher in larger maintenance facilities. This needs to be further researched with the aforementioned recommendations. Since there are more employees at a large maintenance facility, and the quantity of aircraft worked on is higher, there is the possibility that there are more safety-related issues to witness. Likewise, employees at a small maintenance facility may not be exposed to the same amount of incidents due to its size. For this study, it holds true that smaller facilities do not have a greater lack of SMS, and larger facilities have a greater number of incidents. According to the findings of this study, implementation of SMS did not contribute to a safer working environment; however, this study must be replicated in many more organizations across the aviation industry in order to collect and analyze data from a more representative population.

REFERENCES

AOPA, (2009). *Proposed safety management systems spark questions*. Retrieved from website: http://www.aopa.org/News-and-Video/All-News/2009/October/28/Proposed-safety-management-systems-spark-questions

CASA, (2001). *CASR Part 66*. Retrieved from website: http://www.casa.gov.au/wcmswr/_assets/main/lib100056/part66booklet.pdf

CASA, (2012). *SMS for aviation-a practical guide: Safety assurance.*

Connell, L. J. NASA, (2004). Cross-industry applications of a confidential reporting model (Pub. 62). Retrieved from website: http://asrs.arc.nasa.gov/docs/rs/62_Cross_Industry_Applications_of_Reporting_Model.pdf

Curt-Lewis: About us. (n.d.). Retrieved from http://www.curt-lewis.com/about.php

Curt-Lewis: Welcome to our website. (n.d.). Retrieved from http://www.curt-lewis.com/

Electronic report submission. (n.d.). Retrieved from

http://asrs.arc.nasa.gov/report/electronic.html

Federal Aviation Administration, (n.d.). *FAA flight plan*. Retrieved from website: http://www.faa.gov/about/plans_reports/media/flight_plan_2009-2013.pdf

Gay, L. R., Mills, G. E., & Airasian, P. (2012). *Educational research: Competencies for analysis and applications*. (10th ed.). Boston: Pearson.

George, K. W. (2013). Economic modeling to improve estimates of the benefits of safety management systems. *Collegiate Aviation Review*, *31*(1), 128-139. Retrieved from https://elearn.mtsu.edu/d2l/lms/content/viewer/main_frame.d2l?ou=4520532&tId=27813690

IATA, (2015). *IATA releases 2014 safety performance*. Retrieved from website: http://www.iata.org/pressroom/pr/Pages/2015-03-09-01.aspx

International Civil Aviation Organization, (2013). Safety management manual (Doc 9859). Retrieved from website: http://www.icao.int/safety/SafetyManagement/Documents/Doc.9859.3rd Edition.alltext.en.pdf

International Safety Advisory Group, (1992). *INSAG-7, The Chernobyl accident: Updating of INSAG-1*

Kelly, T., Lercel, D., & Patankar, M. (2011). Influence of trust and job satisfaction on safety climate among managers at large U.S. air carrier. Center for Aviation Safety Research, Saint Louis University: Parks College of Engineering, Aviation and Technology.

Kent, L. D. (1976). Aviation. *Lawyer of the Americas*, *8*(2), 552-568.

Key, L. (2014, July). Safety in the air begins with quality maintenance on the ground. *The Grapevine*, *1*, 1-3.

Lercel, D., & Patankar, M. (2011). Applicability-based model for SMS compliance by Part 145 repair stations. Center for Aviation Safety Research, Saint Louis University: Parks College of Engineering, Aviation and Technology.

Lercel, D., Steckel, R., Mondello, S., Carr, E., & Patankar, M. (2011). Aviation safety management systems return on investment study. Center for Aviation Safety

Research, Saint Louis University: Parks College of Engineering, Aviation and Technology.

Lu, C. T., Young, J., Schreckengast, S., & Chen, H. (2011). Safety culture: The perception of Taiwan's aviation leaders. *International Journal of Applied Aviation Studies*, *11*(1), 27-45. Retrieved from http://www.faa.gov/about/office_org/headquarters_offices/arc/programs/academy/journal/pdf/Summer_2011.pdf

McDonald, N., Corrigan, S., Daly, C., & Cromie, S. (2000). Safety management systems and safety culture in aircraft maintenance organisations. *Safety Science*, *34*, 151-176.

Nason, R. (2009). Is your risk system too good? *RMA Journal*, *92*(2), 12-15.

Safety: The foundation of everything we do. (2014, July 24). Retrieved from http://www.faa.gov/about/safety_efficiency/

Seham, L. (2014, July). Whistleblower protection for aviation industry employees. *The Grapevine*, *1*, 7.

Simon, S. I., & Cistaro, P. A. (2009). Transforming safety culture: Grassroots-led/management-supported change at a major utility. *Professional Safety*, *54*(4), 28-35.

Steckel, R., Lercel, D., Rieser, T., Kostal, E., & Patankar, M. (2013). Safety management systems for aviation service providers: a comparison with current federal regulations, industry standards, and programs. Center for Aviation Safety Research, Saint Louis University: Parks College of Engineering, Aviation and Technology.

Stolzer, A., Halford, C., & Goglia, J. (2008). *Safety management systems in aviation*. Farnham, Surrey, England: Ashgate Publishing Limited.

Stout, N. W. (2004). Privileges and immunities available for self-critical analysis and reporting: Legal, practical and ethical considerations. *Journal of Air Law & Commerce*, *69*(3), 561-601.

U.S. Department of Transportation, Federal Aviation Administration. (2009). *A practical guide to maintenance ASAP programs* (DOT/FAA/AR-09/28).

U.S. Department of Transportation, Federal Aviation Administration. (2009). *Safety management system.*

U.S. Department of Transportation, Federal Aviation Administration. (2010). *Safety management systems for aviation service providers* (AC 120-92A).

U.S. Government Printing Office, (2015). *Part 65 – Certification: Airmen other than flight crewmembers*. Retrieved from website: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title14/14cfr65_main_02.tpl

U.S. Government Printing Office, (2015). *Part 91 - general operating and flight rules*. Retrieved from website: http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&sid=3efaad1b0a259d4e48f1150a34d1aa77&rgn=div5&view=text&node=14:2.0.1.3.10&idno=14

U.S. Nuclear Regulatory Commission, (2013). *Backgrounder on Chernobyl nuclear power plant accident*. Retrieved from website: http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/chernobyl-bg.html

APPENDICES

APPENDIX A — IRB APPROVAL LETTER

MIDDLE TENNESSEE STATE UNIVERSITY

11/25/2014

Investigator(s): Daniel Heng Siao, Dr. Wendy Beckman
Department: Aerospace
Investigator(s) Email Address: dhs2j@mtmail.mtsu.edu; Wendy.Beckman@mtsu.edu

Protocol Title: The Implementation of Safety Management Systems in Maintenance Operations

Protocol Number: #15-134

Dear Investigator(s),

Your study has been designated to be exempt. The exemption is pursuant to 45 CFR 46.101(b)(2) Educational Tests, Surveys, Interviews, or Observations.

We will contact you annually on the status of your project. If it is completed, we will close it out of our system. You do not need to complete a progress report and you will not need to complete a final report. It is important to note that your study is approved for the life of the project and does not have an expiration date.

The following changes must be reported to the Office of Compliance before they are initiated:

- Adding new subject population
- Adding a new investigator
- Adding new procedures (e.g., new survey; new questions to your survey)
- A change in funding source
- Any change that makes the study no longer eligible for exemption.

The following changes do not need to be reported to the Office of Compliance:

- Editorial or administrative revisions to the consent or other study documents
- Increasing or decreasing the number of subjects from your proposed population

If you encounter any serious unanticipated problems to participants, or if you have any questions as you conduct your research, please do not hesitate to contact us.

Sincerely,

Lauren K. Qualls, Graduate Assistant
Office of Compliance
615-494-8918

APPENDIX B — LETTER TO REQUEST PARTICIPATION

Hi,

I am Daniel Siao, and I am a graduate student studying Aviation Safety and Security Management at Middle Tennessee State University (MTSU). I hold both A&P and pilot certificates. I am conducting this research to attempt to reveal the hindrances that prohibit the successful implementation of Safety Management Systems (SMS) in maintenance facilities. Your participation in this survey will be greatly appreciated if you work in any capacity as an aircraft mechanic (with or without an A&P certificate). This survey is completely anonymous and should take no more than 10 minutes to complete. Please contact me regarding any questions you may have.

The survey can be accessed with the following link:

https://www.surveymonkey.com/s/66PF7WG

Thank you in advance,

Daniel H. Siao
dhs2j@mtmail.mtsu.edu

APPENDIX C — SURVEY INSTRUMENT

Thank you for choosing to participate in this survey. You are being asked to participate in a research study regarding the implementation of Safety Management Systems (SMS) in maintenance operations. Your participation is completely voluntary and you may withdraw at any time. You are also participating anonymously, and there are no direct benefits or foreseeable risks.

This survey contains 16 questions, and this survey will take approximately 10 minutes to complete. Thank you again for participating. If you have any questions, please contact me, Daniel Siao, at dhs2j@mtmail.mtsu.edu or my Faculty Advisor, Dr. Wendy Beckman, at wendy.beckman@mtsu.edu. Additional information may be obtained by emailing the Middle Tennessee State University Institutional Review Board Compliance Officer at compliance@mtsu.edu.

You are expressing your consent to participate in this research by clicking the “NEXT” button.

APPENDIX C (CONT.)

1. How many Aviation Maintenance Technicians (AMTs) are currently employed at your repair station/maintenance facility?

- ◯ Under 30
- ◯ 30 to 50
- ◯ More than 50

2. What airman certificates/ratings do you hold? (Select all that apply)

- ☐ Mechanic-Airframe
- ☐ Mechanic-Powerplant
- ☐ Mechanic-Inspection Authorization
- ☐ Private Pilot
- ☐ Commercial Pilot (and above)
- ☐ None
- ☐ Other (please specify)

3. How is safety ensured and promoted in your workplace? (Select all that apply)

- ☐ Safety checklists
- ☐ Safety officers
- ☐ Safety binders
- ☐ Safety newsletters
- ☐ Safety training
- ☐ Safety meetings
- ☐ Safety posters
- ☐ Other (please specify)

4. Are you aware of a safety reporting system in your workplace?

◯ Yes ◯ No

APPENDIX C (CONT.)

5. Have you heard about Safety Management System (SMS)?

- ◯ I have never heard of SMS
- ◯ I have heard a little bit about SMS
- ◯ I have heard a sufficient amount about SMS
- ◯ I have heard much about SMS
- ◯ I have heard a lot about SMS

6. Do you know what a Safety Management System (SMS) consists of?

- ◯ I know nothing about SMS
- ◯ I know a little about SMS
- ◯ I know enough about SMS
- ◯ I know quite a bit about SMS
- ◯ I know a great deal about SMS

7. On average, how many safety-related issues do you typically see in a month?

- ◯ Less than 5
- ◯ 6-10
- ◯ 11-15
- ◯ 16-20
- ◯ 20 or more

8. How frequently do supervisors and managers discuss safety-related issues?

- ◯ Never
- ◯ Rarely
- ◯ Occasionally
- ◯ Frequently
- ◯ Very Frequently

APPENDIX C (CONT.)

9. Please select your level of agreement with the following statements.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I believe that current safety procedures and policies in my workplace are effective.	○	○	○	○	○
I believe that safety is a core value of the company.	○	○	○	○	○
I believe managers see safety as a priority.	○	○	○	○	○
I believe Safety Management System (SMS)/safety policies and procedures would be beneficial to my company.	○	○	○	○	○
I believe SMS/safety policies and procedures are worth the cost.	○	○	○	○	○

APPENDIX C (CONT.)

10. Are safety reports submitted anonymously at your company?

- ◯ Yes
- ◯ No

APPENDIX C (CONT.)

11. How confident are you in its actual ability to remain anonymous?

- ◯ Not confident at all
- ◯ Not very confident
- ◯ Neutral
- ◯ Confident
- ◯ Very confident

APPENDIX C (CONT.)

12. Do you think this deters people at your company (including you) from submitting safety reports?

- ◯ Not at all
- ◯ To little extent
- ◯ To some extent
- ◯ To a moderate extent
- ◯ To a great extent

APPENDIX C (CONT.)

13. Are you offered immunity and protection for submitting safety reports?

- ◯ Yes
- ◯ No

APPENDIX C (CONT.)

14. How confident are you in its actual ability to protect you?

- ◯ Not confident at all
- ◯ Not very confident
- ◯ Neutral
- ◯ Confident
- ◯ Very confident

APPENDIX C (CONT.)

15. Do you think this deters people (including you) from submitting reports?

- ◯ Not at all
- ◯ To little extent
- ◯ To some extent
- ◯ To a moderate extent
- ◯ To a great extent

APPENDIX C (CONT.)

16. What is the current need for safety policies at your place of employment?

- ◯ Needs much more
- ◯ Needs slightly more
- ◯ Sufficient
- ◯ Needs slightly less
- ◯ Needs much less