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An Evaluation Of The Relationships Between Safety Management Systems (SMS), Transformational Safety Leadership, Self-Efficacy, And Safety Performance Metrics In A 14 Code Of Federal Regulation (CFR) Part 121 Airline: A Mediation Analysis

Robert John Waltz

AN EVALUATION OF THE RELATIONSHIPS BETWEEN SAFETY MANAGEMENT SYSTEMS (SMS), TRANSFORMATIONAL SAFETY LEADERSHIP, SELF-EFFICACY, AND SAFETY PERFORMANCE METRICS IN A 14 CODE OF FEDERAL REGULATION (CFR) PART 121 AIRLINE: A MEDIATION ANALYSIS

by

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Title	An Evaluation of the Relationships between Safety Management Systems (SMS), Transformational Safety Leadership, Self-Efficacy, and Safety Performance Metrics in a 14 Code of Federal Regulation (CFR) Part 121 Airline: A Mediation Analysis
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LIST OF ACRONYMS

AMOS - IBM® SPSS® AMOS Version 27 SEM software package

ASAP – Aviation Safety Action Program

ATC – Air Traffic Control

CAPSCAS – Collegiate Aviation Program Safety Culture Assessment Survey

CFI – Comparative Fit Index

CFR – Code of Federal Regulations

CMIN – Minimum Discrepancy or Model Chi-Square

FAA – Federal Aviation Administration

FOQA – Flight Operations Quality Assurance data

GFI – Goodness of Fit Index

IFI – Incremental Fit Index

IRB – Institutional Review Board

LOSA – Line Oriented Safety Assessment

MI – Modification Indices

NFI – Normed Fit Index

PA – Path Analysis

RMSEA – Root Mean Square Error of Approximation

SA – Safety Assurance

SC – Safety Compliance scale items

SE – Self-Efficacy scale items

SM – Safety Motivation scale items

SMSPol – Safety Management Systems Policy Implementation scale items

SMSPro – Safety Management Systems Process Engagement scale items

SP – Safety Participation scale items

SRA – Safety Risk Assessment

SRE – Safety Related Events scale items

SRM – Safety Risk Management

TL – Transformational Leadership

TLI – Tucker Lewis Index

TSL – Transformational Safety Leadership scale items

ACKNOWLEDGEMENTS

In this moment of finishing, I want to start by thanking those people whose paths I have crossed, quietly toiling to understand our universe so we can forge a better way. For never saying, “you can’t,” and often saying, “you can!” This document proves it—YOU CAN! Never stop asking tough questions.

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To the participants in the study: I hope this work captures your thoughts and suggestions for even better SMS implementation and execution.

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woods with dad. Thank you for encouraging me to look up and see our world. There are miracles all around us.

To my daughters (Isabella and Elizabeth): You are more intelligent, talented, and well-equipped to be better world citizens than many before you. Your generation is the hope for ours, and I am excited to see where you take us.

And finally, to my bride, Teri Carter-Waltz: you have been there with me through it all, from my first jet flight to this latest endeavor. Though these words will one day fade, my love for you will not. Every time I look at the sky, I think of you.

ABSTRACT

A concurrent-embedded mixed-method triangulation design evaluated observed safety outcomes at a U.S. 14 Code of Federal Regulation (CFR) Part 121 air carrier. A previously validated model that measures Safety Management Systems (SMS process engagement and SMS policy implementation), transformational safety leadership, self-efficacy, safety motivation (mediator), and safety behaviors (safety compliance and safety participation) was assessed using structural equation modeling/path analysis. Semi-structured interviews of SMS subject-matter experts and safety leaders were used to explore the impact of SMS implementation. Factual data from the carrier was examined to provide convergent or divergent information regarding the other portions of the study. The results indicated SMS policy implementation had a significant effect on safety compliance (SC) and safety participation (SP), but SMS process engagement impacted only safety compliance (SC). A moderate relationship was found between safety motivation and both SC and SP. The results also indicated a significant effect of transformational safety leadership on safety motivation and SP. Self-efficacy and SC were weakly related. The results point to the importance of transformational leadership, clear safety policy, and motivation on safety outcomes. Gender differences were noted in SC and safety-related events, while years at the carrier were impactful on SC. Role at the company impacted safety-related event scores. Practitioners might consider tailored training due to the differences noted in this study. Future research is required to explore

the impact of experience, role, and gender on safety outcomes and safety-related events estimation.

CHAPTER I

INTRODUCTION

Continuous improvement of air safety is a critical undertaking for the airline industry. Passenger fatalities resulting from commercial aircraft accidents in the United States have remained at zero per 100,000 departures for the past decade (Bureau of Transportation Statistics, 2021). However, two separate accidents involving Boeing's 737 MAX aircraft have dramatically impacted the world's aviation community resulting in a call for a reassessment of the system safety approach used by regulatory agencies and commercial air carriers.

As a result of the system safety failures identified in the investigation of these two crashes, Safety Management System has been recommended not only for implementation at air carriers but original equipment manufacturers, as well (FAA, 2020). Data-driven assessment of the functioning of an organization's SMS is integral to maintaining the highest level of safety for the flying public and meeting 14 CFR Part 5 Safety Management Systems requirements (USGPO, 2016).

The FAA Safety Management System, FAA Order 8000.369, is the formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls. SMS has been implemented in the commercial aviation arena to integrate safety policies and augment safety performance at organizational and individual levels (Chen & Chen, 2014). SMS is widely recognized as providing a systematic approach to managing safety, including the necessary organizational structures,

accountabilities, policies, and procedures (ICAO, 2013). The study of the implementation of a framework like SMS presents opportunities for both company management and the FAA to gain new insights into the carrier (FAA, 2018; USGPO, 2016).

Figure 1

A proposed model of the integrated systems of the SMS (FAA, 2019).

Under an SMS, regulated entities identify undue risks in their operations and develop systematic procedures, practices, and policies to control such risks. The FAA requires that a carrier's SMS be appropriate to the size, scope, and complexity of the certificate holder's operation and include at least the following components: safety policy; safety risk management; safety assurance; and safety promotion (USGPO, 2016). Figure 1 outlines the key elements of an SMS and captures the extensive effort required of a company to implement and maintain the system. SMS represents a proactive means

to identify and control potential safety risks, rather than a reactive approach focusing on discovering and mitigating the cause of an accident or safety issue after its occurrence (FAA, 2015). A carrier must submit their SMS implementation plan to the State Safety Oversight entity (i.e., the FAA in the case of U.S. Part 121 certificated carriers).

Statement of the Problem

Research into the effectiveness of an SMS post-implementation at commercial carriers in the United States is limited. SMS has been mandated by most state aviation regulatory entities worldwide. SMS can be costly and time-intensive to implement (Adjekum, 2014b; Ulfvengren & Corrigan, 2015). The state of the safety program in an organization at the time of implementation can significantly impact the success of the adoption and execution of an SMS (Ioannou et al., 2017; Robertson, 2016).

Ironically, though not mandated by the FAA in the collegiate setting, a relatively comprehensive body of research addresses SMS implementation in university aviation programs (see Robertson, 2018; Gao & Rajendran, 2017; Adjekum, 2014a). Studies in China, Europe, and Canada have provided some insight into the introduction and maintenance of an SMS in the commercial arena (Insley & Turkoglu, 2020; McDonald et al., 2000; Gerede, 2015; David-Cooper, 2015).

The studies mentioned above focused on the broader aspect of SMS initiatives among the stated population without considering the somewhat nuanced relationships between SMS initiatives and variables such as transformational safety leadership, self-efficacy, and safety performance parameters, such as safety motivation and self-reported safety behaviors. Adjekum (2017) recommended a further inquiry into the relationships between safety management systems (SMS) initiatives, transformational safety

leadership, self-efficacy, and the safety performance parameters mentioned earlier at 14 CFR Part 121 carriers with an SMS. This examination of SMS at a Part 121 carrier aimed to fill a gap in research in the broader U.S aviation industry.

There are other gaps in the research, as well. Previous studies are generally deficient in analyzing the post-implementation efficacy of an organization's SMS. Additionally, most current studies do not occur at a North American commercial carrier, thus possibly limiting their applicability in the U.S. Finally, previous studies focused on the antecedents to an effective SMS by relating post-implementation data to existing safety culture or safety program data.

Though each study contributes to the body of literature and research, much of the work mentioned earlier does not address the issue of assessing the health of an SMS by concurrently gathering survey data, ethnographic interview data, and objective safety artifacts and measures. The lack of such a triangulation approach to determine if line employee attitudes and opinions, management attitudes and opinions, and actual safety data indicate convergence or divergence regarding SMS effectiveness at the carrier weakens the overall body of research.

SMS requires continuous improvement and is not a static process. Given the investment by the enterprise and the requirements of 14 CFR Part 5 to collect assurance data on the SMS performance of the company, a data-driven approach to evaluating the relationship between the study variables and safety outcomes can be a critical part of this understanding. This study can be of use to company leadership (including the Accountable Executive) to provide insight into areas of success and areas of opportunity within an SMS.

At all levels within the organization, this study can provide detailed information by demographic group where opportunities for SMS functional improvement might exist. Additionally, using similar measures like those studied by Adjekum & Tous (2020) and Schwarz et al. (2016), this work can help highlight where an SMS is working exceptionally well, promoting opportunities for incorporation across the broader enterprise in a Safety-II or resilience mindset. Finally, a reliable objective measure can serve as a tool for company management and the state regulatory agency to assess the health and efficacy of a carrier's SMS.

Purpose of the Study

This research uses a concurrent mixed methods data triangulation approach to evaluate the relationships between SMS initiative, transformational safety leadership, self-efficacy, and safety performance parameters such as safety motivation and self-reported safety behaviors in a U.S Part 121 carrier. Safety motivation was used in a mediation analysis, participant perceptions of study variables were examined, and statistically significant differences were reported.

This research was designed to provide a quantitative measurement model for an objective evaluation of SMS effectiveness and the inter-relationships with other study variables at a Part 121 carrier. Additionally, the qualitative portion of the research was designed to unearth themes to provide a contextual understanding of the data gathered using the quantitative models.

Concurrent Triangulation Mixed Method Approach

A concurrent triangulation mixed-method approach was utilized to gather quantitative and qualitative data using various techniques during a fixed time window.

The examination of the data, corporate artifacts, and objective safety outcomes allow the researcher to make holistic inferences regarding the efficacy of SMS implementation (Wahyuni, 2012).

Respondent data was examined for convergence or divergence regarding the study variables and the objective safety artifacts to provide a holistic view of the functioning of the carrier's SMS. Safety artifacts, including aggregate assurance data that objectively captures the airline's safety performance, were assessed. The same approach could be utilized at regular intervals to allow a longitudinal study.

The concurrent triangulation strategy has been effectively used before in the literature to holistically analyze similar variables in a collegiate environment (Adjekum & Jensen, 2016). Concurrent means the quantitative data, qualitative data, and evidence from company artifacts (documentary data) will be gathered over a fixed period in the organization's history, thus providing a single snapshot for analysis. The results from both research approaches are compared to determine if convergence, divergence, or some combinations exist regarding the survey data from line employees, interview data from management, and objective company safety data.

Where convergence exists, the company may infer some confidence in the effectiveness of their SMS program and possibly consider reinforcing these positive measures using a Safety-II mindset. Where divergence exists, potential gaps in a company's SMS may be indicated, highlighting focus areas for deeper analysis for the leadership and safety teams.

The concurrent triangulation mixed-method approach generally uses different quantitative and qualitative methods to offset the inherent weaknesses in one method with

the strength of the other (Creswell, 2009). Additionally, to derive the maximum effectiveness of the approach when gathering data concurrently, equal weight should be assigned across methods--even if skewness is detected in the data set (Plano, Clark & Creswell, 2008).

Figure 2 depicts the relationship between this study's qualitative and quantitative aspects. By utilizing both the qualitative and quantitative approaches in tandem, the researcher obtains a richer and more detailed view of the nuance of the construct being studied (Saldana & Omasta, 2018).

Figure 2

The relationship between the multiple modalities utilized in this mixed methods approach.

Potential Measures

Researchers such as Adjekum and Tous (2020), Adjekum (2017), Meng-Yuan Liao (2015), Chen and Chen (2014), von Thaden (2008), and Gill and Shergill (2004) have proposed a variety of measures that can be used to assess the relationship between

safety culture and SMS in aviation entities such as collegiate aviation and commercial airlines. The following variables were identified and re-validated for this work in line with Adjekum's 2017 work (with supporting documentation for each):

a) SMS - perceptions of the SMS initiative (SMS process engagement and SMS policy implementation) were measured by items developed by Adjekum (2017), with roots in previous research by Adjekum and Jensen (2016), Chen and Chen (2014), and relayed in the Transport Canada SMS assessment guide (2005). Adjekum (2017) reports two distinct alpha coefficients for his instrument (since the SMS construct was divided into separate items): SMS process engagement, .75 and SMS policy implementation, .93.

b) Safety motivation - safety motivation measured the degree to which respondents regard safety as an essential part of their professional development, developed from the work of Neal and Griffin (2006). The reported Cronbach's alpha for this scale is .90.

c) Self-efficacy – self-efficacy was measured by the Generalized Self-Efficacy Scale developed by Schwarzer and Jerusalem (1995) to assess pilot perception regarding their ability to deal with non-normal situations. Previous studies reported a Cronbach's alpha of .86 for this instrument.

d) Transformational safety leadership – adopted from the Survey of Transformational Leadership (STL) developed by Edwards, Knight, Broome, and Flynn (2010). Transformational Safety Leadership (TSL) at the group level of the carrier measured the quality of leadership provided by supervisory

flight managers such as Chief / Assistant Chief Pilots. Previous work by Adjekum (2017) indicates Cronbach alpha coefficients over .84.

e) Safety behavior (safety compliance and safety participation) - safety behavior consisting of two components, i.e., safety compliance and safety participation, is adopted from Neal, Griffin, and Hart (2000) and Neal and Griffin (2006). Safety compliance evaluates the core tasks that pilots must accomplish to maintain flight safety. Safety participation assesses how pilots help develop an environment that supports safety outcomes. The reported alpha coefficients for safety compliance and safety participation are .91 and .84, respectively.

f) Safety-related events – adopted from Adjekum's (2014a) Collegiate Aviation Perception of Safety Culture Assessment Scale or CAPSCAS instrument. These items evaluated the relationship between respondents' knowledge regarding company safety-related events and their safety behavior. The reported reliability of this instrument is .92.

Research Questions

This research utilizes an anonymous survey instrument administered to mid-level managers (base chief pilots and headquarters pilots) and front-line employees (line pilots) who work at the selected carrier. The survey was designed to answer the following questions:

1. What is the effectiveness of a final measurement model that assesses the relationships between SMS process engagement, SMS policy implementation, transformational safety leadership, self-efficacy, and the outcome variable

safety behavior measured by safety compliance and safety participation, when mediated by safety motivation at a commercial air carrier?

2. What are the strengths of the relationship between safety behavior (as measured by safety compliance and safety participation) and safety-related events?
3. What are the differences in perception among the demographic variables (years at the carrier, age group, SMS training status, and flight certification level (first officer, captain, check airman)) on safety behavior?

Semi-Structured Interview Questions

Additionally, the following questions were posed to selected senior management personnel using a semi-structured interview to explore the leadership perspective on the health of the carrier's SMS (Adjekum, 2017):

1. What role does leadership play in the safety policy implementation of the SMS program?
2. What are some of the benefits of SMS implementation at the carrier?
3. What are some of the challenges in executing SMS at the carrier?
4. What recommendations do you have for other carriers that are in the process of implementing SMS?
5. What are some of the measures used to determine how well your SMS is functioning?

Statement of Hypotheses

SMS Process Engagement, Safety Motivation, and Safety Behavior

A final measurement model on the relationship between SMS initiatives and other safety variables proposed and validated by Adjekum (2017) was envisaged to be the framework for this current study. Adjekum (2017) further suggests a strong relationship between a positive perception of an SMS initiative (process engagement and policy implementation) and proactive safety behaviors among aviation service providers.

Other researchers have corroborated similar findings, such as Neal, Griffin, and Hart (2000), Neal and Griffin (2006), and Freiwald (2013). Safety motivation as a mediator between concepts like policy implementation, process engagement, and safety behaviors has been validated in research by Vatankhah (2021), Xia et al. (2020), and Chen and Chen (2014).

Based on the previous findings from the Adjekum (2017) study, it was hypothesized that at U.S. carriers there exists a relationship between personnel perception of SMS initiatives (policy implementation and process engagement) and their motivation to act safely (safety compliance and safety behavior):

H_1: Respondents' perceptions of their carrier's SMS process engagement are related to their safety motivation.

H_2: Respondents' perceptions of their carrier's SMS process engagement are related to safety compliance.

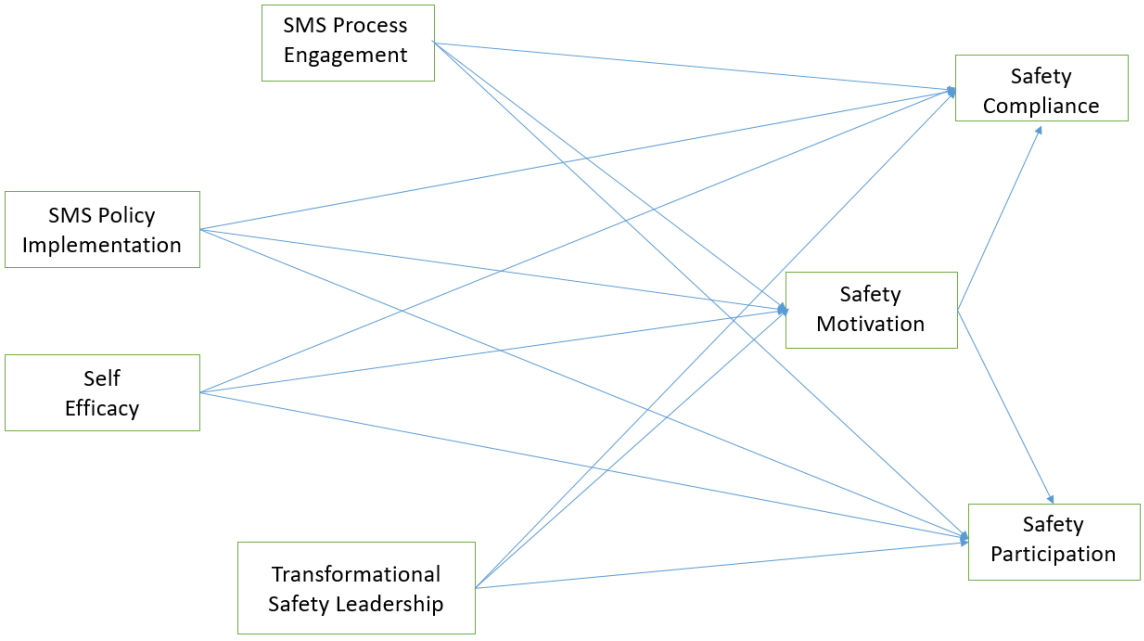
H_3: Respondents' perceptions of their carrier's SMS process engagement are related to safety participation.

H_4 Respondent motivation mediates the relationship between their perceptions of their carrier's SMS process engagement and safety compliance.

H_5: Respondent motivation mediates the relationship between their perceptions of their carrier's SMS process engagement and safety participation.

Figure 3

The fully mediated (baseline) Path Model shows the relationship between SMS process engagement, SMS policy implementation, self-efficacy, transformational safety leadership, safety motivation, and the outcome variable safety behavior, comprised of safety compliance and safety participation.



SMS Policy Implementation, Safety Motivation, and Safety Behavior

Adjekum's 2017 model states that SMS policy implementation quantifies the degree to which an organization has a concise and executable SMS policy with clear roles and responsibilities for all participants. Additionally, a clear chain of command, authority, and lines of communication are crucial (ICAO, 2009; Stolzer et al., 2016; Chen & Chen, 2014). Based on the body of work to date, the hypothesized direct and indirect

effects of perception of SMS policy implementation on the study variables were hypothesized as follows:

H_6: Respondents' perceptions of their carrier's SMS policy implementation are related to their safety motivation.

H_7: Respondents' perceptions of their carrier's SMS policy implementation are related to safety compliance.

H_8: Respondents' perceptions of their carrier's SMS policy implementation are related to safety participation.

H_9: Respondent motivation mediates the relationship between their perceptions of their carrier's SMS policy implementation and safety compliance.

H_{10}: Respondent motivation mediates the relationship between their perceptions of their carrier's SMS policy implementation and safety participation.

Transformational Safety Leadership, Safety Motivation, and Safety Behavior

Existing literature suggests that a higher level of transformational leadership should motivate subordinates to put more effort into their work and go above and beyond the call of duty for their leaders (Barling & Kelloway, 2002; Lowe, et al., 1996; Mirza & Isha, 2017; Inness et al., 2010; and Smith et al., 2016). It was hypothesized supervisory management's transformational safety leadership would motivate respondents to exhibit acceptable safety behaviors during operational tasks. The relationships between transformational safety leadership, safety motivation, and safety behaviors are outlined below:

H_{11}: The transformational safety leadership styles of top-level management are related to the safety motivation of respondents.

H_{12}: Top-level management's transformational safety leadership styles are related to respondent safety compliance.

H_{13}: Top-level management's transformational safety leadership styles are related to respondent safety participation.

H_{14}: Safety motivation of respondents mediates the relationship between their perceptions of transformational safety leadership and safety compliance.

H_{15}: Safety motivation of respondents mediates the relationship between their perceptions of transformational safety leadership and safety participation.

Self-Efficacy, Safety Motivation, Safety Behavior, and Safety-Related Events

Self-efficacy refers to pilot perception regarding their ability to complete assigned tasks and deal with non-normal situations (Schwarzer & Jerusalem, 1995). Existing literature suggests that pilot self-efficacy is a reliable predictor of pilot performance (Ji et al., 2017; Prinzel, 2002; Parasuraman, Molly & Singh, 1993). Additionally, current research suggests that high levels of self-efficacy are directly related to positive performance outcomes in various disciplines, such as academics (Kader, 2022), nursing (Cayir & Ulupinar, 2021), the maritime industry (Kim et al., 2021), and tourism and hospitality (Kautish, et al., 2021). Specifically, in aviation, Ji et al. (2017) found safety motivation and self-efficacy mediate the relationship between flight cadet perfectionism and situational judgment. Additionally, Schwarzer and Jerusalem (1995) found that self-efficacy is relevant to pilot perception regarding goal achievement and effort to improve work-related and management performance. Finally, researchers Schunk & Pajares (2001) and Graham and Weiner (1995) found that self-efficacy can be a reliable predictor

of behavior and behavioral change. The hypotheses outlined below explore the relationships and the mediating effect of safety motivation on the equation:

H_{16}: Respondent perceived self-efficacy is related to their safety motivation.

H_{17}: Respondent perceived self-efficacy is related to safety compliance.

H_{18}: Respondent perceived self-efficacy is related to safety participation.

H_{19}: Respondent motivation mediates the relationship between their self-efficacy and safety compliance perceptions.

H_{20}: Respondent motivation mediates the relationship between their perceptions of their self-efficacy and safety participation.

H_{21}: Respondent safety compliance is related to safety participation.

H_{22}: Respondent safety compliance is related to safety participation when mediated by an awareness of safety-related events.

H_{23}: Respondent safety compliance is related to their perception of safety-related events.

The Rationale for Proposed Methods

Historical Perspective on Proposed Research Methods

There is value to both quantitative and qualitative approaches when studying institutional behavior and group dynamics. Combining the data gathered in the quantitative phase of the effort, coupled with the greater depth and breadth of information captured in the qualitative phase, offers a more holistic analysis than either technique could provide. Thus, a mixed or multi-method design was deemed appropriate for developing a deep and rich understanding of the constructs under examination (Wahyuni, 2012). The mixed-method design allows a researcher to determine paradigmatic

corroboration or consensus between the numbers and the words (Saldana & Omasta, 2018). Additionally, notable studies on SMS effectiveness in aviation have utilized mixed-method designs previously (Adjekum, 2017; Adjekum & Jensen, 2016; Adjekum, 2014a; von Thaden et al., 2006).

Wahyuni (2012) recommends after identification of the central research question(s), the next step will be to determine the best fit of method and methodology to ensure an effective empirical inquiry. The choice of method for any research is driven by overarching considerations regarding the ontology and epistemology of the research paradigm.

In the case of researching the effectiveness of a performance-based, regulatory framework like SMS, it will be expedient to use both objective and subjective measures to conduct the inquiry (Rispler, 2021; Stolzer et al., 2018; Thaden & Gibbons, 2008). Additionally, a mix of conceptual research paradigms such as Positivism, Pragmatism, and Constructivism can be helpful when choosing the empirical approach in a research effort (Saldana & Omasta, 2017; Creswell, 2009).

Positivism can be characterized by external criteria independent of the actors. These criteria can be measured and developed into a comprehensive model of the behavior or phenomena--akin to what many laypeople think of as the "scientific method" (Wahyuni, 2012).

This research effort will be limited in scope if the nature of the social construct regarding the relationship between senior airline management, middle management, and line pilots vis-à-vis the implementation of SMS is not considered. Since there is an element of perception regarding the effectiveness of the carrier's SMS amongst multiple

groups, tools like the line employee survey and the management semi-structured interview are appropriate to capture the data.

Thus, *Pragmatism* is also a necessary framework to capture the variations in attitudes and perceptions that one can expect to uncover as part of this research effort. Pragmatism refers to a level of subjective analysis using sufficient knowledge to synthesize different perspectives to help interpret the data.

Additionally, the *constructivist* paradigm must also be utilized when considering the qualitative aspects of the study. Also known as social conservatism, constructivism generally refers to a scenario in which participants develop subjective meanings for their experience (Creswell, 2009).

When using such an immersive approach as the constructivist paradigm, one should use caution that a researcher's background can shape results, so consideration of bias is crucial. Typically, open-ended instruments are utilized, and it is generally worthy to look for response variability across factors such as gender, nationality, etc. When researching SMS, safety culture may be a constructivist paradigm worthy of consideration.

Review of Techniques

Structural Equation Modeling (SEM) was used to establish paths and determine the strength of relationships amongst the variables. Jausan, et al. (2017) employed structural equation modeling to obtain a holistic view of the cumulative effect of different barriers on safety reporting with an organization's SMS. Mokarami et al. (2019) utilized SEM to examine the relationships between accidents, safety culture, and unsafe behavior of bus drivers. Teske and Adjekum (2021, 2022) used SEM to explore the relationship

between components of SMS and various behaviors in the space operations field. Other researchers (Hair et al., 2021; Reinartz et al., 2009; and Henseler & Sarstedt, 2013) have also utilized SEM in organizational settings. The value of SEM was its applicability to both observed and latent variables.

SEM was warranted since an a priori set of relationships was available (based upon prior research). "The ability to analyze both observed and latent variables distinguishes SEM from more standard statistical techniques, such as the analysis of variance (ANOVA) and multiple regression, which analyze observed variables only" (Kline, 2016, p. 13). SEM can provide information on the magnitude of interactions of variables, and SEM has been used effectively in the analysis of mediating variables (Sardeshmukh & Vandenberg, 2017). The relationship between safety indicators and safety outcomes (safety behavior and self–reported safety events) was also examined.

Simultaneously, the perspectives of a selected group of senior management personnel (leaders at headquarters, leaders at the line pilot or base level, and line pilots) regarding the state of the SMS were assessed through a semi-structured interview. A final triangulation process was used to integrate the quantitative data, qualitative data, and document analysis, including a review of documented aggregate data of safety performance indicators derived from carrier safety assurance data.

The creation of a tool to evaluate the efficacy of a carrier's SMS through examining the study variables will allow both the aviation service regulator and the air carrier to have insight into the health of the carrier's program (in a single department or across multiple work units). The results can help pinpoint areas within the carrier's SMS that might require immediate attention. The tool will allow carriers to prioritize limited

resources based on needs within their SMS. Previous studies have examined the relationship between SMS implementation and employees' attitudes towards safety in airport operations (Remawi et al., 2011). It is essential to replicate and expand such studies at Part 121 carriers.

Research Assumptions & Limitations

Researchers have identified a potential pitfall when utilizing triangulation and a mixed-method approach (Creswell, 2009). The challenge of conducting an inquiry with different methods is the final integration of the data. Care must be taken to ensure statistical rigor throughout the analysis and data reduction. Resolving discrepancies that emerged during the comparative analysis of the findings can also be a challenge. A thorough review of both the qualitative and quantitative data is required to rectify any disparities in the data.

The concept of transformational safety leadership is highly subjective. Traditionally, it can be challenging to control for the contact between pilots and levels of management relative to the respondents, as pilots may encounter a wide variety of operational safety leadership in various settings. A study should consider controlling for potentially confounding influences such as prior flight experience, experience under an SMS, nationality, gender, or other variables that might impact a pilot’s perception of their carrier’s SMS (Adjekum, 2014a; Kearns & Aitken-Schermer, 2017).

Additionally, the literature indicates that cross-sectional studies may be constrained in determining cause and effect relationships (Creswell, 2009). The method is also limited to a snapshot of perceptions of SMS implementation within the study period and may not indicate the general trend over a long period. Consideration must be given to

the possibility that the dynamic nature of flight operations and the real-time occurrence of safety-related events during the study period may unfavorably skew respondents' perceptions.

Scope of Research and Exclusion Criteria

This research did not attempt to address all possible safety behaviors at a commercial air carrier. Although not every permutation of events could be examined, the conditions represented in this study were hypothesized to represent the environment at the airline at the time of study administration (six weeks in 2021).

The study did not include all workgroups at the airline (such a project would be well-suited for follow-on research). Additionally, this research is limited to line pilots, management pilots, and safety-related and SMS-related staff. Thus, the results should not be generalized across a wider population.

Finally, the use of factual safety data for comparison to respondent perception regarding reporting of safety-related events helps understand the efficacy of a carrier's SMS. However, there is also value in examining the relationship between the self-reporting of safety events and respondent perception of SMS, self-efficacy, transformational safety leadership, safety motivation, and safety behavior.

CHAPTER II

LITERATURE REVIEW

The following reviews the components of a Safety Management System (SMS), tools to measure the effectiveness of an SMS (as related generally to the antecedents of safety culture and the resultant safety outcomes), and the theoretical basis of the components of the SMS measurement model proposed in this work. The nominal application of the prescriptive nature of SMS in commercial aviation and the current shift to a performance-based approach in its application are also discussed.

Additionally, the theoretical underpinnings and the work to date regarding the relationship between transformational safety leadership on safety behavior, self-efficacy, safety motivation, safety compliance, and safety participation are addressed. Alternatives to theories and measures are also presented, along with research regarding SMS in other industries. The mediating role of safety motivation on safety behavior is of particular importance in utilizing a model for evaluating the effects of the perception of SMS constructs on safety behavior and events. The literature review also explores gaps in research on the relationships between the constructs mentioned above within the aviation industry and specifically in United States Part 121 (commercial) operations.

A central tenet regarding the efficacy of an SMS (and the quantitative instruments used to assess the effectiveness of its implementation) concerns person-based error management. Various theories are explored as they apply to the proposed model of this research.

Safety Management System Overview

The Federal Aviation Administration Air (FAA) Air Traffic Organization (the operational arm of the FAA) describes SMS as the "formalized and proactive approach to system safety which supports the mission of the FAA, which is 'to provide the safest, most efficient aerospace system in the world.'" (FAA, 2019). Continuous improvement in air safety has always been a critical undertaking for the airline industry. In recent years, regulators and airlines have relied on implementing a Safety Management System (SMS) to integrate safety policies and augment safety performance at both organizational and individual levels (Chen & Chen, 2014). SMS is widely recognized as providing a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures (ICAO, 2013).

Figure 4

SMS policy and requirements hierarchy (FAA, 2019).

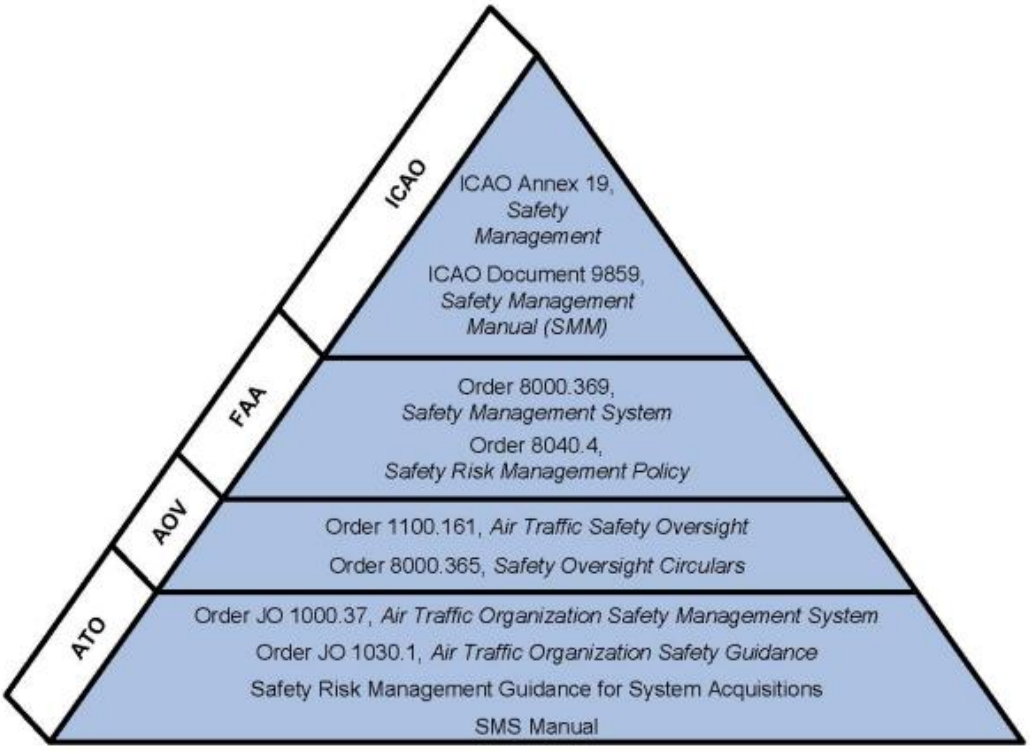


Figure 4 depicts the SMS policy and requirements hierarchy. SMS, as implemented in the United States, has its basis in governing principles based on guidance from several sources, including the International Civil Aviation Organization (ICAO), the FAA, the FAA Air Traffic Oversight Service (AOV), and the FAA Air Traffic Organization (ATO). Together, these multiple sources are integrated into FAA Order JO 1000.37 *Air Traffic Organization Safety Management System* serves as the integration of SMS at the ATO level.

An operator must invest both financial and human resources to ensure SMS implementation is effective. SMS can be costly and time-intensive to implement (Adjekum, 2014b; Ulfvengren & Corrigan, 2015). Additionally, SMS is an ongoing process that seeks continuous improvement. Most aviation companies implement a phased approach to be compliant with FAR and Advisory Circular guidelines, then begin a journey with their regulator to evaluate the performance of their SMS in a dynamic environment. A foundational question emerges: "What are the quantitative and qualitative measures a carrier can use to evaluate to indicate the health of their SMS?" The study of the implementation of a framework like SMS presents opportunities for both company management and the FAA to gain new insights into the safety culture of a carrier (FAA 2018 & 2019; USGPO 2016).

Safety Management System Initiatives, Implementation, and Practices

A Safety Management System can facilitate a productive relationship between the aviation service regulator and the carrier to ensure the highest level of safety for the flying public. By recognizing the organization's role in accident prevention, an SMS is

designed to provide the following to both certificate holders and the Certificate Management Office in the U.S. (FAA, 2019):

- A structured means of safety risk management decision making
- A means of demonstrating safety management capability before system failures occur
- Increased confidence in risk controls through structured safety assurance processes
- An effective interface for knowledge sharing between regulator and certificate holder
- A safety promotion framework to support a sound safety culture

The FAA Safety Management System directive (FAA Order 8000.369) defines SMS as the formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls. Under an SMS, regulated entities identify undue risks in their operations and develop systematic procedures, practices, and policies to control such risks (FAA, 2015).

SMS represents a proactive approach to identifying and controlling potential safety risks, rather than a reactive approach focusing on discovering and mitigating the cause of an accident or safety issue after its occurrence (FAA, 2015). A carrier must submit their Safety Management System to the Administrator for acceptance.

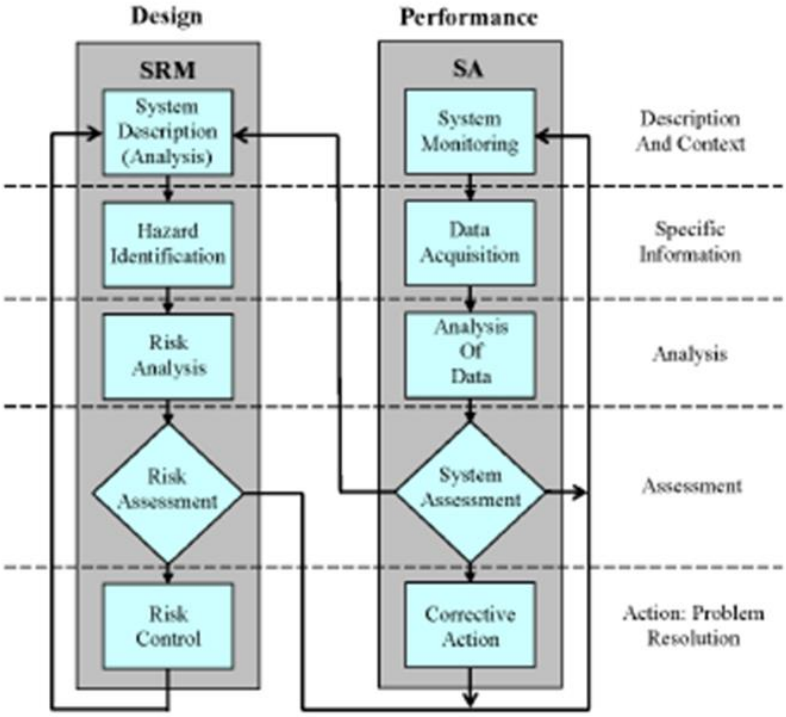
The SMS must be appropriate to the size, scope, and complexity of the certificate holder's operation and include at least the following components: (1) safety policy; (2) safety risk management; (3) safety assurance; and (4) safety promotion (FAA, 2019).

This work will focus on developing an objective measure for the effectiveness of a carrier's SMS to be used as an assurance method on SMS itself.

Figure 5 depicts the design and performance aspects of a Safety Management System. A carrier should plan to function at the lowest level of acceptable risk through the performance of safety risk management (on the design side) and safety assurance (on the performance side).

Figure 5

Integrated components of the SMS (FAA, 2015).



Safety Policy

One of the critical components of an organization's SMS is a *safety policy*. Safety policy contains those overarching precepts that connect leadership with line employees and serve as the basis for the system safety embedded in the organization (FAA, 2019). Safety policy might take the form of a Safety and Security Commitment, Safety

Objectives, designation of key-related personnel (up to and including the Accountable Executive), and other guidelines and principles available to all employees. Further details in an organization's safety policy might address the cadence and type of routine meetings and reporting and the highlights of the structure supporting the carrier's SMS. Organizational artifacts addressing safety policy can provide insights into the effectiveness of its SMS.

Safety Risk Management

Safety risk management (SRM) is designed to reduce organizational safety risk by improving strategic issues management and daily operational decision-making. The safety risk management process should address the following: system analysis, hazard identification, safety risk analysis, safety risk assessment, safety risk controls, and assurance plan implementation (FAA, 2019).

Safety risk management involves using trained subject matter experts to perform the following: describe the system state, produce a hazard statement (if warranted), address controls, identify any new hazards, and then develop an assurance plan. Residual risk must be considered, as well.

The output of SRM should flow to a systematic process to ensure risk is accepted by the appropriate company official at the requisite leadership level, up to and including the Accountable Executive (FAA, 2015, 2019; ICAO, 2013, 2016). This collaborative approach is crucial. SMS can be considered adequate when non-operational business leaders reflexively utilize a risk-based lens to consider organizational change with the same ease and familiarity as the lens of general accounting principles.

At the operator level, safety risk management might entail the development of an operational risk registry, a regular cadence of meetings between company teams, and sessions with the regulator (FAA, 2015, 2019).

Safety Assurance

A vital aspect of an effective SMS implementation is gathering data on the system's performance, known as *safety assurance*. In the realm of flight operations at a United States commercial (Part 121) Carrier, 14 CFR Part 5.71 *Safety Performance Monitoring and Measurement*, 14 CFR Part 5.73 *Safety Performance Assessment*, and 14 CFR Part 5.75 *Continuous Improvement* apply. Thus, operators must utilize data acquisition and analysis to provide feedback on the safety risk management framework.

Data acquisition can take many forms in the realm of commercial aviation: voluntary internal anonymous safety reports, voluntary external safety reports (Aviation Safety Reporting System (ASRS) and the Aviation Safety Awareness Program (ASAP)). Two critical programs at the carrier and workgroup level include de-identified data gathered directly from the aircraft (Flight Operations Quality Assurance data or FOQA) and observations by specially trained peers (Line Orientated Safety Observations or LOSA).

AC 120-82 *Flight Operational Quality Assurance* addresses the specifics of a FOQA program, and its importance in the data assurance realm by sharing de-identified carrier aircraft performance data with the Regulatory Authority (FAA, 2004). Researchers posit the quality and availability of this de-identified data is essential as part of an SMS assurance program that carriers ought to invest in relatively inexpensive

commercial off-the-shelf systems (COTS) that would allow large legacy aircraft to have the same quality of data as the most modern jets (Bromfeld et al., 2020).

LOSA is a program engaged between a carrier, the LOSA Collaborative, and the regulator designed (at its highest level) to provide near real-time observation from the flight deck on a nearly continuous basis (FAA, 2014). The latest version, "continuous LOSA," is considered the gold standard of the LOSA program. However, many carriers also participate in "traditional LOSA," a comprehensive effort every two to three years (LOSA, 2022). The airline in this study participated in continuous LOSA.

Both FOQA and LOSA existed before the implementation of SMS in the United States. Both serve as excellent examples of the use of existing structures/processes during the implementation of an SMS.

In commercial aviation, de-identified aircraft data can be compared to anonymous industry data like the FAA's Aviation Safety Information Analysis and Sharing (ASIAS) program. The exchange of information between departments and the concurrent analysis is crucial for an effective SMS (USGPO, 2016). In safety assurance, an operator must also audit their programs (including internal and external audits) and have specific procedures for investigating accidents and incidents. Safety continuous improvement is also a key result of safety assurance (FAA, 2019; ICAO, 2016; LOSA, 2022).

Safety Promotion

Safety promotion encompasses multiple aspects of an SMS: training for all employees on their role within the system, role-specific training for those responsible for the administration of the SMS, and broad-based communication within and across departments to ensure safety is top of mind for all employees (FAA, 2015, 2019; ICAO

2016). A carrier must be ready to adapt its safety promotion methods and modes to engage employees across the spectrum of communication channels they utilize.

Punitive versus Performance-Based Approach

Until recently, government agencies in the U.S. have pursued a relatively punitive approach with carriers regarding regulatory compliance. The regulator focuses on identifying non-compliance and pushing against the carrier to effect change. The punitive or compliance-based approach resulted in a very reactive structure that did little to promote proactive behavior by commercial airlines to prevent accidents or incidents. After decades of a punitive approach, a Compliance Philosophy approach was introduced along with Safety Management System implementation (FAA, 2021, 2018). In 2021, the FAA released FAA Order 8000.373B *FAA Compliance Program* which states:

> To promote the highest level of safety and compliance with regulatory standards, the FAA is implementing Safety Management System constructs based on comprehensive safety data sharing between the FAA and the aviation community. To foster this open and transparent exchange of data, the FAA believes that its Compliance Program, supported by an established safety culture, is instrumental in ensuring both compliance with regulations and the identification of hazards and management of risk (p. 1).

Compliance philosophy evolved within the last decade as a recognition that a purely "enforcement" based philosophy did little to facilitate collaboration between carriers and the regulator. At the heart of compliance philosophy is the tenet that deviations from compliance occur in highly dynamic operations. Thus, the regulator and carrier should work together to constantly correct back to compliance (FAA, 2021, 2019).

Tenets of "willing and able" to make corrections come into play (FAA, 2021). Though enforcement is no longer the sole emphasis, it has been a challenge for the FAA to accomplish the paradigm shift of perceived non-compliance as analogous to a deviation that must be pursued (rather than utilizing root cause analysis to build processes and procedures that would prevent an escape in the future, per FAA Order 8000.373B *FAA Compliance Program*). Compliance philosophy is necessary for successfully implementing and maintaining an SMS (FAA, 2015, 2019; ICAO, 2013, 2016). The paradigm shift with the FAA might be a challenge until SMS matures: "As the FAA adopts performance-based oversight and eschews prescriptive rule-based oversight, it should be able to achieve the increase in safety it seeks, as it assimilates more and more data and addresses current and future risks, not just past events. This will not occur, however, without a significant cultural change within the agency, without a transformation of its relationships with regulated entities, and without some shifting of liability from the agency to the regulated entities for claims that arise from alleged defects in the regulatory process or the implementation thereof" (Grizzle et al., 2016, Section 5).

SMS can be called a performance-based system since the regulator's role has changed to ensure that carriers have a functioning SMS (with all the components outlined earlier) and that carriers utilize their SMS to ensure compliance and proactive risk management (FAA, 2021, 2019). All Part 121 carriers are now obligated to have an FAA-approved SMS (FAA, 2021, 2015). Part 121 carriers continue to modify their SMS to meet the needs of their operations while comparing notes with each other and the FAA.

Commercial Air carriers also utilize industry groups (like Airlines for America) to advocate for consistency from the FAA regarding regulatory interpretations under SMS, and to manage expectations on what is covered (and not covered) under an SMS. The FAA and industry are maturing together in their knowledge and experience operating under an SMS. Organizations within the FAA (like AFS-900) are also very interested in promoting SMS in other high-reliability organizations.

Application in Other Industries

SMS lends itself to many high-reliability organizations (HROs) and other process-oriented endeavors. SMS has found application in a variety of settings, including construction (Yiu et al., 2018), petrochemical (Wold & Laumann, 2015), medical (Bevilacqua, 2009), nuclear (Bernard, 2021), mining (Thirumalai et al., 2021; Haas & Yorio, 2016), maritime (Nordmo et al., 2022; Akyuz & Celik, 2014; Valdez-Banda & Goerlandt, 2018), and emergency medical/fire services where safety outcomes are essential (Lefsrud, et al., 2020). Additionally, SMS has found application in industries where a reduction of injury, fatalities, and equipment damage is a priority (Nwankwo, et al., 2020).

Review of Other Measurements of SMS Related Studies

Before the advent of SMS, many researchers attempted to demonstrate proposed links between facets of safety culture, the components of SMS, and safety outcomes. Additionally, others have tried to develop objective measures for all three constructs in organizations--see Ahmad, T., Guilbaud, P., Louis, G., Anderson, K., Bouabid, A., & Siriwardana, M. (2003) and Mendonca & Carney (2017).

In 2008, Terry von Thaden and Alyssa Gibbons carried out a significant effort to develop a unified measure of safety culture, called the Safety Culture Indicator Scale Measurement System (SCISMS). With the sponsorship of the FAA, the researchers set out to provide a tool that would allow operators to derive actionable information to ensure regulatory compliance (von Thaden & Gibbons, 2008).

The work intended to integrate SCISMS as an additional tool in the framework of aviation safety management and reporting, which includes the Advanced Qualification Program (AQP), Aviation Safety Analysis Program (ASAP), Flight Operations Quality Assurance Program (FOQA), and Line Oriented Safety Audit (LOSA). The final SCISMS model measures organizational commitment, operations interaction, formal safety indicators, informal safety indicators, and safety behaviors/outcomes (von Thaden & Gibbons, 2008). Sub-factors for the primary constructs were developed for each employee group at an airline. The 2008 study was built upon measures included in previous work by von Thaden, Yongjuan, Jiang, and Dong (2006), which validated the Commercial Aviation Safety Survey (CASS) in the Chinese context.

In 2015, Ulfvengren & Corrigan took an innovative approach and applied Lean theories to the development and implementation of SMS at an airline. Specifically, the pair developed the System Change and Operations Evaluation (SCOPE) model. This model was developed using Structured Enquiry (SE), designed to assess the change required during the implementation of an SMS.

The authors proposed the SE would generate favorable recommendations for a proposed enhanced SMS (Ulfvengren & Corrigan, 2015). Their work pointed out that even if all of the necessary components for SMS implementation are in place, additional

cycles of communication and sufficient time to strengthen social relations (like trust and team-building) are required to ensure the change associated with the implementation of an SMS will be successful (Ulfvengren & Corrigan, 2015).

In their 2018 study, Stolzer, Friend, Truong, Tuccio, and Aguiar evaluated the potential use of Data Envelopment Analysis (DEA) as an assessment tool for the effectiveness of an SMS. DEA is a quantitative programming technique initially developed for analyzing the performance of Decision-Making Units (DMUs) by looking at the output efficiency scores of a system. The benefit of DEA is it requires very few assumptions, allowing it to be applied in a wide variety of scenarios in which other models cannot be used due to complexity or unknown factors (Stolzer et al., 2018).

The study combined a preliminary qualitative approach with a quantitative survey instrument that measured: safety policy and objectives, safety risk management, safety assurance, and safety promotion. Though there were some concerns with the discriminate validity of the final model (the square root of the average variance extracted (AVE) for the construct variables was not more significant than the correlations amongst the construct variables), the method proved helpful (Stolzer et al., 2018).

Robertson researched the relationship between elements of SMS and safety culture. In his 2016 research, Robertson found strong relationships between the four components of an SMS (safety policy, safety risk management, safety assurance, and safety promotion). In 2018, Robertson demonstrated strong relationships between safety culture and SMS implementation, safety promotion, and management commitment to SMS. Wang (2018, p. 104) posited that safety culture is one of the "deliverables of SMS," The elements of safety culture and SMS were examined. Finally, Velazquez and

Bier (2015) determined that the limited exposure to SMS in an undergraduate setting might hurt SMS implementation in other settings later in a pilot's career.

Transformational Safety Leadership

This research refreshes work done by Adjekum's 2017 study examining the relationship between Safety Management System initiatives, transformational safety leadership, self-efficacy, safety-related behavior, and safety-related events in a collegiate aviation setting. This study addresses many of the same factors in a Part 121 setting. A key aspect of his proposed model is the influence of transformational safety leadership on safety outcomes. Thus, a fundamental understanding of transformational leadership is required.

In their 2006 work, Bass & Riggio state leadership can occur at all levels and by any individual—a fundamental tenet of a Safety Management System. There are numerous examples within the safety and organizational realms where a disconnect between leadership's vision and line employees allows organizational drift (resulting in a negative safety outcome). A leader's vision is necessary (but not sufficient) to promote and sustain a healthy safety culture (and hence a successful SMS). Without support from line personnel, the central aspects of SMS (safety policy, promotion, safety risk management, and assurance) cannot be effective. Faranhak et al. (2020) found team member attitude toward change and transformational leadership are essential determinants of implementation success. Hussain et al. (2021) reported a high degree of transformational leadership could increase job satisfaction and organizational commitment. Their meta-analysis found that in 13 of 19 valid cases, transformational leadership and job satisfaction were positively related, and in 11 of 13 valid cases,

transformational leadership and organizational commitment were positively correlated. Thus, there is value in taking a closer look at transformational safety leadership and its impact on safety outcomes.

Other researchers, such as Nordmo et al. (2022), Cavazotte et al. (2021), Smith et al. (2020), and Jian and Probst (2016), all reported direct positive effects of transformational leadership on individual and organizational safety outcomes.

Historical Background

Transformational leadership is the culmination of two earlier schools of thought regarding leadership: charismatic leadership and transactional leadership. Weber (1947) examined charismatic leadership. This school of thought posits the traits and characteristics of the individual are the causal factors for leadership success. There are multiple examples of charismatic leaders (from Gandhi to Christ to Hitler). An essential distinction between charismatic leadership and transformational leadership regards the notion of *authentic* versus *inauthentic* (or *pseudo transformational*) leadership (Bass & Riggio, 2006).

Authentic transformational leadership is morally uplifting and can be further characterized as *socialized* leadership. Socialized leadership is based on egalitarian behavior, serves the collective interests, and develops and empowers others (Bass & Riggio, 2006). On the contrary, *personalized* leadership is based on personal dominance and authoritarian behavior and tends to be exploitive of others. Whereas charismatic leadership can be socialized or personalized, transformational leadership can only be socialized (Bass & Riggio, 2006).

Burns (1980) branched out from the charismatic leadership model and further characterized leadership as *transactional* or *transformational*. Transactional leadership captures the most fundamental relationship between politicians when jobs for votes or subsidies for campaign contributions are exchanged. Similarly, transactional leaders offer incentives for desired behaviors and deny rewards for undesired behaviors (Burns, 1980). Though there is some validity to aspects of the transactional model, more evidence has accumulated to demonstrate that transformational leadership can move followers to exceed expected levels of performance and lead to high levels of follower satisfaction and commitment to the group and the organization (Bass, 1998).

Transformational leaders seem to motivate others to do more than they initially thought they would do and even more than they thought was possible. While studying maritime cadets at sea, Normo et al. (2022) found significant positive main effects of transformational leadership and sleep quality on naval job performance. Thus, when tired, cadets working under a supervisor who exhibited transformational leadership demonstrated better job performance than those whose leader did not exhibit transformational leadership. Irshad et al. (2021) reported that transformational leadership in a healthcare setting enhanced caregiver psychological well-being by mediating the perceived impact of Covid-19 (thus providing better availability of caregivers for patients).

Transformational leaders have higher expectations and typically achieve higher performance (Hussain et al., 2021; Farahnak, 2020). Transformational leaders also tend to have followers who are more committed and satisfied than others. Moreover, transformational leaders empower followers to pay attention to their individual needs and

personal development, helping followers to develop their leadership potential. Transformational leadership involves inspiring others to commit to a shared vision, and the development of the followers is as important as the attainment of the goal (Joubert & Feldman, 2017; Bass & Riggio, 2006).

Components of Transformational Leadership

There are four core components of transformational leadership. Bass and Riggio (2006) posit transformational leaders employ one or more of these core tenets to achieve superior results.

Idealized influence. Transformational leaders serve as role models for their followers. The leaders are admired, respected, and trusted. Followers identify with the leaders and want to emulate them; leaders are endowed by their followers as having extraordinary capabilities, persistence, and determination (Bass & Riggio, 2006). There are two unique aspects of idealized influence: the leader's behavior and the elements attributed to the leader by followers and other associates (both attributes can purportedly be independently measured using the Multifactor Leadership Questionnaire (MLQ).

Inspirational motivation. Transformational leaders motivate and inspire others by providing meaning and challenge to their work. Enthusiasm and optimism are displayed, and leaders communicate and garner buy-in for a shared vision of the future state. Idealized influence leadership and inspirational motivation form a combined single factor of charismatic-inspirational leadership (Bass & Avolio, 1993).

Intellectual stimulation. Transformational leaders stimulate their follower's desire to be innovative and creative by questioning assumptions, reframing problems, and using novel approaches to old problems (Bass & Riggio, 2006). There is no public

criticism, every member must be heard, and followers are encouraged to try new approaches. The MLQ can help quantify this aspect of transformational leadership.

Individualized consideration. Transformational leaders play the role of coach or mentor appropriate to each follower (i.e., leaders use the Platinum Rule--do unto others as they would be done unto) versus the Golden Rule. Followers and colleagues are developed to achieve the highest levels of their potential. Individual differences in terms of needs and desires are recognized. A two-way exchange in communication is utilized, and "management by walking around" is practiced (Bass and Riggio, 2006). The MLQ is designed to capture this aspect of transformational leadership.

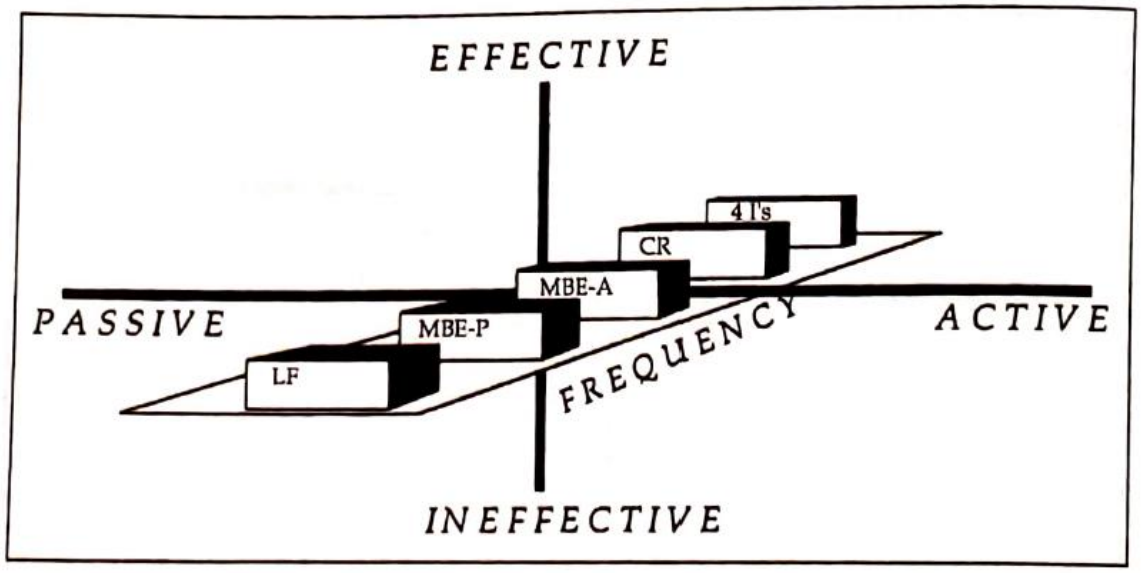
The Full Range Leadership Model

The Full Range Leadership Model encapsulates the various aspects of transformational leadership and some aspects of transactional leadership and laissez-faire (or non-leadership) behavior. Figure 6 below depicts the relationship between the different leadership approaches (the *frequency* axis denotes the least effective approach toward the reader and the most effective approach away from the reader).

4 I's. The 4 I's refer to the core components of transformational leadership (idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration) discussed earlier. Remember, a transformational leader uses one or more of the 4 I's to theoretically ensure the highest level of success (Bass & Riggio, 2006).

Figure 6

The full range leadership model (Bass & Riggio, 2006).



Contingent reward (CR). *Contingent Reward* is a form of transactional leadership that has limited efficacy in motivating others to achieve higher levels of performance and development. The contingent reward is transactional (i.e., I will give you *X* if you reach *Y*). Robinson and Boies (2016) found team members under a contingent reward scheme generated more creative ideas on a project than those under an *intellectual stimulation* condition. Additionally, if a leader exhibited contingent reward or intellectual stimulation in their leadership style, the team member would work harder and longer than those in a control group (Robinson & Boies, 2016). Buengeler et al. (2016) found contingent reward behaviors might facilitate both leaders claiming and follower giving regarding the leadership role. With age as a moderator, younger leaders who utilized contingent reward effectively reduced voluntary turnover. In other research, if the contingent reward was psychological (such as praise), the contingent reward can be considered transformational (Antonakis et al., 2003).

Management by exception (MBE). *Management by Exception* is considered a corrective transaction, and Bass & Riggio posit that it is less effective than contingent reward or the components of transformational leadership (2006). The corrective action may be active (MBE-A) or passive (MBE-P). Though the MBE approach has only limited uses, one case where it might be required and effective is in safety-sensitive situations when errors need immediate correction (Bass & Riggio, 2006). Even in the safety-sensitive situation, a mix of the 4 I's of transformational leadership theory will lead to more permanent results. Leaders sometimes might be forced to practice MBE-P when monitoring many subordinates or a large operation.

Laissez-Faire leadership (LF). *Lassiez-faire Leadership* is avoidance or absence of leadership and is the most passive approach (and it also tends to be the least effective). Lassiez-faire (LF) represents a non-transaction (or inaction), authority unused, and actions delayed. In this mode, the leader avoids getting involved.

Breevaart and Zacher (2019) evaluated the impact on perceived leadership effectiveness after using a transformational leadership or laissez-faire leadership style. In this study, perceived leadership effectiveness decreased when leaders exhibited less transformational leadership (TL) and more LF. However, if leaders utilized greater than one standard deviation beyond the mean amount of TL, followers gave higher ratings on leadership effectiveness regardless of LF level (Breevart & Zacher, 2019).

The interaction between bullying, work pressure, and day-to-day leadership of supervisors was studied by Agotnes et al. (2021). The researchers found that laissez-faire leadership behavior (but not transformational leadership) moderated work pressure. and bullying-related negative acts relationship. The findings support the assumption that

laissez-faire leadership facilitates the development of conflict escalation and workplace bullying, while transformational leadership does not (Agotnes et al., 2021).

Connecting Transformational Leadership and Objective Measures

There are some strong indicators that transformational safety leadership is a valuable metric when considering the connection between the implementation of a Safety Management System and objective safety measures. A few other studies expound upon the work of Bass and Riggio and others who are proponents of the positive impact of transformational leadership on safety climate and safety outcomes. Meta-analysis was used to collapse multiple studies regarding the primary instrument used to assess the Full Range Leadership Model (known as the Multifactor Leadership Questionnaire or MLQ) and subjective leadership style measures and objective measures of leadership performance (Bass, 2006).

Lowe, Kroeck, & Sivasubramaniam (1996) found the average correlation coefficients between characteristics like *charisma* (r = .71 from 32 studies), *intellectual stimulation* (r = .58 from 31 studies), and *individualized consideration* (r = .59 from 29 studies) and subjective measures of leader performance are generally higher than the correlations between the same characteristics and objective measures of performance (*charisma*, r = .30 from 15 studies; *intellectual stimulation*, r = .22 from 14 studies; and *individualized consideration*, r = .24 from 12 studies). The meta-analysis indicates that the foundational assumptions in Adjekum's model have widespread application and appear to be valid.

Mullen and Kelloway (2009) indicate that further evidence is needed to better comprehend the relationship and mechanism of transformational leadership over time. A

longitudinal study by Franke and Felfe (2011) reported that transformational leadership had positive effects on followers' health in the short run but opposite effects in the long run. The results are not surprising as exhaustion may set in due to over-commitment and continuous effort required by the transformational leaders, resulting in adverse safety outcomes.

Mirza & Isha (2017) added a twist to a systems-based approach to safety: supervisory leadership style impacts safety outcomes, but a savvy safety leader should also adapt their style to different circumstances. The researchers posit that both safety and leadership research give too little attention to context. They state that three different leadership styles are prevalent in high-reliability organizations: transformational leadership, leader-member exchange (LMX), and transactional leadership.

Leader-member exchange (LMX) involves a dyadic relationship between a leader and a follower. Pairs of folks build solid bonds and information flows freely between them. High-quality LMX leads to better safety outcomes than low-quality LMX (Mirza & Isha, 2017). In many ways, low-quality LMX resembles a more transactional approach to leadership, so this initial view holds to the earlier discussion of the effectiveness of transformational leadership. High-quality LMX is exhibited in a flying organization when leadership listens to their crews, develops policy, process, and procedure that is executable and reliable, and employees feel empowered to make a change. One interesting study might involve parsing out the variance accounted for in the various models between transformational leadership and LMX.

Taken by themselves, measures of transformational leadership, transactional leadership, and LMX do not tell the whole story. Additionally, one should consider the

organizational context when evaluating the effectiveness of a particular leadership style. Mirza & Isha (2017) recommend a supervisor tailor their approach to safety leadership based upon the organizational context of culture, structure, processes, and/or people. Mirza and Isha's research is not surprising, as much of what is known about organizational behavior is strongly related to context. The researchers are very clear when they point out that their model (as proposed above) is by no means exhaustive and there is still room for substantial study.

Transformational Leadership Measures and Safety Outcomes

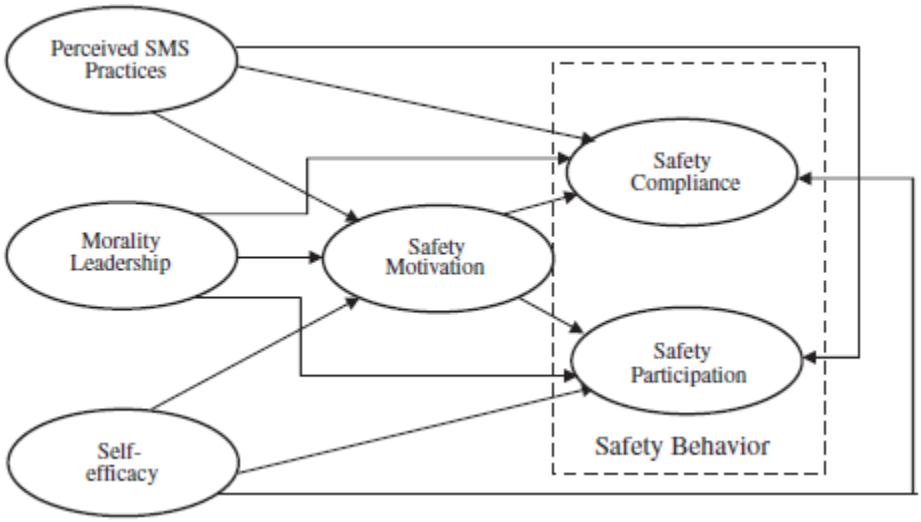
Chen and Chen (2014) carried out an integrated study that considers three antecedents of pilot safety-related behavior, including organizational, group, and individual factors (Figure 7). Specifically, their research examines the impact of pilots' perceptions of Safety Management System (SMS) practices, fleet managers' morality leadership, and pilots' self-efficacy on flight crews' safety behaviors through the mediation of safety motivation. Using a sample of 239 commercial pilot participants, and the Structural Equation Modeling (SEM) technique, the results indicate that both perceptions of SMS practices and self-efficacy have direct, positive effects on pilots' safety behaviors, while the effect of fleet managers' morality leadership on such behavior is fully mediated by pilots' safety motivation.

Chen & Chen's (2014) research served as part of the foundation of Adjekum's (2017) model regarding the relationship between SMS perception, safety motivation, and safety participation. Note the further similarity in this model of the concept of safety behavior as quantified by safety participation and safety compliance. Chen & Chen also pointed out the issue of the cultural setting in their study, as the power-distance

relationship in a Taiwanese carrier may not be representative of the flight deck culture at all carriers (2014).

Figure 7

Chen & Chen's conceptual model (2014).



Chen & Chen's (2014) study predicted a positive correlation between pilot perceptions of the SMS practices within their airlines and motivation to perform related safety behaviors. Since the researchers assume that safety motivation mediates the relationship between the selected antecedents and pilots' safety behaviors, the direct and indirect effects of SMS practices on safety outcomes are hypothesized as follows: pilot perceptions of their airline SMS practices are positively associated with their safety motivation; pilots' perceptions of their airline SMS practices are positively associated with their safety compliance and safety participation; and pilots' safety motivation mediates the relationship between their perceptions of their airlines' SMS practices and safety behaviors--both compliance and participation (Chen & Chen, 2014)). Adjekum carries the same view forward into his research, and like Chen & Chen, his study produces similar results.

Shen, Ju, Koh, Rowlinson, & Bridge (2017) examine the relationship between transformational leadership and safety outcomes in a construction environment. Shen et al. (2017) posited safety behavior was an interaction between proximal individual differences (safety knowledge and safety motivation) and distal contextual factors (leadership and safety climate). In line with other studies examined thus far, the researchers took social context into effect, as well.

Given the cultural background of the sample, their study makes a slight modification to the conceptualization and view of transformational leadership as an antecedent of safety climate. Shen et. al. (2017) established multiple mediator models showing the mechanisms through which transformational leadership translates into safety behavior. The multiple mediator models were assessed using the structural equation modeling (SEM) technique and individual questionnaire responses from a random sample of construction personnel based in Hong Kong.

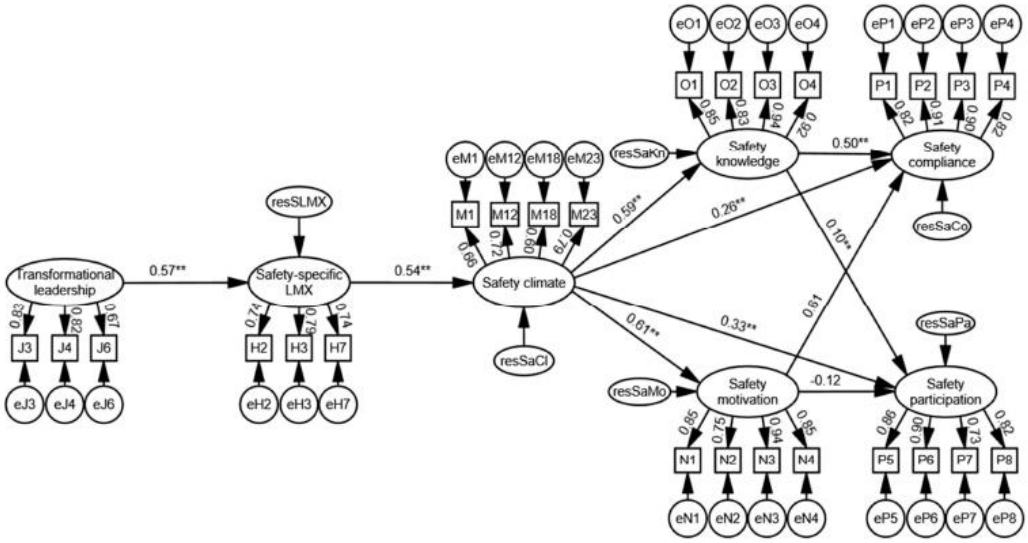
The results of the study indicate transformational leadership has a significant impact on safety climate, which is mediated by safety-specific leader-member exchange (LMX). Shen et al. (2017) state safety climate in turn impacts safety behavior through safety knowledge. The results suggest that future safety climate interventions should be more effective if supervisors exhibit transformational leadership, encourage construction personnel to voice safety concerns without fear of retaliation, and repeatedly remind them about safety on the job (Shen et al., 2017).

Shen et al. (2017) backed the general premises of Adjekum's (2017) work regarding a relationship between transformational safety leadership (TSL) and safety outcomes (safety participation and safety compliance). However, rather than the safety

motivation moderator variable discussed by Adjekum, Shen et al. (2017) proposed TSL is moderated by leader-member exchange (LMX) to produce a safety climate which then impacts safety outcomes (either via safety knowledge which impacts safety compliance or safety motivation which impacts safety participation--see Figure 8 below).

Figure 8

Final structural model (Shen et al., 2017).



There are many similarities between Adjekum and Shen et al.'s (2017) models--namely the foundational basis for variables like safety compliance, safety participation, and safety motivation. Yet there are key differences, as well. Shen et al. (2017) posited safety culture is a moderator variable in their model connecting TSL to safety participation and safety compliance. Adjekum (2014a) does not call out safety culture per se as a variable in his model. However, when discussing the Safety Management System construct Adjekum's (2014a) work points to the theoretical positive impact of SMS on safety culture.

Both models posit a mediating effect for safety motivation. It is interesting to note that Chen & Chen (2014) demonstrated a weak, directionally appropriate relationship between safety motivation and safety participation ($r = 0.28$, $p < .01$) and a strong, directionally appropriate relationship between safety motivation and safety compliance ($r = 0.70$, $p < .01$). Adjekum (2014a) found a weak, directionally expected relationship between safety motivation and safety participation ($r = 0.29$, $p < .001$) and a weak, directionally appropriate relationship between safety motivation and safety compliance ($r = 0.23$, $p < .001$). Shen et al. (2017) did not find a significant relationship between safety motivation, safety participation, and/or safety compliance.

Also of interest is the relationship between safety leadership and safety motivation. Chen & Chen (2014) found a weak, directionally appropriate relationship between morality leadership and safety motivation ($r = 0.25$, $p < .05$). Adjekum's research found a weak, directionally unexpected relationship between transformational safety leadership and safety motivation ($r = - 0.13$, $p < .05$). Shen et al. (2017) found a moderate, directionally appropriate relationship between transformational safety leadership (via safety specific LMX and safety climate) and safety motivation ($r = 0.61$, $p < .01$). Thus, there is still room for further research regarding the relationship between transformational safety leadership and safety outcomes moderated by safety motivation.

Other researchers have continued to explore the connection between transformational leadership and positive safety outcomes. Jiang and Probst (2016) examined the relationship between leadership style and safety knowledge and safety participation. They confirmed safety knowledge and safety motivation were positively related to safety participation. Additionally, though passive leadership and safety

participation is not related, transformational leadership (TL) and safety participation (SP) are positively related. And finally, TSL moderated the relationship between SM and SP (Jiang and Probst, 2016). Thus, in high TSL settings, folks with high SM demonstrated high SP. Additionally, when TSL was low, there was no relationship between SM and SP (Jiang and Probst, 2016).

Cavazotte et al. (2021) researched authentic leadership. The researchers found leader selflessness and morality can influence safety outcomes, by improving employee psychological capital (PsyCap) and organizational citizenship (exhibited by organization citizenship behaviors or OCB). Both PsyCap and OCB influence safety performance. However, PsyCap influences safety compliance (but OCB does not). Figure 9 depicts the model examined by Cavazotte et al. (2021).

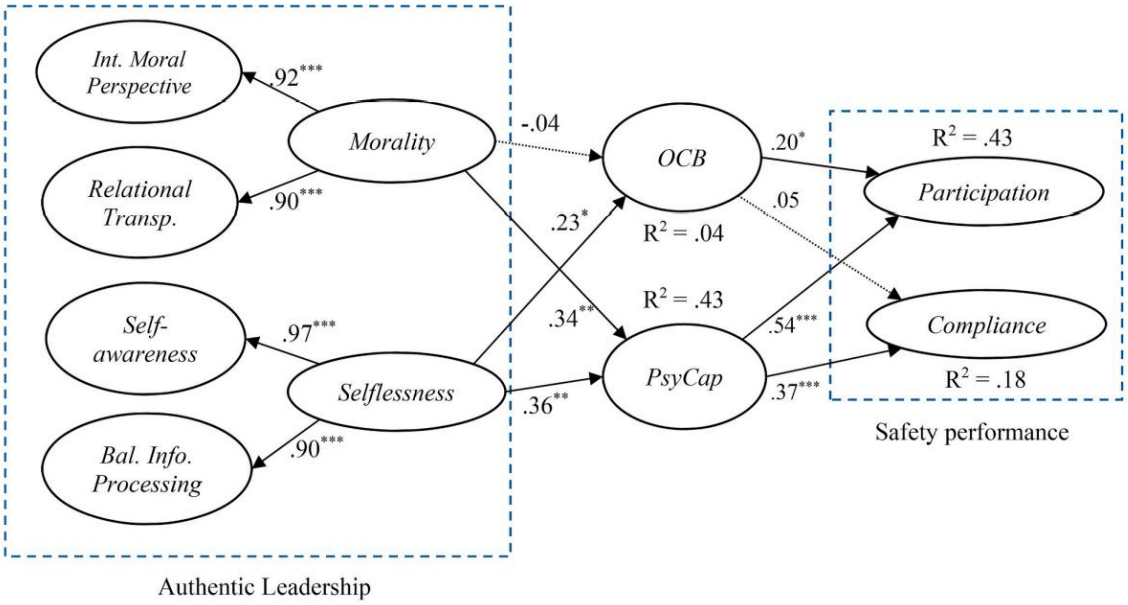
Recent Challenges to Transformational Safety Leadership

There is by no means unanimity on the effectiveness of the measures of transformational leadership and/or its efficacy.

Cho et al. (2018) examined the unique effects of ethical leadership while controlling for various aspects of the Full Range Leadership Model (FRLM). The researchers found that both affective commitment and normative commitment were influenced by ethical leadership, controlling for the components of the FRLM. Thus, other external factors to the FRLM might have a significant impact on team members.

Figure 9

Model depicting the relationship between authentic leadership and safety outcomes (Cavazotte et al., 2021).



Authentic leadership also impacts safety climate and outcomes. Borgersen et al. (2019) found authentic leadership made a significant contribution to explaining variance in safety culture in a maritime setting. Leaders who demonstrated authentic leadership through balanced processing internalized moral perspective, relational transparency, and self-awareness were given higher total safety climate scores from their team than those who did not (Borgersen et al., 2019).

Cavazotte et al. (2021) researched authentic leadership (as discussed earlier). In their study, psychological capital and organizational citizenship behaviors impacted safety participation and safety compliance. Thus, there might be other relevant factors that must be considered when examining safety outcomes. Figure 9 depicts the relationship between authentic leadership and safety compliance and safety participation.

Not all research is completed from the leader's point of view. Joubert and Feldman (2017) conducted a study in an air traffic services environment. Their

ethnographic study gathered leadership experiences and expectations from team members, to determine their effect (if any) on leadership effectiveness and development. Their results reflected personnel preferred the positive support aspects of transformational leadership as followers (Joubert & Feldman, 2017). The researchers posit the organization should focus on ensuring the employee support and growth aspects of transformational leadership are incorporated into leadership training (Joubert & Feldman, 2017).

Opera et al. (2020) researched team member job crafting outcomes (specifically job demands, and job resources made by employees) while working for a transformational leader, a transactional leader, or a laissez-faire leader. Results confirm one should consider the leadership style of a supervisor as it can directly impact the job shaping behaviors of teams (Opera et al., 2020).

Collegiate Aviation Program Safety Culture Assessment Survey (CAPSCAS)

The Collegiate Aviation Program Safety Culture Assessment Survey (CAPSCAS) was developed by Adjekum (2014) and used to examine the relationship between safety culture and various aspects of the implementation of a Safety Management System in a collegiate environment (Adjekum et al., 2016, Adjekum, 2017; Robertson, 2016). Robertson (2018) also examined the relationship between an organization's safety culture and SMS implementation in a collegiate setting.

Measuring safety culture is a key aspect component of continuous improvement within an SMS. Many studies have assessed safety culture in a variety of organizations, but few studies exist which examined the relationship between SMS implementation and its impact on developing a strong safety culture (McNeely, 2012).

According to AC 120-92B (FAA, 2015): “Cultures are the product of the values and actions of the organization’s leadership as well as the results of organizational learning. Cultures are not really ‘created’ or ‘implemented’, they emerge over time and as a result of experience. Organizations cannot simply purchase a software program, produce a set of posters filled with buzzwords, require their people to attend an hour of slide presentations, and instantly install an effective SMS. As with the development of any skill, it takes time, practice and repetition, the appropriate attitude, a cohesive approach, and constant coaching from involved mentors.’’ (p. 3). Robertson stated: “SMS was not designed to create a ‘culture of safety,’ an SMS was designed to build upon and improve an existing ‘culture of safety’’’ (2018).

Adjekum and Tous (2020a) examined four key management factors they posited to have a significant predictive relationship regarding resilient safety culture: principles, policy, procedure, and practice. Using SEM-PA, the researchers found that policy had the highest predictive power, and practices was the weakest. Thus, resilient safety culture is influenced by policies, procedures, and principles (Adjekum & Tous, 2020a).

Adjekum and Tous (2020b) researched the role of cultural drivers in organizational resilience in a collegiate setting. Three cultural drivers (commitment, cognizance, and competence) were found to have a strong significant relationship between the three aforementioned factors and safety resilience. Additionally, using SEM-PA, commitment was found to significantly mediate the path between cognizance and competence (Adjekum & Tous, 2020b). Finally, the perception of organization resilience by flight operations and ground operations personnel was significantly higher than that of senior leaders (Adjekum & Tous, 2020). Both studies provided valuable

insights into the relationship between factors that influence SMS and those that influence safety culture.

Transformational Safety Leadership and Safety Performance

Transformational Safety Leadership is a variable that potentially influences safety behavior and safety-related outcomes like violations, incidents, and accidents (i.e., outcomes impacted by the health of a carrier's SMS). In studies by Zohar (2002, 2010) for example, the role of leadership is emphasized as a factor in improving safety. Additionally, studies by Barling, Loughlin and Kelloway (2002) indicate a positive influence on the effect of transformational leadership on safety promotion. Kelloway, Mullen, and Francis (2006) posit safety specific transformational leadership has a positive effect on organizational safety--to include perceived safety climate, safety events, and safety consciousness. In their 2006 study, Clarke and Ward demonstrated transformational safety leadership is positively related to employee safety participation.

Other researchers have continued the connection between transformational leadership and positive safety outcomes. Jiang and Probst (2016) examined the relationship between leadership style and safety knowledge and safety participation. They confirmed safety knowledge and safety motivation were positively related to safety participation. Additionally, though passive leadership and safety participation is not related, transformational leadership (TL) and safety participation (SP) are positively related. And finally, TSL moderated the relationship between SM and SP (Jiang and Probst, 2016). Thus, in high TSL settings, folks with high SM demonstrated high SP. Additionally, when TSL was low, there was no relationship between SM and SP (Jiang and Probst, 2016).

Farahnak et al. (2020) examined the relationship between transformational leadership (TL), attitudes towards change, and implementation success of evidence-based practice (EBP) in the mental health field. The researchers found positive relationships between transformational leadership and staff attitudes toward EBP, as well as staff attitudes toward EBP and implementation success (Farahnak et al., 2020). Results also supported an indirect relationship between transformational leadership and implementation success through employees' attitudes toward EBP. The results suggest that the leader's behaviors are likely more critical to innovation implementation than the leader's attitudes (Farahnak et al., 2020).

Hussain et al. (2021) reported a high degree of transformational leadership can increase job satisfaction and organizational commitment. In their meta-analysis, they found in 13 of 19 valid cases, transformational leadership and job satisfaction were positively related, and in 11 of 13 valid cases, transformational leadership and organizational commitment were positively related.

Irshad et al. (2021) reported the use of transformational leadership in a healthcare setting enhanced caregiver psychological well-being by mediating the perceived impact of Covid-19 (thus providing better availability of caregivers for patients). Specifically, for those healthcare providers with low safety consciousness, the level of transformational safety leadership (TSL) had no impact on their perceived risk from Covid-19. However, high levels of TSL coupled with high safety consciousness led to a significantly lower perception by employees regarding their specific risk from Covid-19 (Irshad, 2021).

Senior Leadership Attitudes towards Safety and Safety Culture Perception of Personnel

There is a strong body of research connecting the attitudes of senior leadership and the safety culture perception and outcomes of personnel. In their 2001 work, Helmreich & Merritt found a strong positive correlation between organizational leadership's commitment to safety (or pilot perception thereof) and pilot safety practices and norms. Simon posits a key indicator of senior management's commitment to safety is the adequacy of resources, including financial support and their active involvement in safety initiatives (2009). Thus, leadership's involvement becomes very clear to employees, leading to positive safety outcomes.

Research has demonstrated senior leadership's attitude toward safety directly impacts safety climate and outcomes. Borgersen et al. (2019) found authentic leadership made a significant contribution to explaining variance in safety culture in a maritime setting. Leaders who demonstrated authentic leadership through balanced processing internalized moral perspective, relational transparency, and self-awareness were given higher total safety climate scores from their team than those who did not (Borgersen et al., 2019).

Gerede (2015) posited SMS implementation is impacted by the support senior leadership gave to the initiative and safety initiatives in general. Due to the transformational nature of SMS itself (seeing the world for what it is rather than what one desires it to be), a high degree of effort may be required for SMS to be successful. Key components of an effective implementation include senior leadership support, support from the regulator, effective training, and the integration of multiple SMSs of stakeholder organizations (Gerede, 2015).

Studies in the firefighting arena also have demonstrated the positive impact of transformational safety leadership (TSL) on crew use of personal protective equipment (PPE). Smith et al. (2020) found that amongst firefighters, TSL had a positive impact on safety motivation (SM). SM was found to have a significant and large impact on PPE use. Finally, the compound impact of TSL on SM which impacts PPE use was significant (Smith et al., 2020).

Cavazotte et al. (2021) researched the role of authentic leadership on safety participation (SP) and safety compliance (SC). The researchers found senior leader selflessness and morality can influence safety outcomes, by improving employee psychological capital (PsyCap) and organizational citizenship (exhibited by organization citizenship behaviors, also known as OCB). Both PsyCap and OCB influence SP. However, PsyCap influences SC, but OCB does not (Cavazotte et al., 2021).

Underlying Theories of Safety Motivation, Safety Behavior, and Safety Performance

Commercial aviation in the United States is as safe as it has ever been (Bureau of Transportation Statistics, 2021). Much of the credit for the high level of safety in the commercial arena falls to the pilots. The following section is a brief overview of the theoretical underpinnings of why pilots exhibit safety-related behavior.

Skinner's Operant Learning Theory

Operant Learning Theory states behavior is a function of a person's environment and can be modified by manipulating the consequences of behavior (Skinner, 1953). Thus, behavior with positive reinforcement (a desirable outcome) tends to increase in frequency, versus behavior with negative reinforcement (undesirable outcome or punishment) tends to decrease in frequency (Skinner, 1953).

In the realm of Part 121 operations and safety, pilots will tend to exhibit behaviors that result in desirable outcomes (i.e., respecting the operational policy and the flight manual limits of the aircraft, both result in a positive outcome). Operant Learning Theory would also predict pilots will avoid behaviors that might result in a negative outcome.

The theory may be challenged a bit in the case of a novel situation or one in which a Pilot cannot clearly determine an outcome. Additionally, a pilot may "press a limit" or allow their standards to creep in such a way that over time she may engage in behavior without an accurate perception of risk due to the lack of negative outcomes when the behavior was done in the past. Thus, an illusion of invulnerability can occur (Reason, 2008).

Thorndike's Reinforcement Theory

Thorndike's *Reinforcement Theory* states behavioral responses to stimuli that are followed by a satisfactory response will be strengthened, but responses that are followed by discomfort or a negative outcome will be weakened (Nevin, 1999). The focus is behavior and its outcomes, based upon reinforcement (which can be positive or negative).

Positive reinforcement can take many forms in Part 121 operational world. Public recognition, cash incentives, even small gifts or "badges" have been associated with increased safety behavior in an organization. Awards given for a certain period of incident-free operation (a desirable outcome), if seen as a positive outcome by the recipient (positive reinforcement), can lead to an increase in desired safety performance (Mazur, 2013).

Negative reinforcement (or avoidance) refers to consequences that are not perceived as desirable. These consequences are associated with certain behaviors, and the theory states the pilot will not perform the undesirable behavior in an effort to avoid less than desirable consequences. Examples of negative reinforcement might be a call from the FOQA Gatekeeper for an exceedance detected by aircraft electronic data (slightly undesirable) to suspension or termination due to a wanton or reckless violation of policy or procedure (a very undesirable outcome). Thus, the theory states a pilot will gravitate toward positive reinforcement and avoid negative reinforcement. One might find positive and negative reinforcement is too simplistic and the approach does not always work. Other factors such as punishment and extinction should also be considered (Mazur, 2013). Additionally, such strategies might not always be employed. Ground Crews might take risks because of poor procedures, technology, etc. to improve turn times to receive a bonus, despite the potential negative outcomes if the gambit fails (Greenberg, 2013).

Maslow's Hierarchy of Needs

All human beings are motivated by unsatisfied needs, lower-level factors need to be satisfied before higher-level needs can be satisfied (motivation is derived from the need to satisfy lower-level needs enroute to satisfying higher-level needs). Thus, if one can identify and satisfy lower-level needs, then higher-level needs can be addressed (Maslow, 1970).

In the case of Part 121 operations, if pilots feel like their contract is adequate regarding terms of employment, they are supported by leadership, and the company backs up their decisions when flying the line, more desirable safety outcomes occur. On the

contrary, if the lower-level needs of a pilot are not met (i.e., the pilot is distracted by needs not being fulfilled because of a sub-par contract or they do not feel supported by leadership regarding operational decision making) one might expect a lower level of safety outcomes.

Vroom's Expectancy Theory

Vroom's *Expectancy Theory* focuses on behavior based on conscious internal choices to maximize pleasure and minimize pain, rather than the impact of external outcomes. The theory separates effort (which arises from motivation), performance, and outcomes. Individual performance is looked at holistically, based on individual factors such as personality, skills, knowledge, experience, and abilities (Vroom, 1964).

Vroom's theory attempts to account for the richness of individual differences amongst personnel. Specifically, the variables of expectancy, instrumentality, and valence are tied to motivation (Vroom, 1964). Personnel change their level of effort based upon their assessment of the value of the "bonus" they might receive, and their perception of the link between effort and outcome. (Bandura, 1986; Greenberg, 2013). In a Part 121 setting, leadership must closely connect rewards with specific safety-related behavior while ensuring Pilots want these rewards. A clear relationship between behavior and reward must be established, and pilots must unequivocally see that their safety-related behavior will result in the desired reward.

Herzberg's Two Factor Theory

Herzberg's *Motivational Theory* or *Two-Factor Theory* is another important foundational element that supports safety motivation and safety behavior. Herzberg posits a person is motivated to act to satisfy individual needs and desires. Motivation can

be split into two major categories: Hygiene factors and mptivation factors (Greenberg, 2013). Hygiene factors are necessary (but not sufficient) for job satisfaction. Motivation factors lead to job satisfaction. Hygiene factors include supervision, interpersonal relationships, physical working conditions, and salary. Motivational factors include achievement, advancement, recognition, and responsibility (Greenberg, 2013).

Herzberg's theory is limited in that it does not consider an individual's expectancy. It is not a given that well-motivated and satisfied personnel will demonstrate safe behavior. If a pilot's expectancy is low regarding the potential certain behavior will bring a valued result, variance in performance and effort to achieve the desired result will occur (Mazur, 2013).

Ajzen's Theory of Planned Behavior (TPB)

Another foundational element of safety motivation, safety behavior, and safety performance is Ajzen's *Theory of Planned Behavior (TPB).* TBP considers the psychological aspects of human behavior. TBP considers the intentions behind human action (Ajzen, 2005). Intentions are guided by different considerations: attitude toward behavior, subjective norm, and perceived behavioral control. Intentions can be predicted with a high degree of accuracy by one's attitudes toward behavior, subjective norms, and perceived behavioral control constructs. Perceived intentions, together with perceived behavioral control, can explain variance in actual behavior (Ajzen, 2005).

Ajzen introduced the variable intention to strengthen the connection between attitudes and behavior. Attitudes sometimes fail to result in behavior for a wide variety of reasons. However, an individual's attitude toward behavior, subjective norms, and

perceived behavioral control can be used to predict intentions that can predict safety behavior (Fogarty and Shaw, 2009).

In a Part 121 setting, Ajzen's work supports the premise that pilot attitude (as measured by intention) can directly impact safety behavior and safety performance. Thus, a carrier can assess the pilot's attitude toward safety-related behaviors as a leading indicator of safety-related outcomes.

McGregor's Theory X and Theory Y

McGregor offers two theories regarding employee motivation within organizations, *Theory X* and *Theory Y*. *Theory X*: motivation occurs only at the physiological and security levels of Maslow's *Hierarchy of Needs* (McGregor, 1960). People must be closely controlled and often coerced. The main source of employee motivation is money, followed by security. *Theory Y*: employees are motivated by esteem and self-actualization. Employees are self-directed and will meet organizational goals if committed to them. Employee buy-in is needed (McGregor, 1960).

In the Part 121 arena, aspects of both approaches are impactful. Employee involvement in setting safety policies and processes tends to be more effective than a purely punitive approach (Sorenson, 2015).

Behavior-Based Safety and Safety Compliance Theory

There is a deep body of research connecting an individual's perception to their behavior. Studies have shown interventions and strategies that aim at positively influencing personnel behavior (and perception of said behavior) will ensure safety performance meets safety goals and objectives (Yates, 2015).

In the realm of safety-related behavior, research indicates a perception of risk affects the likelihood of certain behaviors. BBS or Behavior-Based Safety within the organization is one good example of connecting perception with the outcome. Behavior-Based Safety (BBS) and safety behavior modification involve a continuous focus of attention on what people do and why they do it. Then, after the analysis of their safety outcomes is complete, research can be accomplished to design a strategy to improve what they do (Cooper, 2009; Geller, 2004).

Other research stresses a behavior modification approach to enforce discipline and drive behavior. And though there has been documented effectiveness of this approach (Cooper, 2009), SMS per se is not purely a behavior modification system. Rather it is a holistic approach to safety, and it needs to take into consideration the workarounds, potential intentional violations, and other non-compliant behaviors behavior that impact performance in a large organization (Stolzer, Halford & Goglia, 2011).

Person-Centered Safety Theory

Heinrich's *Domino Theory of Accident Causation* posits an accident only occurs because of the result of a human or mechanical failure. Thus, the hazard only exists because of the actions of careless people or poorly designed equipment (Hollnagel, 2009). Thus, attention to the humans in the system (both at the design phase and in the execution phase of the operation) is warranted. Accordingly, enforcement methods such as punishment can be effective in modifying behavior and outcomes if applied correctly (Holden, 2009).

Greenberg (2013) recommends a system of punishment for non-compliance or unsafe acts to send a clear signal to the workgroup that such actions will not be tolerated.

These punishments should be graduated, tied to the severity of the outcome of the action, and they should be applied consistently. Communication regarding the reason for the punishment (to the offender and the entire group) is also very important to ensure the workgroup understands the connection between action and outcome (Greenberg, 2013). The challenge with Greenberg's approach is in the application: how does an enterprise develop and administer a system to effectively monitor the behavior and administer punishment without destroying other important areas of organizational health?

Organizational and Systems-Centered Theory

In contrast to the proponents of *People-Centered Theory*, experts like Reason (2008) and Dekker (2011, 2014) posit accidents are caused by multiple factors and incidents occur because of the complex interactions of numerous work system elements involving both human and non-human components. Dekker (2014) does not support punishment as a safety behavior modification tool, especially in high-reliability organizations like aviation, healthcare, and nuclear power.

Dekker (2014) states an interesting premise: punishment is tied to the outdated theory which focuses on poor human performance. This belief derives from a supposition that both the system and the equipment are inherently safe, and people are the least reliable component. Punishment masks the fact that the system and/or the equipment might also bear much of the blame for an accident. Punishment emphasizes that failures are deviant behavior, and it does not recognize the role that drift, and deviance play in all systems. The consideration that deviance and drift can exist in all systems is a crucial foundational principle of Safety Management Systems (Dekker, 2014).

Human Factors Theory

According to Goetsch (2010), accidents are generally a result entirely of human error. The errors result from overloading human capabilities, environmental factors (heat, noise, distractions), situational factors (unclear instructions or risk level), and/or personal factors (individual issues with family, life, etc., or emotional stress). Additionally, Yates (2015) posits human error results when personnel undertake tasks without requisite or sufficient training, and/or unfamiliarity with equipment and procedures, as well as misjudging risk resulting in unsafe activities.

Multiple factors such as deadlines, peer pressure, and budget may cause a person to decide unconsciously or consciously to deviate from the process or procedure (Yates, 2015). Additionally, *Human Factors Theory* makes a connection between management and the operation regarding setting policy, procedures, training, and follow-up. Management is also responsible for enforcing standards and carrying out and documenting corrective actions--most of the components of the SMS construct (Yates, 2015).

Person Attribution Theory

Person Attribution Theory states that variability in human behavior can be modified with blame and punishment (Reason 2000, 2008). Proponents of this theory support the use of fear, disciplinary measures, litigation, retraining, and shaming to drive desired behavior.

Petersen's Accident/Incident Theory

Petersen's Accident/Incident Theory takes the *Human Factors Theory* a step further. Human Factors Theory extends to include additional elements: ergonomic traps, the decision to err, and system failures (Goetsch, 2010).

The *Bad Apple Theory* of safety management focuses on the identification and removal of unreliable human operators within the system. The *Bad Apple Theory* posits the system is essentially safe and success is intrinsic so long as a human does not deviate. This view is known as the "old view" of human error (Reason, 2008). The "old view' of human error states the major threat to safety is the inherent unreliability of people in the system. An acceptable level of safety performance can be achieved if the system is shielded from human vagaries through selection, proceduralization, automation, training, and discipline (Dekker, 2014).

Relationship between Pilot Self-Efficacy, Safety Motivation, and Safety Behavior

Multiple studies have indicated that individual self-efficacy (SE) can be a reliable predictor of the work-related behavior of pilots (see Parasuraman, Molly & Singh, 1993; Prinzel, 2002). Additionally, current research suggests that high levels of self-efficacy are directly related to pilot perception regarding goal achievement and the level of effort spent on improving work-related and management performance (Schwarzer & Jerusalem, 1995).

Ji et al. (2017) found an interesting permutation on the relationship between SE and student pilot situational awareness. In their study, concern over mistakes and personal standards had direct effects on flying cadets' situational judgment. Additionally, concern over mistakes, parental expectations, and organization had indirect effects on

flying cadets' situational judgment through safety motivation. And finally, concern over mistakes and parental criticism had indirect effects on self-efficacy (Ji et al., 2017).

The positive relationship between SE and SC is normally welcome and leads to positive safety outcomes. However, Prinzel (2002) pointed out that employees with high self-efficacy might be extremely goal-oriented at the expense of general safety procedures. Under a certain set of conditions (high pressure, tight budget, etc.) some employees with high self-efficacy may decide to disregard proper procedures. Under Petersen's *Accident Theory*, such behavior is termed the "*Superman Syndrome*." To avoid this negative outcome, employees should be engaged to equip them with a sense of process ownership and peer review.

Ślazyk-Sobol et al. (2021) engaged ground crew in a Polish aviation environment (ground handling personnel, firefighters, engineers, mechanics, and electricians) to explore the relationship between self-efficacy, levels of work stress, and attitudes towards safety-related behaviors at work. Using a survey instrument, the researchers found sense of effectiveness was an important mediator between a participant's level of perceived stress and their attitudes toward safety. Namely, as the subjectively perceived sense of self-efficacy increased, the level of experienced stress decreased. Thus, a participant's positive attitude toward safe actions and behaviors in the workplace is strengthened (Ślazyk-Sobol et al., 2021).

Cayir and Ulupinar (2021) examined the relationship between self-efficacy, using educational skills, and perceptions regarding performance amongst nurses. A predictive relationship was found between the nursing instructors' educational skills, general self-efficacy perceptions, and performance. Participant perceptions of general self-efficacy

and performance increased as their frequency of using educational skills increased, and their performance increased as their perceptions of general self-efficacy increased. Differences were also noted by gender, age, years of experience in the job, and level of educational experience (Cayir & Ulupinar, 2021).

Other researchers (Schunk & Pajares (2001) and Graham and Weiner (1995)) determined self-efficacy can be a reliable predictor of behavior and behavioral change.

The Challenge of the Behavior-Based Approaches and Error Management in SMS

The debate continues on the best approach to fully understand the causes of accidents and incidents, to positively impact the humans in the system and the system in which they operate. The theories of Safety I and Safety II (and their relationship to Resilience Engineering) are briefly discussed as potential enablers regarding the effectiveness of an SMS in an organization.

Safety I and Safety II / Resilience Engineering

Rather than focusing on the lack of negative outcomes (generally known as accidents and/or incidents, and connected to technological failure, human failure, and/or organizational system failure), Hollnagel (2014) proposes that safety scientists should focus on what goes right. Simply put, Safety I is then described as keeping the number of adverse outcomes as low as possible. Safety-II is defined as: "…the ability to succeed under expected and unexpected conditions alike so that the number of intended and acceptable consequences is as high as possible" (Hollnagel, 2014, p. 23). The definition of Safety-II is very similar to the definition of resilience in resilience engineering (Hollnagel, Paries, Woods, & Wreathall, 2011).

Thus, Safety II studies the operationalization of safety or applied safety in the organization (Hollnagel, 2014). The connection between the focus on Safety II and the proactive nature of SMS (especially with its implication on continuous improvement) is undeniable and worthy of consideration in the context of this work.

Just Culture

Just Culture refers to a framework within an organization that fosters a culture of trust, learning, and accountability. A Just Culture framework outlines the processes by which employees report safety issues, the disposition of the data, the management process to determine if employee conduct was an honest mistake, at-risk behavior, or negligent/reckless behavior, and the mechanism to ensure oversight of the process. Sydney Dekker opines in a contribution *Just Culture: Restoring Trust and Accountability to Your Organization* that: "…a Just Culture framework foster improved morale, employee commitment to the organization, job satisfaction, and willingness to do that "little extra" or step outside of their role" (Dekker, 2017, p. xiii).

In the same vein as Safety I versus Safety II, leaders of high-reliability organizations face a choice when dealing with accidents or incidents. Regarding the employees involved in a safety escape, leaders can choose to take either a punitive or *retributive* approach, or a healing and learning-based or *restorative* approach. Dekker posits that an organization must clearly answer two questions related to addressing issues on "who was hurt (first victims, second victims, the organizational community) and what are their needs" (Dekker, 2017, p. 13).

Just Culture is complimentary to an SMS regarding the systematic evaluation of both the latent conditions and human actions surrounding a safe escape. Both

frameworks espouse a reporting culture, and both embed continuous improvement as an outcome (FAA 2013, 2019). In practice, the relationships between the regulator and the organization and the organization's leadership and its employees are crucial. Dekker posits: "Unjust responses to incidents are less likely the result of bad judgment calls by those involved in that aftermath" (2017, p. 144). At times, it is the building of this trust within the organization that can stymie the implementation of a Just Culture system.

Summary and Conclusions

The literature review serves as a foundation for the work in this study. By no means is the literature review a complete review of SMS metrics, models addressing the relationship between safety behaviors and attitudes with safety outcomes, nor the potential further contribution of the examination of safety culture and SMS outcomes. Rather, the literature review helps connect core concepts with the model proposed in this (and previous work), while highlighting the need to further research the aforementioned variables in a commercial aviation or 14 CFR Part 121 environment. The importance of metrics regarding the measurement of the effectiveness of an SMS cannot be overstated—as part of a performance-based scheme, an operator and the regulator must continuously evaluate the functionality of a carrier's SMS. The intent is to develop an objective, rather than subjective assessment tool.

CHAPTER III

METHODOLOGY

This study utilized a concurrent triangulation mixed methods approach to examine the relationships between SMS initiatives (SMS policy implementation and SMS process engagement), safety leadership, self-efficacy, safety motivation, safety-related events, and safety behavior (as evidenced by safety compliance and safety participation) at a 14 CFR Part 121 U.S. commercial carrier. The measurement model proposed in this study is an extension of Adjekum's (2017) final measurement model designed to examine the same variables in a collegiate aviation setting (14 CFR Part 141).

This study is designed to fill a gap in research on SMS initiatives in U.S. commercial aviation operations, add to existing literature, and further quantify the relationship between the study variables by using a holistic concurrent triangulation approach. Finally, this study intended to provide an objective measure for air carriers to use as part of the assessment and continuous improvement of their SMS.

As discussed earlier in this work, a quantitative survey instrument and qualitative semi-structured interviews were used to gather data to compare to objective company safety outcomes and artifacts. The quantitative survey contained 42 items, designed to examine the relations between the perceptions of company line and check pilots on SMS process engagement (SMSPro), SMS policy implementation (SMSPol), transformational safety leadership (TSL), self-efficacy (SE), safety related events

(SE), safety participation (SP), and safety compliance (SC). Please see Appendix A and Chapter One of this paper for a more in-depth discussion of the various dimensions and the validated scales.

The hypothesized measurement model was evaluated using Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM/Path Analysis (PA)) to determine the strength of relationships among the variables while simultaneously determining the quality of the measurement model used in the study. The relationship between the safety indicators obtained from the surveys and safety outcomes (self-reported safety events) was explored, as well.

Selected company leadership personnel were concurrently assessed using semi-structured interviews to understand their perspectives on the state of the SMS and the implementation of the program (Maxwell, 2005; Glesne, 2011). The primary purpose of this portion of the study was the identification of any gaps in the perceptions of senior leaders and those of the front line regarding the health and efficacy of the company's SMS. More detail on the survey participants can be found in the *Methodology* section of this paper.

Comparison of safety artifacts, objective safety data, and the reflections captured in the semi-structured interviews provided insight into the accuracy of the perceptions of senior leadership regarding the functionality of their SMS. This analysis aimed to highlight potential blind spots or gaps in senior leadership's assessment of their SMS and its implementation.

The final step of the process involved a triangulation approach, designed to consolidate the data gathered from the quantitative online survey of line pilots and check

pilots regarding the study variables, the holistic themes which emerged from the semi-structured interviews of company leaders on SMS efficacy and implementation, and company artifacts and safety performance indicators. Multiple company safety performance indicators were used, including normalized data on safety reporting by crews, SMS training data, company safety reports, and other flight-related performance indicators.

Research Design

Concurrent Triangulation Mixed Method Approach

A concurrent triangulation mixed-method approach was utilized to gather both quantitative and qualitative data using a variety of techniques during a fixed period. The examination of the data, along with corporate artifacts and objective safety outcomes allows one to make holistic inferences regarding the efficacy of SMS implementation (Wahyuni, 2012).

Respondent data was examined for convergence or divergence regarding the study variables and objective safety artifacts to provide a holistic view of the functioning of the carrier's SMS. Safety artifacts included aggregate assurance data that objectively captured the safety performance of the airline. The same approach could be utilized at regular intervals to allow for a longitudinal study, as well.

The concurrent triangulation strategy has been effectively used before in the literature to holistically analyze similar variables in a collegiate environment (Adjekum & Jensen, 2016). Concurrent means the quantitative data, qualitative data, and evidence from company artifacts (documentary data) will be gathered over a fixed period in the organization's history, thus providing a single snapshot for analysis.

The results will be compared to determine if convergence, divergence, or some combinations exist regarding the survey data from line employees, interview data from management, and objective company safety data. Where convergence exists, the company may take some confidence in the effectiveness of their SMS program, and possibly consider reinforcing these positive measures using a Safety-II mindset. Where divergence exists, potential gaps in a company's SMS may be indicated, highlighting areas of focus for the leadership and safety teams for deeper analysis.

The concurrent triangulation mixed-method approach generally uses separate quantitative and qualitative methods to offset the inherent weaknesses in one method with the strength of the other (Creswell, 2009). Additionally, to derive the maximum effectiveness of the approach when gathering data concurrently, equal weight should be assigned across methods--even if skewness is detected in the data set (Plano, Clark & Creswell, 2008).

Methodology

Population

The qualitative and quantitative phases of this effort used different pools of respondents. The quantitative portion of the study utilized a within-case purposive sample, made up of pilots at a large U.S. commercial carrier (N = 8,500). The population is divided roughly equally regarding duty position: captain or first officer. Additionally, there are approximately 300 check airmen in the pilot group at this carrier, as well. The sample who was administered the quantitative instrument represented the line employee level of the organization.

The qualitative portion of the study utilized a purposive sampling of 12 high-level leaders from multiple departments. Specific details regarding the respondents have been left out at the request of the carrier. The selected company leadership positions included a sampling of personnel from the carriers required 14 CFR Part 119 personnel and their assistants, one individual from Air Ops, one from Technical Operations, three from Operations Quality Assurance, and seven from Flight Operations Safety, Assurance, and/or SMS. The company positions of those interviewed included Senior Director to Manager, and all have authority, responsibility, and resources to manage within their areas. Additionally, the Flight Ops SMS managers were responsible for all aspects of implementation and execution of the SMS within the third-largest department at the carrier (over 10,000 employees), behind only Ground Operations and Inflight Operations. The Flight Ops managers supervised and accomplished safety risk management, safety promotion, safety training, safety assurance, and several other tasks associated with the carrier's SMS. There were two females and ten males in the interview group. The experience level of the personnel in the sample ranged from 12 to 25 years at the carrier. The semi-structured interview questions can be found in Appendix A.

Sampling Procedures

Power Analysis and Sample Size Selection

The sample size required for empirical studies or measurement model assessments can be approached from a variety of perspectives. Kim (2005) posits that estimates of power and minimum sample size vary based on the choice of the index, the number of observed variables, model degrees of freedom, and the magnitude of the covariation

amongst the variables. Field (2018) simplifies the discussion by recommending increasing the sample size to improve power.

Kline (2016) suggests consideration of the number of parameters in the model is appropriate when considering smaller sample sizes--the larger the number of model parameters, the larger the required sample size. Kline (2016) proposes that a sample of 10 respondents per parameter is reasonable, but 20 respondents per parameter ensures adequate power for the analysis. Since this study contains 14 parameters, a minimum sample size of 280 was deemed sufficient for this research.

Though the survey instrument would ensure coverage and randomization across respondents, a purposive sampling plan limited the quantitative portion of the study to only respondents who were on the pilot seniority list at the major U.S. carrier surveyed. Non-pilots and other workgroups were not included in this research (but should be considered for follow-up studies).

The purposive sample of management personnel included many of the relevant leaders with roles in the carrier's SMS. The holistic approach allowed a much richer view of the perceptions of these leaders for comparison to both the results of the quantitative data and the company artifacts.

Procedures for Recruitment, Participation, and Data Collection

An Institutional Review Board (IRB) approval from the university was obtained because the study involved the use of human subjects. Permission was also garnered from the senior leadership of the commercial carrier to engage both line pilots and applicable leaders involved with the company's SMS.

For the qualitative portion of the study, the link to a confidential Qualtrics® generated online survey instrument was posted in the company-provided pilot weekly update, accessible only via log-in by pilots on the seniority list. Once logged in to the Qualtrics® survey, respondents were required to acknowledge their rights as study participants and digitally sign a consent form.

Respondents who agreed to the consent form were allowed to complete the survey. Respondents who did not complete the consent form were logged out. Respondents who continued through the survey could stop at any time and quit the survey without penalty or repercussions. The completed responses were stored in the secure Qualtrics® online database in accordance with the terms of the IRB approval.

The semi-structured interviews were performed virtually, using a Microsoft Teams® meeting. The interviewees were given sufficient notice (two weeks) of the interview, along with the questionnaire for the interview and the IRB consent form. Transcripts were generated by Microsoft Teams®, and the transcripts were provided to the interviewees for authentication and validation of content. The validated content was then reduced using in vivo coding and codes, categories, and themes to extract emergent themes and classification.

The coding and classifications were completed using a mix of manual processes and computer-assisted qualitative software (NVivo® software suite). Field notes were also taken during the recording sessions to add clarifying details, rich text descriptions, and in situ researcher observations (Saldaña and Omasta, 2017).

The carrier authorized the use of de-identified aggregate safety performance data for use in the study. This data included: the total number of Safety Reporting System

(SRS) reports submitted by year (2016-2021) across the entire enterprise; SRS reports submitted by workgroup over the same period; the number of Aviation Safety Action Program (ASAP) reports filed (2015-2021); the ASAP filing rate per 10,000 hours of flight time and per 10,000 flights (2016-2021); the number of personnel trained in SMS by year (2016-2021); the number of new hazards identified (2016-2021); and the number of new Operational Risk Registry entries (2016-2021). This data provides good insight into the safety culture and reporting culture of the carrier, and it serves as potential confirmatory evidence regarding the effectiveness of a carrier's SMS. This data formed the third component of the triangulation process while providing insight into the overall function of the carrier's SMS (Creswell, 2009; Patankar et al., 2012).

Demographic Details

Demographic details such as age, gender, pilot seat, years at the company, and first exposure to SMS were gathered from study participants. The demographic information gathered helped to identify individual differences regarding the study variables across respondents. Per the Institutional Review Board (IRB) approval, no identifying data was gathered as part of the study. The field notes and transcripts of the qualitative portion of the study were retained per the terms of the IRB policy.

Instrumentation and Operationalization of Constructs

All constructs of the study are discussed below. A five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree or 1 = Extremely Rare to 5 = Very Frequent) was utilized. Upon the completion of data collection, composite reliability was assessed, using a minimum value of Cronbach's alpha ≥ 0.70 (Field, 2018). The quantitative survey can be found in its entirety in Appendix B.

Perceptions of SMS Initiative

SMS - perceptions of the SMS initiative (SMS process engagement (SMSPro) and SMS policy implementation (SMSPol), 6 items each) were measured by 12 final measurement model items developed by Adjekum (2017). Alpha coefficients of .93 (SMSPol) and .75 (SMSPro) were reported for this instrument (Adjekum, 2017).

A typical item in the SMSPol group (responses were limited to a 5-point Likert scale, Strongly Disagree = 1 to Strongly Agree = 5): *Safety professionals with the appropriate skills, knowledge, and experience conduct SMS training*.

A typical item in the SMSPro group (responses were limited to a 5-point Likert scale, Strongly Disagree = 1 to Strongly Agree = 5): *Safety concerns reported through the safety reporting system are corrected in a timely manner.*

Transformational Safety Leadership

Transformational safety leadership – contained 6 items adopted from the Survey of Transformational Leadership (STL) developed by Edwards, Knight, Broome, and Flynn (2010). Transformational Safety Leadership (TSL) is at the group level of the carrier and it denotes the quality of leadership provided by supervisory flight managers such as Chief / Assistant Chief Pilots. Previous work by Adjekum (2017) indicated Cronbach alpha coefficients above .84. A typical TSL item (responses were limited to a 5-point Likert scale, Strongly Disagree = 1 to Strongly Agree = 5—reverse coding was handled in the data analysis phase): *Chief Pilots/Flight Ops Leadership do not listen to my concerns.*

Self-Efficacy

Self-efficacy – measured by 4 items from the Generalized Self-Efficacy Scale developed by Schwarzer and Jerusalem (1995) to assess pilot perception regarding their ability to deal with non-normal situations. Previous studies reported a Cronbach's alpha of .86 for this instrument. A typical item in the SE group (responses were limited to a 5-point Likert scale, Strongly Disagree = 1 to Strongly Agree = 5): *I am confident that I could deal efficiently with unexpected events.*

Safety Motivation

Safety motivation - used 3 items to measure the degree to which respondents regard safety as an essential part of their professional development, developed from the work of Neal and Griffin (2006). The reported Cronbach's alpha for this scale was .90. A typical item in the SM group (responses were limited to a 5-point Likert scale, Strongly Disagree = 1 to Strongly Agree = 5): *It's important to maintain safety at all times.*

Safety Behavior

Safety behavior (safety compliance and safety participation) - safety behavior consisted of a total of 6 items divided into two components (i.e., safety compliance and safety participation), developed from work by Neal, Griffin, and Hart (2000) and Neal and Griffin (2006). Safety compliance evaluated the core tasks that pilots have to accomplish to maintain flight safety using 3 items. Safety participation assessed the extent to which pilots help develop an environment that supports safety using 3 items. The reported alpha coefficients for safety compliance and safety participation were .91 and .84, respectively.

A typical item in the safety participation portion of the safety behavior construct (responses were limited to a 5-point Likert scale, Strongly Disagree = 1 to Strongly Agree = 5): *I promote the safety program within the organization.*

A typical item in the safety compliance portion of the safety behavior construct (responses were limited to a 5-point Likert scale, Strongly Disagree = 1 to Strongly Agree = 5): *I follow correct safety procedures when operating*.

Safety Related Events

Safety-related events – adopted from Adjekum's (2014a) Collegiate Aviation Perception of Safety Culture Assessment Scale or CAPSCAS instrument. These 4 items were used to evaluate the relationship between a respondent's knowledge regarding company safety-related events and their safety behavior. The reported reliability of this instrument was .92. The SRE scale was coded on a 5-point Likert scale to capture the frequency of occurrence of events (1 = extremely rare to 5 = very frequent): *Across the operation every month, how often do company flights encounter proximity to another aircraft requiring evasive action?*

CHAPTER IV

DATA ANALYSIS AND RESULTS

Demographic Information

The survey was made available to the 10,500 flight operations personnel at the carrier via general newsletter announcements. No incentives were paid to participants. The carrier reported a 50% read rate for the weekly newsletter in which the link to the survey was provided. Thus, the effective response rate was 5.4%. Though historically one might prefer a higher response rate, upwards of 80% is the expected norm for federally funded studies (Hendra and Hill, 2015), both Hendra and Hill (2015) and Rindfuss et al. (2015) reported no evidence of an increased level of non-response bias from a lower number of responses.

The online survey closed after a six-week response period. Tables 1, 2, and 3 contain the respondent demographic data. Two hundred fifty-six (n = 256) complete cases proceeded beyond the consent phase. Thirty cases (n = 30) were excluded from the analysis due to lack of consent or the data was incomplete for analysis. Respondents represented various roles within Flight Operations. Ninety–seven (n = 97) Check Airmen, seventy-eight (n = 78) Captains, fifty-four (n = 54) First Officers, four (n = 4) Instructors, and twenty-three (n = 23) "Other" responses were recorded. Respondents in the "Other" category included various staff and management pilots, and other staff analysts and safety professionals.

Table 1

Demographic Variables Age and Gender

	N	Percentage
Age		
>25 - 30 Years	6	2.3%
>30 - 35 Years	1	0.4%
>35 - 40 Years	18	7.0%
>40 - 45 Years	18	7.0%
>45 - 50 Years	16	6.3%
>50 - 55 Years	86	33.6%
>55 - 60 Years	64	25.0%
> 60 Years	47	18.4%
Total	**256**	**100%**
Gender		
Female	22	8.6%
Male	232	90.6%
No Report	2	0.8%
Total	**256**	**100%**

Respondents were asked to report their years of experience at the company by selecting one five-year category. Thirty (*n* = 30) reported less than one year to five years, twenty-five (*n* = 25) reported greater than five to ten years, thirty (*n* = 30) reported greater than ten to fifteen years, fifty-nine (*n* = 59) reported greater than fifteen to twenty years, sixty-five (n = 65) reported greater than twenty to twenty-five years, forty-one (*n* = 41) greater than twenty-five to thirty years, and six (*n* = 6) greater than thirty years.

Table 2

Demographic Variables Role and First Experience with SMS

	N	**Percentage**
Role at the Company		
Check Airman	97	37.9%
Captain	78	30.5%
First Officer	54	21.1%
Instructor	4	1.6%
Other	23	9.0%
Total	**256**	**100%**
First Experience with SMS at the Company?		
True	192	75%
False	64	25%
Total	**256**	**100%**

Table 3

Demographic Variable Years at Company

	N	Percentage
Years at the Company		
0 - 5 Years	30	11.7%
>5 - 10 Years	25	9.8%
>10 - 15 Years	30	11.7%
>15 - 20 Years	59	23.0%
>20 - 25 Years	65	25.4%
>25 - 30 Years	41	16.0%
>30 Years	6	2.3%
Total	**256**	**100%**

Approximately 9% of the respondents to the survey were female (*n* = 22), 91% were male (n = 232) and 1% did not report (*n* = 2). The skew in the gender statistic is not surprising, as only 4.7% of the pilots who held an Airline Transport Pilot license in 2021 were female (FAA, 2022). The response rate for females to the survey exceeds the carrier's overall number of female pilots (which is close to 4%).

Quantitative Data Analysis and Validation

The quantitative data for this research effort was gathered using the Qualtrics® XM survey package. IBM SPSS Statistics 27® and IBM SPSS Amos 27® software packages were used to perform an analysis of the data from the survey. All analyses were done with an a priori statistical significance of 0.05 (two-tailed) unless otherwise specified. Because this work was based upon existing, validated measures and a robust model (Adjekum, 2017), a first-order Confirmatory Factor Analysis (CFA) was used to assess the strength of relationships between constructs and their underlying scale items.

A first-order CFA allows the researcher to determine whether scale items in the measurement model, like SMS (SMSPol and SMSPro) and self-efficacy (SE) performed satisfactorily and in line with the researcher's knowledge of the constructs in the existing theory. CFA was also utilized to assess whether the research data fit hypothesized measurement models of the constructs in the study. The Composite Reliability (CR) method was used to analyze the reliability or repeatability of the scale, using Field's (2018) recommendation of a value of 0.70 or higher. Figure 10 contains a visual depiction of the final measurement model, including regression weights. Table 4 contains goodness-of-fit indices for the various models considered and the modifications made on each iteration.

As part of the CFA process, convergent validity was assessed using the Average Variance Extracted (AVE) method. The criterion for determining convergent validity was an AVE above 0.50 for each construct as proposed by Fornell and Larcker (2018). To assess discriminant validity, the square root of each AVE was compared with the correlation coefficients for each construct. A correlation coefficient of less than the

square root of the AVE suggests discriminant validity if the inter-correlations among a set of variables presumed to measure different constructs are not high (Kline, 2016).

A first-order CFA was performed on each of the constructs explored in this study using a measurement model encapsulating the following seven constructs: SMS policy implementation (SMSPol), SMS process engagement (SMSPro), transformational safety leadership (TSL), self-efficacy (SE), safety compliance (SC), safety participation (SP), and safety motivation (SM). IBM SPSS AMOS 27 Graphics® was used to carry out the analysis to determine the goodness of fit indices, factor loading, and other relevant inferential outputs.

Competing measurement models were assessed, and sequential iterations based on theoretical guidance and the modification indices from the AMOS software were used to select the measurement model with the best fit for the observed data. Each assessment iteration resulted in post hoc modifications to the model, generally due to low factor loadings. Low factor loadings led to the exclusion of items from the following constructs: safety compliance (SC), safety participation (SP), safety motivation (SM), SMS policy implementation (SMSPol), SMS process engagement (SMSPro), self-efficacy (SE) and safety motivation (SM). Specifically, SMSPOL2, SMSPOL5, SMSPRO3, SE3, SE4, SC1, SP1, and SM1 were excluded from the final measurement model. Additionally, consideration was given to instrument performance by construct in the final measurement model (an attempt was made to retain at least three items per construct for better reliability). In the final iteration, the covariances were added between errors as suggested by the AMOS modification indices, leading to the final measurement model.

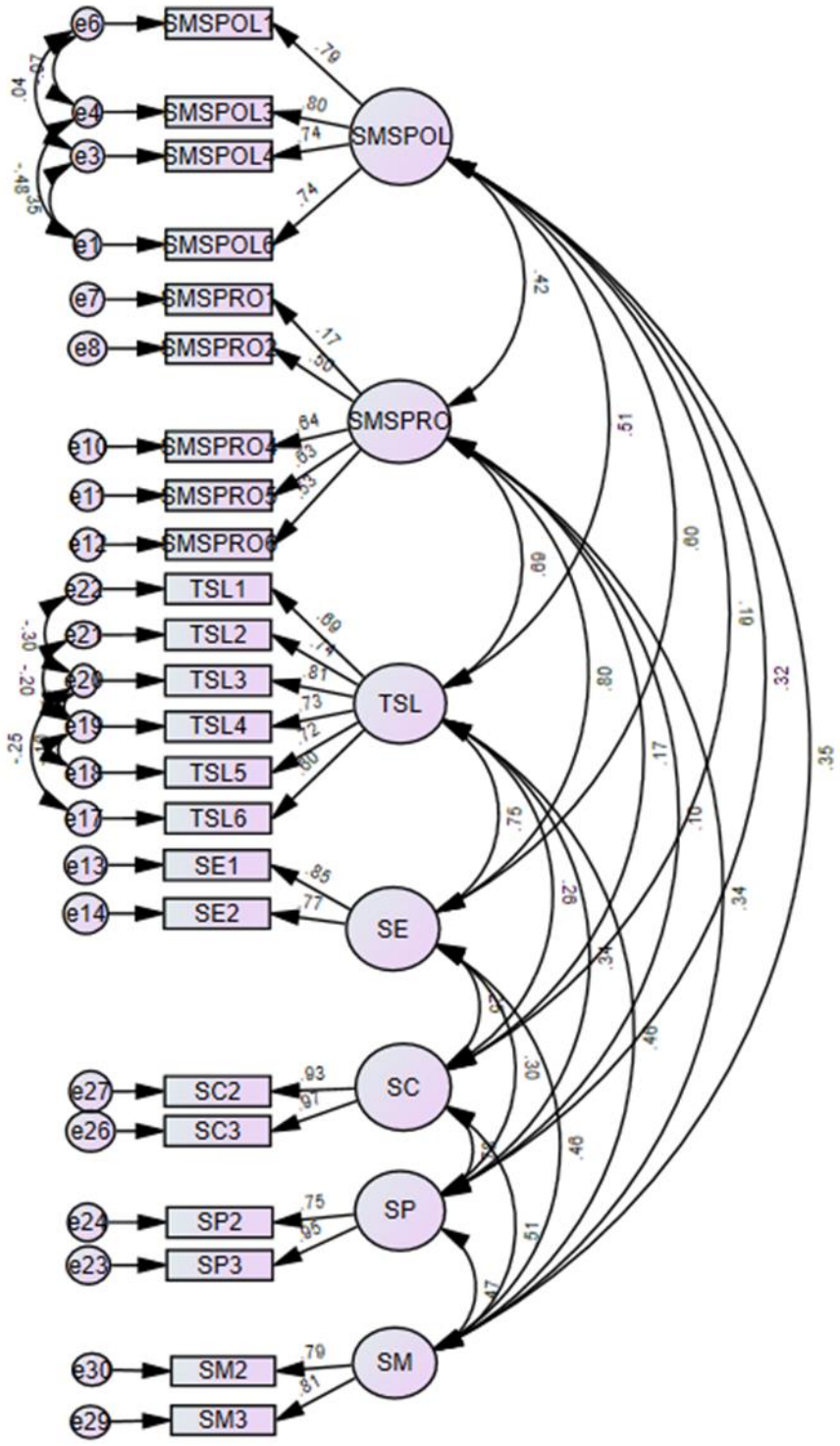
Table 4

Goodness-of-Fit Estimates for Various Measurement Models.

Iteration	Chi-square ($\chi 2$)	NFI	IFI	TLI	CFI	RMSEA
Model I	$\chi 2$ (413, 256) = 1273.14, CMIN/DF = 3.083, $p < .001$	.736	.805	.778	.803	.090 (.085 - .096)
Model II	$\chi 2$ (329, 256) = 1007.84, CMIN/DF = 3.063, $p < .001$ (remove: SC1; SP1; SM1)	.762	.826	.798	.824	.090 (.084 - .096)
Model III	$\chi 2$ (278, 256) = 785.79, CMIN/DF = 2.827, $p < .001$ (remove: SMSPol 2; SE4)	.793	.856	.829	.854	.085 (.078 - .092)
Model IV	$\chi 2$ (209, 256) = 524.26, CMIN/DF = 2.513, $p < .001$ (remove: SMSPol5; SMSPro3; SE3)	.836	.894	.870	.893	.077 (.069 - .085)
Final Model	$\chi 2$ (200, 256) = 427.98, CMIN/DF = 2.14, $p < .001$ (covary: e20/e22; e19/e21; e19/e20; e18/e19; e17/e20; e4/e6; e3/e6; e1/e4; e1/e3)	.866	.924	.902	.923	.057 (.050 - .064)

Figure 10

Final Measurement Model



Descriptive statistics including mean, median, standard deviation, and standard error of the mean were assessed and normality (kurtosis and skewness) was checked for the emergent data set. Additionally, a visual inspection of the data versus the normal distribution curve was conducted. All subject variables indicated nominal performance, except safety motivation (SM) and safety compliance (SC). Safety motivation (SM) was negatively skewed at -2.99 and exhibited a kurtosis of 9.99. Safety compliance (SC) exhibited negative skewness of -1.86 and a kurtosis of 7.65.

Table 5

Descriptive Statistics and Scale Reliabilities of Study Variables (I).

	SMSPol	**SMSPro**	**SE**	**SM**
N	256	256	256	256
Mean	4.1904	4.2296	4.2910	4.8414
Std. Error of Mean	.04796	.03038	.03903	.02237
Median	4.3300	4.1700	4.5000	5.0000
Std. Deviation	.76740	.48607	.62448	.35788
Skewness	-.912	-.339	-.905	-2.990
Std. Error of Skewness	.152	.152	.152	.152
Kurtosis	-.096	-.706	.008	9.993
Std. Error of Kurtosis	.303	.303	.303	.303
Composite Reliability	0.95	0.86	0.80	0.88
# Items in Scale	4	5	2	2

The negative skewness and leptokurtic nature of both distributions are not surprising given the scale used for the constructs (one to five, five being the most positive selection). However, due to the adequate sample size, it was assumed that any potential issues with normality will be mitigated.

In terms of scale consistency and reliability, all the constructs assessed had composite reliability above the 0.70 thresholds, consistent with findings from previous studies. Tables 4 and 5 contain the information on the descriptive statistics and composite reliability for all scales used in the study.

Convergent validity was assessed using the AVE method (Fornell & Larcker, 1981). This method allows the assessment of the amount of variance captured by the construct (Fornell & Larcker, 1981). The AVE values for all scales were above the 0.50 threshold, except SMS Process Engagement (SMSPro) at 0.49. Convergent validity could not be ascertained for SMSPro based on the data using the Fornell-Larcker approach. However, based on theoretical foundations, one can still include items that narrowly fail to meet a priori criteria (Bollen and Lennox, 1991). Thus, due to the high composite reliability of the scale for the construct demonstrated in the study (CR = .86), further analysis will be done using SMSPro in the analysis.

Table 6

Descriptive Statistics and Scale Reliabilities of Study Variables (II).

	SC	SP	TSL	SRE
N	256	256	256	256
Mean	4.4691	4.3881	4.2595	2.8131
Std. Error of Mean	.03713	.03713	.04047	.02628
Median	4.6700	4.3300	4.3300	2.8100
Std. Deviation	.59413	.59411	.64758	.42047
Skewness	-1.869	-1.009	-.584	.376
Std. Error of Skewness	.152	.152	.152	.152
Kurtosis	7.651	2.838	-.842	.595
Std. Error of Kurtosis	.303	.303	.303	.303
Composite Reliability	0.95	0.84	0.98	0.88
# Items in Scale	2	2	6	4

Discriminant validity (or the degree to which items within a construct only measure the construct in question and no other construct) was assessed by comparing the square root of each AVE with the correlation coefficients for each construct (Kline, 2016). Using this method, so long as the correlation coefficient is less than the square root of the AVE, discriminant validity is believed to exist (Fornell & Larcker, 1981).

Given the results of the analysis, discriminant validity can be assumed. Table 7 contains the AVE and correlation values used in the analysis.

Table 7

The square root of AVE (diagonal) and correlation between constructs (off-diagonal).

	AVE	**SMSPol**	**SMSPro**	**SE**	**TSL**	**SM**	**SC**	**SP**
SMSPol	0.59	**0.767**						
SMSPro	0.49	0.421	**0.523**					
SE	0.66	0.604	0.801	**0.809**				
TSL	0.52	0.506	0.689	0.751	**0.718**			
SM	0.64	0.352	0.337	0.459	0.461	**0.799**		
SC	0.90	0.186	0.169	0.252	0.261	0.508	**0.949**	
SP	0.73	0.319	0.102	0.312	0.341	0.473	0.785	**0.857**

Question One

What is the effectiveness of a final measurement model that assesses the relationships between SMS process engagement, SMS policy implementation, transformational safety leadership, self-efficacy, and the outcome variable safety behavior measured by safety compliance and safety participation, when mediated by safety motivation at a commercial air carrier?

A Structural Equation Model (SEM)/Path Analysis (PA) approach was used to determine the strength of relationships between study variables, including the fit indices of all competing structural models and the model with the best fit selected. Multiple measures for goodness-of-fit indices were reported as part of the model effectiveness: Chi-square ($\chi 2$), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Normed Fit Index (NFI), Root Mean Square Error of Approximation (RMSEA), and Incremental Fit Index (IFI).

The chi-square ($\chi 2$) is a classic goodness-of-fit measure used to assess overall model fit. A potential shortcoming of chi-squared is its sensitivity to sample size (i.e., it becomes more difficult to retain the null hypothesis as the number of cases increases (Kline, 2016)). Chi-square tests the null hypothesis that the predicted model and observed data are equal.

The Comparative Fit Index (CFI) evaluates the fit of a user-specified solution concerning a more restricted model in which the covariance among all input indicators is fixed to zero, or no relationship among variables (Brown, 2006, p.86). CFI ranges from 0 (poor fit) to 1 (good fit).

The Tucker-Lewis index (TLI) is a non-normed fit index, and like the CFI a value of 0.95 or above is considered a good fit. TLI can have values outside of the range of 0.0 – 1.0, but the ideal value approaches 1.0 (Brown, 2006). The Normed Fit Index (NFI) and Incremental Fit Index (IFI) should be above 0.90, otherwise, the model may need improvement (Kline, 2016).

Root Mean Square Error of Approximation (RMSEA) is another commonly reported statistic used in SEM. A value of 0.05 or less indicates a close fit of the model

about the degrees of freedom, while greater than 0.10 could indicate a problem (Kline, 2016). RMSEA is not as sensitive to sample size as is chi-square but can be sensitive to model complexity (Brown, 2006).

An assessment was performed on the first competing hypothesized measurement model (fully mediated) that captured the relationship between the variables (Model I). The fully mediated measurement model did not produce acceptable goodness-of-fit indices. See Appendix E for the fully mediated initial measurement model. Using theoretical guidance and recommendation from the AMOS modification indices (MI) function, covariances were added between the error terms of the endogenous variables to produce another competing model with a relatively improved model fit (Model II, shown in Appendix F).

Additional iterations were done to improve Model II by removing various combinations of variables (namely TSL-->SC, SMSPro --> SP; SE --> SP). Various fit indices measures fluctuated, and another competing model with better fit indices was recommended by MI and explored. The final best-fit indices were obtained on Model V. The direct path between SMSPro and SP was removed, and a covariance term was added between error terms e6/e7.

The resulting competing model (Model V as shown in Figure 11) was adopted as the final structural model with the best indices across all measures: $\chi 2$ (1, 256) = 0.152, CMIN/DF = .003, p = .956, NFI = 1.000, IFI = 1.002, TLI = 1.038 , CFI = .999, and RMSEA = .000 (.000 - .000). Table 8 shows the goodness-of-fit indices for the competing models. Table 9 depicts estimates of the Relationships Between SMSPol, SMSPro, TSL, SE, SM, SC, and SP in the final model.

Additionally, Table 9 addresses the estimates for the constructs in the model, including maximum likelihood estimates (MLE), standard error (SE), critical ratios (CR), p-values, estimated effect sizes, and hypothesis of the final measurement model with the best goodness-of-fit.

Table 8

Goodness-of-Fit Estimates for Various Structural Models

Iteration	Chi-square ($\chi 2$)	NFI	IFI	TLI	CFI	RMSEA
Model I	Unspecified	N/A	N/A	N/A	N/A	N/A
Model II	$\chi 2$ (4, 256) = 74.07, CMIN/DF = 18.518, p = .000 (TSL-->SC removed; SMSPro --> SP removed; SE --> SP removed; remove covary e6/e7)	.871	.871	.332	.873	.262 (.212 - .316)
Model III	$\chi 2$ (2, 256) = 0.015, CMIN/DF = .005, p = .995 (TSL-->SC removed; SMSPro --> SP removed; SE --> SP restored; covary e6/e7)	1.000	1.003	1.035	.999	.000 (.000 - .039)
Model IV	$\chi 2$ (3, 256) = 0.152, CMIN/DF = .051, p = .985 (TSL-->SC removed; SMSPro --> SP removed; SE --> SP removed; covary e6/e7)	1.000	1.005	1.036	.999	.000 (.000 - .000)
Model V	$\chi 2$ (1, 256) = 0.152, CMIN/DF = .003, p = .956 (TSL-->SC restored; SMSPro --> SP removed; SE --> SP restored; covary e6/e7)	1.000	1.002	1.038	.999	.000 (.000 - .000)

Figure 11

Model V - final structural model with best-fit indices.

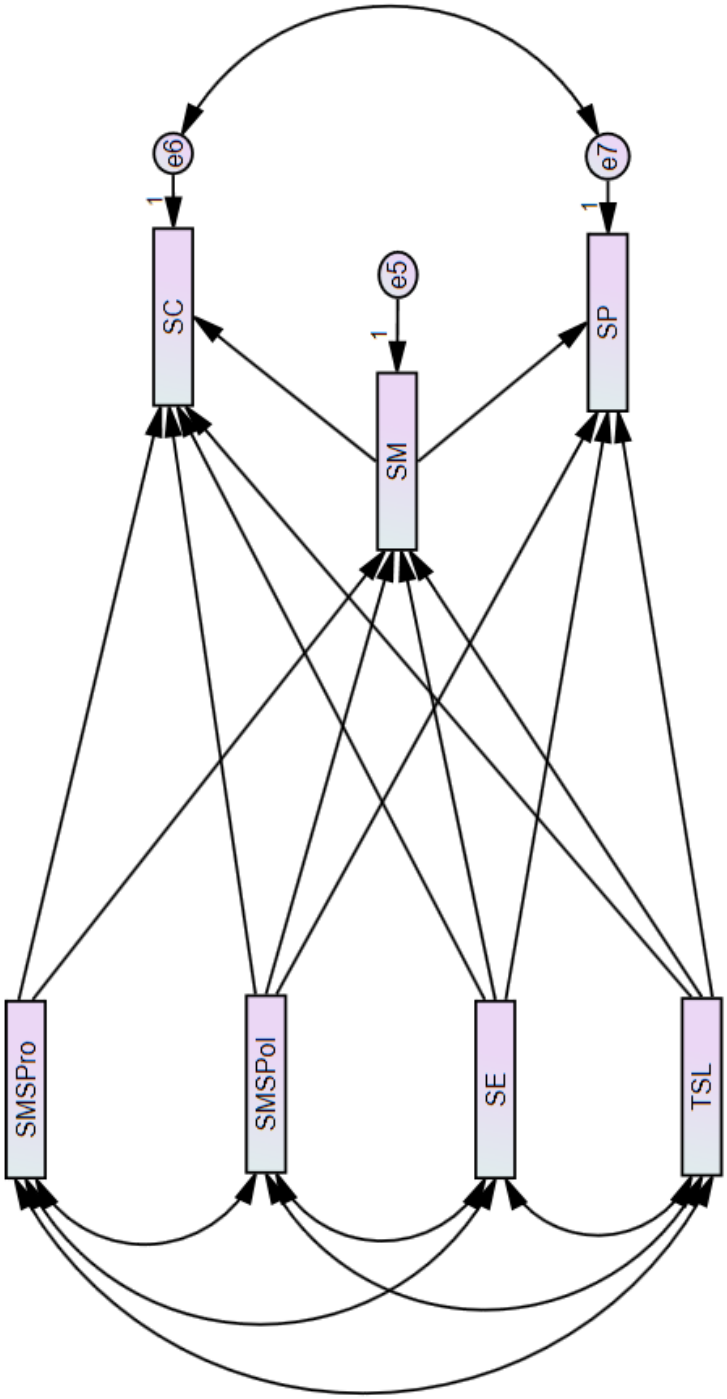


Figure 12

Final structural model with standardized regression weights.

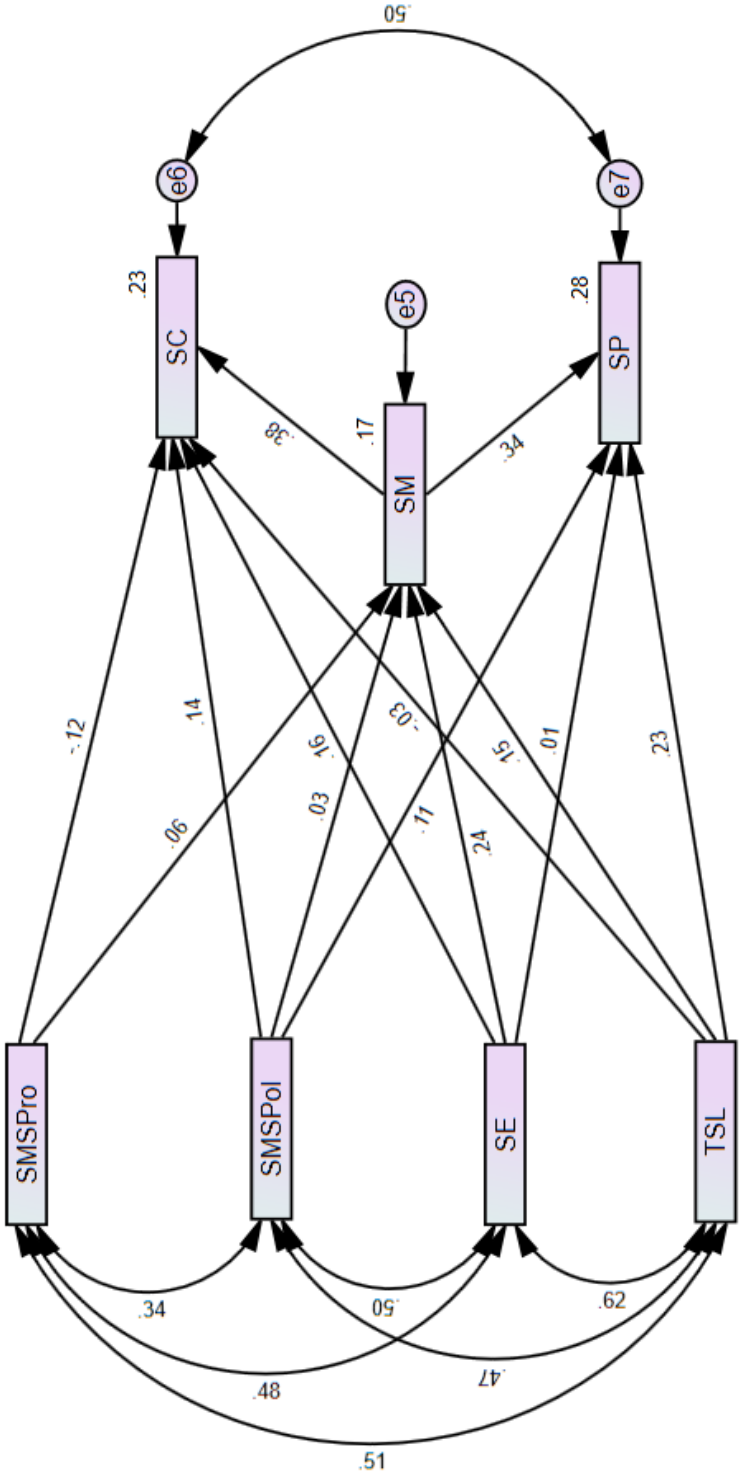


Table 9

Estimates of Final Measurement Model of the Relationship Between SMSPol, SMSPro, TSL, SE, SM, SC and SP

Interactions			Estimate	S.E.	C.R.	*p*	*β*	Direct Effect	Indirect Effect	Total Effect	Hypothesis Testing
SM	<---	SMSPro	.046	.050	.914	.361	.063	.063	.000	.063	Not Supported
SM	<---	TSL	.083	.043	1.928	*	.150	.150	.000	.150	**Supported**
SM	<---	SE	.140	.045	3.134	.*	.244	.244	.000	.244	**Supported**
SM	<---	SMSPol	.014	.032	.451	.652	.031	.031	.000	.031	Not Supported
SC	<---	SMSPro	-.147	.070	-2.103	*	-.120	-.120	.024	-.097	**Supported**
SC	<---	TSL	-.025	.067	-.378	.706	-.028	-.028	.056	-.029	Not Supported
SP	<---	TSL	.213	.057	3.723	***	.232	.232	.051	.283	**Supported**
SC	<---	SM	.625	.100	6.260	***	.376	.376	.000	.376	**Supported**
SP	<---	SM	.565	.094	5.988	***	.341	.341	.000	.341	**Supported**
SC	<---	SE	.149	.063	2.372	*	.157	.157	.092	.249	**Supported**
SP	<---	SE	.006	.069	.081	.936	.006	.006	.078	.084	Not Supported
SP	<---	SMSPol	.089	.047	1.905	*	.115	.115	.010	.125	**Supported**
SC	<---	SMSPol	.105	.050	2.097	*	.136	.136	.012	.147	**Supported**

Note: ***$p < .000$, **$p < .001$, *$p < .05$

Hypothesis Testing

The study was designed to evaluate the strengths of relationships between of SMSPol (SMS policy implementation) and SMSPro (SMS process engagement) on safety behaviors as measured by SC (safety compliance) and SP (safety participation). Additionally, the mediating role of SM (safety motivation) on the relationships between SMS components, TSL (transformational safety leadership), and SE (self-efficacy), and the variables measuring safety behaviors (SC and SP) were assessed. The results of the interactions between the constructs based on the final measurement model adopted were used to validate the 23 hypotheses initially postulated. Standardized R-squared coefficients were reported in the results to quantify the effect of the exogenous variables on the endogenous variables.

Hypothesis 1. Respondents' perceptions of their carrier's SMS process engagement are related to their safety motivation. The results indicated that the strength of the relationship between SMSPro and SM was not statistically significant ($p = 0.361$). The null hypothesis is retained in favor of the alternative which is not supported.

Hypothesis 2. Respondents' perceptions of their carrier's SMS process engagement are related to safety compliance. The results indicated that a weak relationship between SMSPro and SC was statistically significant ($\beta = -0.120$, S.E. = 0.070, C.R. = -2.103, $p < .05$). The null hypothesis was rejected in favor of the alternate hypothesis.

Hypothesis 3. Respondents' perceptions of their carrier's SMS process engagement are related to safety participation. The final structural model did not include

a direct link between SMSPro and SP. Thus, the hypothesis could not be validated in the study population.

Hypothesis 4. Respondent safety motivation mediates the relationship between their perceptions of their carrier's SMS process engagement and safety compliance. The results indicated that the relatively weak direct relationship between SMSPro and SC was statistically significant (β = -0.120, S.E. = 0.070, C.R. = -2.103, $p < .05$). The direct effect of SMSPro on SC was -.120, the indirect (mediated) effect was .024, for a total effect of -.097. Thus, the null hypothesis was rejected.

Hypothesis 5. Respondent safety motivation mediates the relationship between their perceptions of their carrier's SMS process engagement and safety participation. The results indicated that there is no direct link between SMSPro and SP in the model. The hypothesis therefore could not be validated.

Hypothesis 6. Respondents' perceptions of their carrier's SMS policy implementation are related to their safety motivation. The relationship between SMSPol and SM failed to achieve significance in the study ($p = 0.652$). Thus, the null hypothesis was retained.

Hypothesis 7. Respondents' perceptions of their carrier's SMS policy implementation are related to safety compliance. The study revealed a relatively weak relationship between SMSPol and SC (β = 0.136, S.E. = 0.050, C.R. = 2.097, $p < .05$). The direct effect of .136 and the indirect effect of .012 reflected a total effect of .147. Thus, the null hypothesis was rejected in favor of the alternate hypothesis.

Hypothesis 8. Respondents' perceptions of their carrier's SMS policy implementation are related to safety participation. The study revealed a relatively weak

relationship between SMSPol and SP (β = 0.115, S.E. = 1.047, C.R. = 1.095, $p < .05$). The direct effect of .115 and the indirect effect of .010 reflected a total effect of .125. Thus, the null hypothesis was rejected in favor of the alternative hypothesis.

Hypothesis 9. Respondent safety motivation mediates the relationship between their perceptions of their carrier's SMS policy implementation and safety compliance. The study results achieved significance regarding a moderate effect of SM on SC (β = 0.376, S.E. = 0.100, C.R. = 6.260, $p < .001$). The direct or unmediated effect was .136, the indirect (mediated) effect was .012 for a total effect of .147. Thus, the null hypothesis was rejected in favor of the alternative hypothesis.

Hypothesis 10. Respondent safety motivation mediates the relationship between their perceptions of their carrier's SMS policy implementation and safety participation. The study results achieved significance regarding an unmediated moderate effect of SM on SP (β = 0.341, S.E. = 0.094, C.R. = 5.988, $p < .001$). The direct or unmediated effect was .115, and the indirect (mediated) effect was .010 for a total effect of .125. Thus, it was appropriate to reject the null hypothesis.

Hypothesis 11. The transformational safety leadership styles of top-level management are related to the safety motivation of respondents. The study results achieved significance regarding an unmediated weak effect of TSL on SM (β = 0.150, S.E. = 0.043, C.R. = 1.928, $p < .05$). Thus, it was appropriate to reject the null hypothesis.

Hypothesis 12. The transformational safety leadership styles of top-level management are related to safety compliance. The relationship between TSL and SC

failed to achieve significance in the study ($p = 0.706$). Thus, the null hypothesis was retained.

Hypothesis 13. The transformational safety leadership styles of top-level management are related to safety participation. The study revealed a relatively weak relationship between TSL and SP ($\beta = 0.232$, S.E. = 0.057, C.R. = 3.723, $p < .001$). The direct effect of .232 and the indirect effect of .051 reflected a total effect of .283. Thus, it was appropriate to reject the null hypothesis.

Hypothesis 14. The safety motivation of respondents mediated the relationship between their perceptions of transformational safety leadership and safety compliance. The study results suggested no significant relationship between TSL, and SC when mediated by SM ($\beta = -0.028$, S.E. = 0.067, C.R. = -0.378, $p = 0.706$). The direct effect of -.028 and indirect effect of .056 reflected a total effect of .029. Due to the failure to achieve the a priori significance level, the null hypothesis was retained.

Hypothesis 15. The safety motivation of respondents mediates the relationship between their perceptions of transformational safety leadership and safety participation. The study results achieved significance between TSL, and SP mediated by SM ($\beta = 0.232$, S.E. = 0.057, C.R. = 3.723, $p < 0.001$). The direct effect of .232 and the indirect effect of .051 reflected a total effect of .283. Thus, it was appropriate to reject the null hypothesis in favor of the alternative hypothesis.

Hypothesis 16. Respondents perceived self-efficacy is related to their safety motivation. The study revealed a relatively weak relationship between SE and SM ($\beta = 0.244$, S.E. = 0.045, C.R. = 3.134, $p < .05$). The direct effect was .244 with no observed indirect effect. Thus, it was appropriate to reject the null hypothesis.

Hypothesis 17. Respondents perceived self-efficacy is related to safety compliance. The study results achieved significance for the weak direct effect between SE and SC ($\beta = 0.157$, S.E. = 0.063, C.R. = 2.372, $p < .05$). Thus, it was appropriate to reject the null hypothesis.

Hypothesis 18. Respondents perceived self-efficacy is related to safety participation. The analysis resulted in a non-significant direct link between SE and SP, thus the null hypothesis is retained.

Hypothesis 19. Respondent safety motivation mediates the relationship between their perceptions of their self-efficacy and safety compliance. The study results achieved significance for the weak effect between SE and SC ($\beta = 0.157$, S.E. = 0.063, C.R. = 2.372, $p < .05$). The direct effect was .157 and the indirect (mediated) effect between SE and SC was .092, for a total effect of .249. Thus, the null hypothesis was rejected.

Hypothesis 20. Respondent safety motivation mediates the relationship between their perceptions of their self-efficacy and safety participation. The study results contained a non-significant direct path between SE and SP (mediated by SM). Thus, the null hypothesis is retained.

Question Two

What are the strengths of the relationship between safety behavior (as measured by safety compliance and safety participation) and safety-related events?

Hypothesis 21. Respondent safety compliance is related to safety participation. The study results indicated a strong relationship between SC and SP ($\beta = 0.590$, S.E. = 0.053, C.R. = 11.216, $p < .001$). Thus, the null hypothesis was rejected.

Hypothesis 22. Respondent safety compliance is related to safety participation when mediated by an awareness of safety-related events. The study results indicated a moderate relationship between SC and SP mediated by SRE (β = 0.310, S.E. = 0.052, C.R. = 4.232, $p < .001$). The direct effect of SC and SP, when moderated by SRE, was .310, and the indirect (mediated effect) was .001, for a total effect of .311. Thus, it was appropriate to reject the null hypothesis.

Hypothesis 23. Respondent safety compliance is related to safety-related events. The study results did not indicate a significant direct effect between SC and SRE (p = 0.781). Thus, it was appropriate to retain the null hypothesis.

Table 10 shows the details of the Path Analysis estimates for the relationships between SC, SP, and SRE. Figure 13 also shows the Path Analysis diagram of the relationships. Table 11 provides a summary of all the hypotheses tested and their final validation outcomes.

Table 10

Path Estimates for Interactions between SC, SP, and SRE

Interactions	MLE	S.E.	C.R.	*p*	*β*	Direct Effect	Indirect Effect	Total Effect	Null Hypothesis
SP <--- SC	.591	.053	11.216	***	.590	.591	.003	.594	Reject
SRE <--- SP	.219	.052	4.232	***	.310	.310	.001	.311	Reject
SC <--- SRE	.032	.114	.279	.781	.023	.000	.023	.023	Accept

Note: ***p<.000, **p<.001, *p<.05

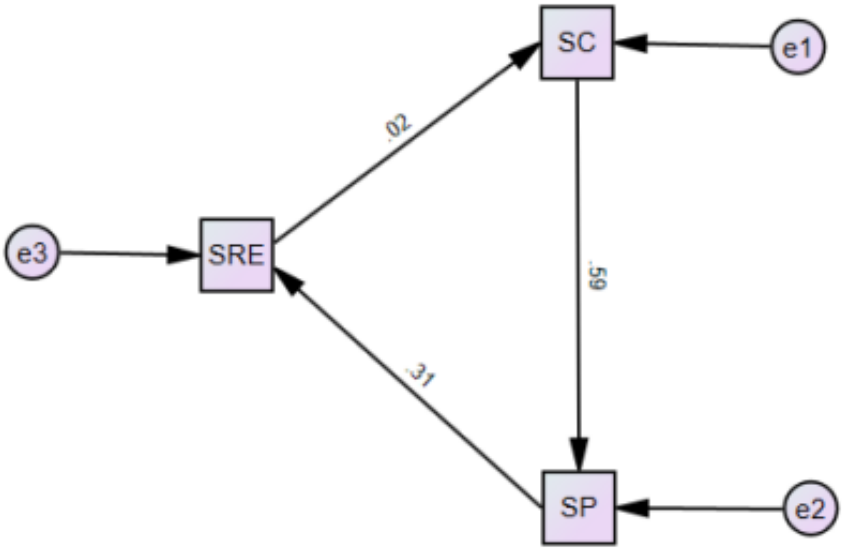


Figure 13. SEM-PA relationship between SP, SC, and SRE.

Table 11

A summary of the results of the hypotheses tested.

Hypothesis	Results
H_1: Respondents' perceptions of their carrier's SMS process engagement are related to their safety motivation.	Not Supported
H_2: Respondents' perceptions of their carrier's SMS process engagement are related to safety compliance.	Supported
H_3: Respondents' perceptions of their carrier's SMS process engagement are related to safety participation.	Not Supported
H_4 Respondent safety motivation mediates the relationship between their perceptions of their carrier's SMS process engagement and safety compliance.	Supported
H_5: Respondent safety motivation mediates the relationship between their perceptions of their carrier's SMS process engagement and safety participation.	Not Supported
H_6: Respondents' perceptions of their carrier's SMS policy implementation are related to their safety motivation.	Not Supported
H_7: Respondents' perceptions of their carrier's SMS policy implementation are related to safety compliance.	Supported
H_8: Respondents' perceptions of their carrier's SMS policy implementation are related to safety participation.	Supported
H_9: Respondent safety motivation mediates the relationship between their perceptions of their carrier's SMS policy implementation and safety compliance.	Supported
H_{10}: Respondent safety motivation mediates the relationship between their perceptions of their carrier's SMS policy implementation and safety participation.	Supported
H_{11}: The transformational safety leadership styles of top-level management are related to the safety motivation of respondents.	Supported

Table 11 continued

Hypothesis	Results
H_{12}: The transformational safety leadership styles of top-level management are related to respondent safety compliance.	Not Supported
H_{13}: The transformational safety leadership styles of top-level management are related to respondent safety participation.	Supported
H_{14}: Safety motivation of respondents mediates the relationship between their perceptions of transformational safety leadership and safety compliance.	Not Supported
H_{15}: Safety motivation of respondents mediates the relationship between their perceptions of transformational safety leadership and safety participation.	Supported
H_{16}: Respondent perceived self-efficacy is related to their safety motivation.	Supported
H_{17}: Respondent perceived self-efficacy is related to safety compliance.	Supported
H_{18}: Respondent perceived self-efficacy is related to safety participation.	Not Supported
H_{19}: Respondent safety motivation mediates the relationship between their perceptions of their self-efficacy and safety compliance.	Supported
H_{20}: Respondent safety motivation mediates the relationship between their perceptions of their self-efficacy and safety participation.	Not Supported
H_{21}: Respondent safety compliance is related to safety participation.	Supported
H_{22}: Respondent safety compliance is related to safety participation when mediated by an awareness of safety-related events.	Not Supported
H_{23}: Respondent safety compliance is related to their perception of safety-related events.	Not Supported

Question Three

What are the differences in perception among the demographic variables (years at the carrier, age group, flight certification level (first officer, captain, check-airman), SMS training status, and gender) on safety compliance and safety-related events?

A one-way between-S ANOVA was utilized to compare the mean scores on the respondent perception of safety compliance (SC) and safety-related events (SRE) by years at the carrier. Visual examination of the data for outliers, as well as inspection of the histograms, confirmed a normal distribution for the SC and SRE data.

As part of the analysis, a Levene test was conducted to detect serious violations of homogeneity of variance assumptions across years at the company groups with respect to SC. No significant violations were found, F (6, 256) = 1.49, p = .182. The overall F value for the one-way ANOVA was statistically significant, F (6, 256) = 2.44, p = .026. A Bonferroni-Tukey post hoc test revealed significant differences between the mean scores on SC of the >20 – 25 Years at the company group (M = 4.31, SD = .653) and the >25 – 30 Years at the company group (M = 4.72, SD = .425), suggesting that the latter had more favorable perceptions on SC items.

An examination of safety-related events (SRE) and years at the carrier revealed no significant differences, F (6, 256) = 2.11, p = .052.

Though there was a significant difference noted in SC scores and years at the company, there were no significant differences in SC and age, F (6, 256) = 1.41, p = .202, nor SRE and age, F (6, 256) = 1.03, p = .410. The significant difference in SC by tenure, with the most tenured folks showing the highest level of SC, may indicate that these personnel have internalized the safety culture of the carrier and they exhibit it in the

operation, or they may have become the most tenured in the group because they exhibit the qualities demonstrated as part of the SC construct.

There were no significant differences detected between the pilot workgroups and safety compliance, F (4, 256) = 1.76, p = .138. Regarding workgroup and safety-related events, a significant difference was detected between groups, F (4, 256) = 3.03, p = .012. A Bonferroni-Tukey post hoc test revealed significant differences between the mean scores of First Officers (M = 2.67, SD = .363) and Check Airmen (M = 2.91, SD = .384). The First Officers perceived a lower occurrence of safety-related events than the Check Airmen.

SC and gender were examined using an independent t-test of means. Statistically significant results were found during the Levene Test, F (2, 252) = 14.96, p < .001. Thus, homogeneity of variance or equal variances could not be assumed. The t-test indicated significant results between SC and gender, t (51.50) = 5.61, p < .001. Female pilot perception of safety compliance (M = 4.80, SD = .243) was significantly higher than that of male pilot perception regarding safety compliance (M = 4.44, SD = .609). The Cohen's d estimate was .626, indicating a medium effect size.

An analysis of SRE and gender using an independent t-test of means revealed statistically significant results during the Levene Test, F (2, 252) = 9.76, p = .002. Thus, homogeneity of variance or equal variances could not be assumed. As mentioned earlier, the scale for SRE was: Extremely Rare (1); Rare (2); Occasional (3); Frequent (4); Very Frequent (5). The t-test indicated significant results between SRE and gender, t (52.54) = 3.85, p < .001. Female pilots perceived a higher rate of safety-related events (M = 2.98,

SD = .171) than male pilots (*M* = 2.80, *SD* = .434). The Cohen's *d* (effect size) was .426, indicating a weak to moderate effect.

The final analysis examined the differences in respondents' perceptions of safety compliance, safety participation, and safety-related events based on their initial exposure to SMS training. No significant differences were noted between SC and first exposure to SMS, t (254) = .804, p = .422.

However, a significant difference was noted between SRE and first exposure to SMS, t (254) = 3.37, $p < .001$. Results suggest that pilots whose first exposure to SMS was at the carrier (*M* = 2.86, *SD* = .428) perceived higher rates of SRE than those who had experienced SMS training for the first time elsewhere (*M* = 2.66, *SD* = .359). The Cohen's *d* (effect size) was .486, indicating a weak to moderate effect. Finally, no significant differences were noted between safety participation (SP) and those who experienced SMS at a place other than the carrier than those whose first experience was at the carrier, t (254) = .124, $p < .901$.

Semi-Structured Interviews

Qualitative Data Analysis and Validation

The qualitative data portion of the study was designed to gather the opinions and recommendations of middle management and senior leaders regarding the implementation and execution of SMS at the carrier. All interviews were conducted remotely using Microsoft Teams® software. This video conferencing suite contained audio, video, and transcription capabilities that were appropriate for the research.

Initial quality assurance tests confirming the accuracy of the transcription function within the Teams® software were completed before formal interviews began. A small

number of random scripts were read in an environment representative of the interview conditions, and audio (MP3) recordings and transcripts were automatically produced. The transcripts were then manually checked for errors. Once it was determined the Microsoft Teams package was fit for the task, the interview portion of the study began. Per the design of the study, interviews were recorded via MP3 files while being simultaneously transcribed by the Teams® software. After completion of the interview, the transcript was examined for any obvious errors, and if there was a need for clarification, the MP3 file was accessed. The cleaned-up transcript of each session was then sent to the respondent for their review before inclusion in the analysis. Respondents were given the opportunity to ask the researcher to remove or modify content for errors, inadvertent misstatements, or poorly transcribed items. After the respondent review was complete, the data was integrated into the larger package of de-identified data.

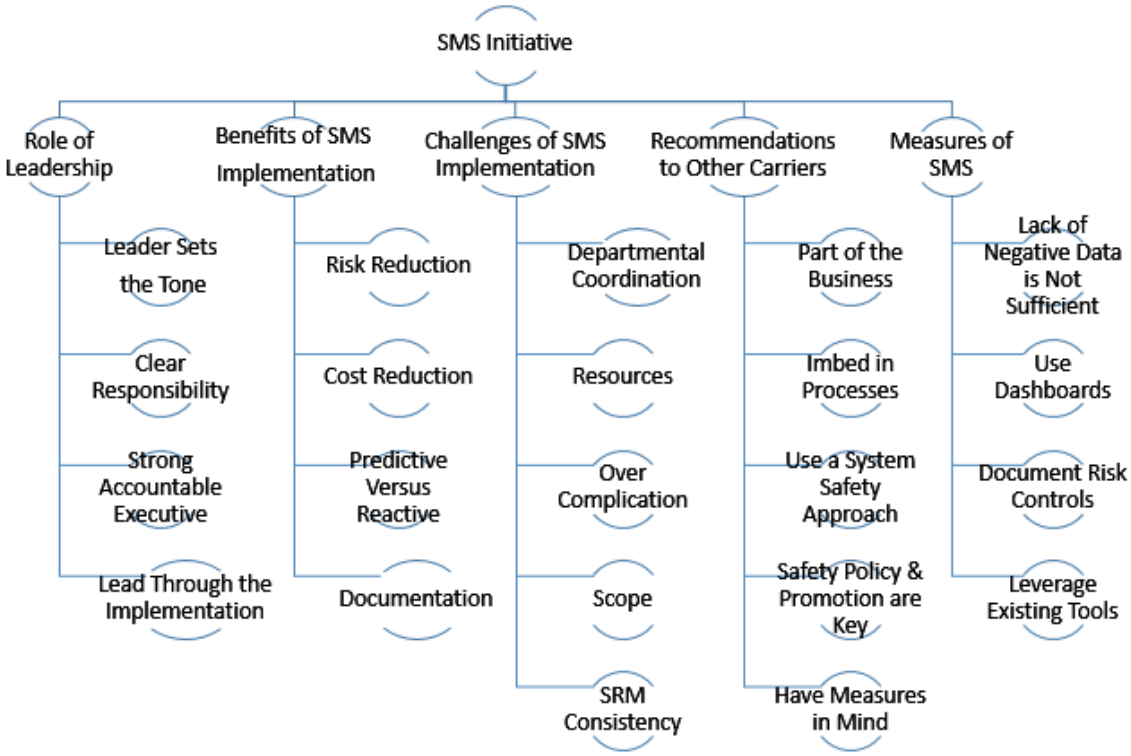
The data from the transcripts was imported into NVivo 12® for further analysis. NVivo 12® is a capable software package that facilitates the coding and theming of information gathered from a wide variety of sources. The package also allows a researcher to develop a visual or schematic presentation of the data, such as the use of word clouds, thematic trees, etc.

The transcripts were coded using an in-vivo approach (using the words of the respondents) and descriptive coding (summarizing the respondent's words into a short phrase) as discussed by Saldaña and Omasta (2018). A deductive framework that was guided a priori using themes found in previous research was utilized (Adjekum, 2014b; 2017; Adjekum & Tous, 2020). The themes which emerged were generally in line with previous studies, but additional information applicable to Part 121 carriers was extracted,

as well. Additionally, field notes and analytic memos were used in conjunction with the interview transcripts to round out the data gathered (Saldaña & Omasta, 2018). Some direct quotes were added to the discussion to reinforce the points made by the participants. The major themes of the qualitative portion of the study included: the role of leadership, benefits of SMS implementation, challenges of SMS implementation, recommendations to other carriers, and measures of SMS.

Figure 14

Conceptual tree of study codes and themes.



Role of Leadership

As was accomplished in Adjekum and Jensen's 2016 work, the following question was asked: "*What role does leadership play in the safety policy implementation of the SMS program?"* The question was designed to evaluate the perceptions of senior

leaders regarding the potential connection between transformational safety leadership and the successful implementation of an SMS. Four distinct themes emerged from the responses (covered below). The respondents were unanimous in their belief that strong leadership is a necessary ingredient for the successful implementation and maintenance of an SMS.

Leader sets the tone. Multiple respondents clearly reported the leader sets the tone for the safety culture of the organization. The leader also gives priority, energy, and is the driving force for the implementation and execution of an SMS. Though there is an important element of SMS that originates from the shop floor, respondents repeatedly stated that active leadership is key to the successful implementation of SMS:

Leader A reinforced the leadership view:

"I think leadership plays a pretty important role in the overall implementation of SMS and just setting the clear expectations of all of the people, whether it's management or frontline, giving them an expectation of what we're working towards."

Leader B added clarification—the leader must believe in the effort:

"Well, I mean, at least from where I sit, understanding that you're supported in this effort by senior leadership and that it is something not just directed, but that we actually believe in the benefits of it. Buy-in can be facilitated from the top down."

Clear responsibility. Respondents also reiterated that leadership must have clear responsibility (via the Accountable Executive). The organization must empower the Accountable Executive with the resources, people, and authority to execute an SMS:

Leader A reinforced the connection between SMS and safety performance:

"Leadership is ultimately responsible for safety performance, so I don't think that's too revolutionary. But just like leadership is responsible for financial performance, operational performance, it's yet one more dimension that leadership has always been responsible for, but SMS just clearly defines it and gives us some good fundamental tools to actually accomplish that."

Leader B captured the need for clear accountability from the top:

"I think overall that SMS is driven from the top, and without that energy, I don't think you really have anything to stand on."

Respondents reinforced the expectation of clear lines of responsibility in multiple answers. Additionally, participants discussed the potential issues that might arise when clear responsibility was lacking.

Strong accountable executive. One of the notable aspects of the construction and implementation of an SMS is the concept of the Accountable Executive. Even in a consensus-driven organization (like the carrier in this study), leaders saw the need for a capable and empowered Accountable Executive:

Leader A reinforced the need for the role:

"I think the Accountable Executive plays a significant role. The Accountable Executive signs the safety policy (safety commitment) and leaders have to provide the resources (really the money) to pull off an SMS. So, with that, you do have every single layer of our leadership from the very top all the way down to your frontline leaders really engaged in the safety policy part of SMS."

Lead through the implementation. Respondents addressed both the pre-SMS period at the carrier and the current day policy requiring SMS at U.S. 14 CFR Part 121 companies. The importance of a clear leader helping the carrier navigate both the pre-SMS implementation setting and the post-implementation environment was addressed by multiple participants.

Benefits of SMS Implementation

The following question was asked: "*What are some of the benefits of the implementation of SMS at the carrier?"* This question was designed to initiate a discussion on the positive aspects of SMS implementation and execution at the carrier. Responses ran a wide gamut from the reduction of risk and cost to better documentation of processes to provide for a safer operation. A number of the themes are discussed below.

Risk reduction. Multiple respondents cited various aspects of risk reduction as a major benefit of SMS implementation. Though a carrier may have a very robust safety culture, without the prescriptive framework of SMS, there are many opportunities or gaps through which errors or safety miscues might make it through.

Leader A connected risk reduction and the leadership "heart" of the company:

> *"So first and foremost, I think we have reduced risk in the organization and reduced risk is a reduction in injuries and reduction in damage and both of those have a cost element. But more importantly on the injury side, it just improves the relationship between the company and our employees. If our people genuinely feel that we're looking out for their best interest, employees perceive that as our 'heart'. At best, 'heart' is a hard thing to measure in terms of dollars, but I think*

you'd find that it's just better for their management/employee relationship overall."

Leader B relayed the need for a clear link between hazards and mitigations:

"You know, I feel confident in what we are doing, especially with regards to identifying what the hazards are. By identifying those ineffective risk controls, I can feel comfortable where I need to focus my resources because it's actionable based on what's been provided."

Cost reduction. Not only did the respondents point out risk reduction as a benefit of SMS, but they also mention cost reduction, as well. Whether through reduced injuries, less damage to equipment, or the implementation of efficiencies, cost reduction goes runs parallel with risk reduction when implementing and executing an SMS.

Leader A relayed any cost of SMS implementation will be offset by the operation:

"And then there's the hard dollars, damages, and injuries cost money. So, it behooves us to manage those things from a few financial standpoints, but also it better connects our leadership with our employees by showing that we're looking out for their best interests."

Predictive versus reactive. Over half of the respondents mentioned aspects of the proactive nature of SMS as a benefit to the company. Unlike the traditional Safety I program (which tends to wait for an outcome and then dissect it), SMS enables the organization to identify risks and mitigate them, thus being proactive.

Leader A supported the notion that SMS allows the carrier to be proactive:

"I think the probably the biggest benefit is basically changing from a reactive method to a proactive method. We used to have a lot of data (and we still have a lot of data) that we look at and we would allow the data to kind of guide us in a direction based on whatever it was for that month. Now proactively we can say these are the things that we're wanting to look at because these are what impact risk in our operation, and these are the things we must manage. And so, we can actually go out and specifically collect the data around those specific things, rather than just wait for an event to happen."

Leader B succinctly addressed the benefits of SMS given the lack of negative outcomes:

"We don't have a lot of outcomes. We don't have a lot of big significant incidents (thankfully), and so we as an industry over the last 20 years or so have had to transition into thinking about risk--and that's really important. As you know from the leadership perspective because what we're about now is avoiding the outcome, and so we have to think about probability and severity. We have to base our decision-making based on risk."

Leader C spoke to hazards and proactive implementation of mitigations:

"Evaluating everything and saying OK, what kind of pops to the top? The goal now is to identify those things before they turn into incidents, accidents, injuries, and what have you."

Documentation. A number of the participants in the interviews pointed out an aspect of the implementation of SMS that provided an unforeseen benefit—

documentation. Respondents described a time at the carrier in the recent past when a change was considered, but not implemented, and there was little to no documentation to capture the work accomplished in the evaluation. Under SMS, and the use of several governance tools at this carrier, documentation is much more thorough post SMS implementation, allowing employees to go back and see the "why" behind decisions involving operational risk.

Leader A lauded the greater "lookback" capability under SMS:

"We never kept notes on the things we didn't want before, right? So, you're going to throw away the paperwork on the stuff that you did not want, then five years later (when you go back to the same decision), you will wish you kept the work. Unlike that scenario, SMS does keep everything. It keeps all the decisions that we've made and details of the process. Unlike the scenario I mentioned, we have the details on the ones we agreed upon, and ones that we disagreed about, too. So, when we go back three or five years later, and we have the same airplane with the same issues, we can see why we made decisions and why we may be where we are."

Leader B highlighted the benefits of better record keeping under SMS:

"And there's the documentation piece. In Flight Ops we maintain operational risk records on mitigations and assurance, not just for today, but things we can go back and look at later. As to explaining the 'why' behind actions, this info is critical. It provides for continuity, and it provides also in the case you need to explain something down the road."

Challenges of SMS Implementation

The following question was asked: " *What are some of the challenges in the execution of SMS at the carrier?"* This question was designed to initiate a discussion on the ongoing issues with SMS execution at the company. This item opened the door to a wide discussion of challenges seen in larger organizations: communication, coordination, and mission creep. Additionally, leaders reiterated the importance of being properly resourced (this group overwhelmingly reported they were properly resourced), and the value of trying to not over-complicate one's SMS.

Departmental coordination. Multiple respondents addressed the issue of challenges between departments regarding SMS implementation and execution. Different unions and the mix of contract and non-contract workgroups exacerbate the issue. Additionally, the failure of the regulator to direct Just Cause/Just Culture implementation along with SMS allowed various walls to be reinforced, rather than sharing all safety data without concern between departments (and potentially the regulator). Though the carrier in this study has a robust set of safety programs, there still exist challenges in exchanging information in a wider forum to facilitate learning (outside of ASAP).

Leader A related the work required to facilitate cross-departmental coordination:

> *"Some of our biggest challenges, honestly have been getting all the departments to play together--realizing that a change that you make in your department impacts others. Now, whether it's in Ground Ops or Inflight or Flight Ops—an implementation could have an adverse impact on a safety concern in a different department. We have to ask: 'how do we go about it?"*

Leader B expressed concern regarding potential deelays during implementation:

"You're probably not as efficient in your implementation as you'd like to be, so it's viewed as a bureaucratic type of tool here (i.e., something we have to do). Many will question why do we have to document or write down something for just a small change? Additionally, all of this coordination can result in delays when departments struggle to make sure their systems 'talk to each other'."

Resources. Many respondents highlighted the resources needed to both set up the SMS (during the implementation phase) and execute an SMS (during normal operations). Most of the respondents indicated it takes a lot of time and skilled personnel to implement and administer an SMS—the number might be larger than what the team thought they might need at the outset. All reported satisfaction regarding the level of personnel and material resources dedicated to the SM effort at the carrier.

Leader A relayed the need to resource the effort:

"Again, there's a resourcing section where, hey, we just put this policy in place. We're gonna train it. We're going to resource it. We're going to make sure that our employees have the tools to go out and execute. And all that builds into what we determine is acceptable and not acceptable from a safety standpoint."

Leader B discussed some of the nuances of the resources during implementation:

"Additionally, we have to resource those items, to ensure everybody is up to speed to learn the methodologies of how this applies to my day in and day out duties. And you'll need resources for continuing training."

Leader C bluntly captured it takes resources to keep an SMS going:

"It is imperative to continue to build on that safety culture after we've implemented SMS, so where we identified things that aren't working and then relayed that to our people. It takes resources to keep it all going."

Over-complication. Throughout multiple conversations, leaders indicated potential missed opportunities to keep the approach to SMS implementation and execution simple. Questions one might ask before implementation might include: "Will our program be an 'all-hazards' program, or one that addresses only catastrophic losses?" or "Will our program address just operational risk, business risk, and/or other types of risk?"

The carrier in the study implemented a broad program that took some time to fully deploy. Some of the professionals involved relayed if they had a chance to do it over, they would recommend that only those issues that are required by regulation should be covered. After the initial roll-out, the program can be expanded as desired.

Leader A relayed the sentiment to keep the roll-out simple:

"The implementation of SMS resulted in the creation of many jobs and the development of many processes, and ultimately what I believe has been kind of a complication of a pretty easy concept. It doesn't have to be magic; it just has to work right. SMS is simply the formalization of risk management processes, and then the babysitting of those processes by leadership at all levels. And we have developed this monster machine for good reason which ultimately gets the job done."

Leader B spoke about complexity slowing down processes at the ground level:

"The implementation was easy to understand as we've scaled this across the company. It's gotten very complex because our company is very complex. We've included all parts of the operation--identification of hazards is not limited to airplane operations and risks. Until we really get a chance for this to sink in and become part of the operation, it's probably going to be more complex. The people that are not exposed at the ground level can slow things down—when we bring other departments into risk assessments, and we get wrapped up and it takes a while to sort out."

Leader C reinforced the keep it simple concept:

"Start smaller and start in a simple format and then expand from there. But I think if you had the opportunity to if you're doing it from scratch, I think building out those systems (and saying this is what it looks like for us) is best. You can say these are what the hazards are, and you can really build your assurance processes to really be closely aligned with what you're looking for--being able to manage those risks."

Scope. Closely related to complexity is the concept of scope. A number of the leaders at the company in the study expressed a desire to remain more focused on the objective of program compliance than covering the entire operation in the program at rollout. The desire seemed to emanate from an attitude of "let's roll out something that meets the requirements well, and as we get more proficient, we can widen the scope." Thus, the carrier might avoid adding layers of complexity in an FAA-approved program that does not require some of that level of detail.

Leader A stressed the need to keep the focus narrow:

"We would have been better served to do that very narrow focus—14 CFR Part 5 aircraft accident/incident. Get that program running and then expand it. On the other hand, I really don't know if you'd ever expand it if we did that, so I think you're actually better off going all in and recognizing that you're going to be a little bit behind the power curve when it comes to the non-aircraft accident stuff (but I think that's going to be a self-imposed challenge, but I think it's worth taking)."

SRM Consistency. There were many comments from participants surrounding the need for consistency when performing Safety Risk Management or SRM. Who should be involved? How should they be trained? How do you keep folks calibrated? How do we handle issues or instances where one carrier uses SRM, but another does not?

The carrier in the study relayed the general perception amongst its SRM participants that almost any issue could be construed to theoretically result in a hull loss as an adverse outcome—but what is the likelihood of that happening? Issues regarding calibration of SRM team members are probably more common across companies and industries than not.

Recommendations to Other Carriers

Respondents were asked: "*What recommendations do you have for other carriers that are in the process of implementing SMS?"* The participants in the study were very willing to share their ideas, which included a quote:

"Keep the SMS embedded in the operation or the business, imbed it in your processes, design it with measures in mind, and use a system safety approach by

stepping back a bit and constantly assessing the equation: …am I inducing more risk?."

Part of the business. Multiple leaders pointed out that an SMS can only work if it resides in the business, and the entire workforce is fluent in its language and process.

Leader A relayed SMS as a normal business practice:

"So, one of the things that I've kind of figured out is SMS is really pretty simple. It's just normal business practice. The airline has been effectively managing operations and finances and all the other things that businesses have to be good at for a long time. And all SMS has really done is placed that same business discipline on safety management. If we keep SMS in the business (as we do with all the other leadership responsibilities) we'll be successful."

Leader B mentions that SMS in the business is required to keep it energized:

"It was a lot of work for SMS to kind of seamlessly flow into our normal processes. The key to keep it vibrant is to insure it sits side-by-side with the business."

Imbed in processes. Respondents were quick to point out that SMS is truly about the process—good design, execution, assessment, and correction. From a company perspective, if you have sound processes and procedures already—use them. There is no need to have to create everything from scratch in this process.

Leader A supported the concept of not "throwing away" good work:

"One of the things that helped us a lot was the ability to leverage work we have already done. It would have been foolish to toss away all of the good work we had completed to date."

Use a system safety approach. Respondents were unanimous in their guidance around the value of a holistic approach when implementing an SMS. Many cautioned against losing the "big picture" and the need to consider the system as a system, interfaces, controls, etc. It can be tempting to rush into a problem-solving phase right away, but the participants reiterated the importance of the process.

Leader A emphasized understanding the hazards and the controls in your systems:

"And I think in the SMS world, that's exactly what you should be asking yourself -- what are your systems? What are the hazards that are in your systems? What are your controls designed to manage those hazards? And then are those controls effective? And then when you get to that question, the next question is how do I know? Do I have the assurance programs designed to measure that? And so, I think if I was going to do it all over if I knew I had some time, I would step all the way back out and quantify our systems."

Leader B discussed the components of a system:

"The interesting part of the systems approach -- if you ask the FAA what a system is, they may have a different answer than what the airline might say. The term system is loosely defined. You could argue the FAA defines it as the things that they do their surveillance on. So, if you looked at this you could say: a system are those things the FAA is evaluating."

Safety policy & promotion are key. Respondents universally discussed the importance of a concise safety policy, efforts to ensure it is well communicated (safety promotion), and then continuing involvement from the leadership team to ensure others

are getting the message and fully adopting the SMS. The SMS does not exist in a book or a vacuum, it exists on the shop floor and in the heart and mind of every employee.

Leader A stressed the need for leadership to push safety policy down into the organization:

> *"Well, I think that's the key, isn't it? Safety policy has got to come from the top as one of the foundational pillars if you will. Just like 'safety first' -- it's got to be an all the time thing, it can't be a some of the time thing. It's incumbent upon leadership to impress upon all of the folks that work for them. And then on down and down and down into the organization that we do mean safety first and everything else comes secondary, including on-time performance."*

Leader B reiterated safety policy as the core of SMS:

> *"I think the safety policy is the core of your SMS. Make sure that you write something that you believe in and that you're willing to go out and stand behind. Let all of your other communications support that. It's fundamental. The leader has got to get everybody on board from the get-go. The leader has to have people understand definitions. What do we mean by safety? What do we mean by risk? What do we need mean by mitigations and assurance? And then ensure you have a well-informed educated workforce."*

Have measures in mind. When designing an SMS (or performing a system assessment), ultimately one knows there will be a need for an objective measure to quantify success and allow the oversight of the assurance function. Thus, it is important to be fluent with the types of measures that are readily available in the operation, as well as the opportunity to develop new measures as required.

Leader A stressed the connection between available data and an effective SMS:

"In our operation you know we have lots of data we have access to. We have very well-thought-out means to reduce and analyze the data. And before we implement a certain system or control to a system, we think through how we can measure the effectiveness and so that has worked well. Thus, to the operator at the deck plate level, the system seems to be pretty effective. Outside of that though, we have the whole audit system. So internal and external audits do their part to make sure that our SMS is operating as designed and that our system safety is working, as well (which is not the same thing as our SMS). But overall, our system safety is operating at an acceptable level."

Leader B expressed satisfaction with the use of data under SMS:

"I think the probably the biggest benefit is basically changing from a reactive method to a proactive method has to do with how we use data. Before we had a lot of data, and we still have a lot of data that we look at. and we would allow the data to kind of guide us based on whatever it was for that month. Now proactively we can say these are the things that we're wanting to look at because these are what impact our risk in our operation and how we manage that. And so, we can actually go out and specifically collect that data around those specific things, rather than just kind of waiting for things to happen."

Measures of SMS

Participants were asked the following question: **"***What are some of the measures used to determine how well your SMS is functioning?"* This question was designed as a follow-on to the last regarding recommendations. Much can be inferred about the

maturity of an SMS program if one understands how and what a company measures. The level of sophistication in this space might be a good indicator of the penetration of a company's SMS into the operation.

Lack of negative data is not sufficient. It might be tempting for one to say: "we have no accidents; therefore, we must be safe." On the contrary, under an SMS an operator must actively pursue data (via audit and similar programs) rather than passively wait for negative news to bubble up. The carrier under examination in the study has worked very closely with the LOSA Collaborative to develop both a continuous LOSA (Line Oriented Safety Audit), an industry-leading approach to operational safety.

Leader A stressed the necessity of an active surveillance program:

> *"Lack of negative data is good, but you know, you have to actively pursue data about the performance of your systems. In fact, you have to actively seek out both negative and positive data -- more of a Safety II approach than a Safety I approach."*

Use dashboards. One of the tools that seems to be growing in popularity amongst operational groups is safety or SMS dashboards. A safety or SMS dashboard is data that is aggregated into a central repository and then used to brief responsible parties (including the Accountable Executive and regulatory agencies) on the workings of a company's SMS). Dashboards can be an effective tool in the SMS space. The carrier in question uses such dashboards at the departmental and senior leadership levels to ensure there is one set of information being briefed and worked on across the operation.

Leader A reinforced the tactic of continued use of good pre-SMS products:

"We should still use our dashboards that have been in existence since pre-SMS that truly show our safety status within the operation. It doesn't show you how all the processes behind it work but coupled with the new dashboards they are useful. You need the dashboards with your safety look and then a look behind the curtain at how the processes really work. Additionally, you need to see where something is sitting stagnant in the process for years and nobody has even looked there and touched it."

Document risk controls. Multiple leaders commented on the need to properly document systems, hazards, and risk controls early in the process. This discussion also ties in with the discussion around the scope of the SMS upon implementation. Proper scaling of the effort at inception will allow timely implementation while still allowing the program to grow as the operation dictates and the carrier sees fit.

Leader A emphasized the proper identification of hazards at the appropriate level:

"Then there is looking at those big hazards and then trying to evaluate do you have controls? If you do the groundwork beforehand as you implement your SMS, it'll be much easier. We're doing a lot of catch-up right now. I'm going back and doing some of that work, and it's hard because we're in the day-to-day of running the SMS. And now we're going back in trying to do some of the things that would have been beneficial to do prior to the full implementation."

Leader B stressed the documentation of controls:

"Understanding what you control, what the control levers exist, and the performance output of those levers is key. SMS allows one to really be clear on

what changes are going to be made and how the organization is going to watch the metrics to evaluate performance."

Leverage existing tools. Another important realization after SMS implementation was the value of leveraging existing tools and processes to facilitate a timely implementation. At the time of SMS implementation, most organizations will have safety systems and processes in place that can help serve as the foundation for the requirements of 14 CFR Part 5.

Leader A reinforced the strategy of using effective tools that are already available:

"Well, my primary recommendation is don't reinvent the wheel. Everyone's got a unique operation and that's why you can't regulate exactly how one would implement an SMS. Since everyone's got unique procedures based on their operation, you can't just do that. But you can find like-minded similar organizations and start from a position of somewhat formalized processes which you can then adapt to make your own. I think that not only will that help a new organization looking to adopt an SMS get started more easily, but it also can provide valuable feedback to the companies that they work with, where they're adopting the SMS. It's just continuous improvement."

Leader B pointed out existing measures are more than likely avaialble:

"At the outset, examine all of your existing measures and programs, because chances are you are very close to what you need to be compliant under Part 5. Then, begin the process of implementing your SMS from the top-down, from the big picture to the small, with an eye on systems and measures throughout the process."

Figure 15 shows a Word cloud of qualitative data highlighting salient codes and themes.

Figure 15

Word cloud of SMS qualitative data.

Factual Operational Performance Data

To complete the triangulation process, real-time and historic safety data at the carrier was examined. This data includes: the total number of Safety Reporting System (SRS) reports submitted by year (2016-2021) across the entire enterprise; SRS reports submitted by workgroup over the same period; the number of Aviation Safety Action Program (ASAP) reports filed (2015-2021); the ASAP filing rate per 10,000 hours of

flight time and per 10,000 flights (2016-2021); the number of personnel trained in SMS by year (2016-2021); the number of new hazards identified (2016-2021); and the number of new Operational Risk Registry entries (2016-2021). This data provides insight into the safety culture and reporting culture of the carrier, and it serves as potential confirmatory evidence regarding the effectiveness of a carrier's SMS.

Note: at the request of the carrier, the graphics that typically would accompany this information were not included, to potentially prevent their inappropriate use out of context in non-academic settings.

Factual Safety Reporting Data

To provide some perspective on the scale of the carrier's operation, the airline operated in over 100 cities (domestic and international) throughout the period and conducted approximately 3,000 to 4,000 flights per day (except during the height of the Covid pandemic (March 2020 through May 2021), when the flight count decreased dramatically).

Safety Reporting System (SRS) reporting. The carrier uses its Safety Reporting System as an all-hazards tool for employees across the enterprise. It is important to note that safety leaders involved in the study reported aircrew tend to favor ASAP over SRS, but the two systems together provide valuable insight into the functioning of the SMS.

The carrier began its SMS certification journey in 2015 and was recognized as being fully compliant by the FAA in 2017. As part of the study, the normalized total of SRS reports submitted by year (2016-2021) was examined. Since the certification of its SMS, the carrier has seen an increase in the number of submissions, trending towards the six-year rolling average. This trend is consistent with a healthy safety reporting culture.

The normalized SRS report count by workgroup (2016-2021) was also examined. As mentioned earlier, it was not surprising to see that Flight Ops had fewer reports relative to other groups, since they tend to use ASAP (with its tie to the FAA's Aviation Safety Reporting System). Anonymity is important to crew members. The data suggest that Ground Ops is by far the most frequent user of the SRS, generally reporting at almost double the rate of the next nearest group. The six-year rolling trend line was positive. The data reflected a positive safety and reporting culture at the carrier both before and after the implementation of SMS.

Aviation Safety Action Program (ASAP) reporting. The six-year rolling average for ASAP reports was normalized to the 2016 total as a baseline. A closer look at normalized data per 10,000 flight hours and 10,000 flights was also accomplished. The general downward trend in absolute report numbers is more than likely influenced by a significant reduction in flights during the Covid pandemic period (March 2020 through May 2021), and the continued operation of SMS. One might surmise if there was not an already intact and healthy reporting culture before the implementation of an SMS, one would see a marked increase in safety reporting post SMS implementation. If a robust reporting culture existed prior to SMS implementation, it is not unusual to see the number of reports continue the trend that was indicated pre-SMS implementation.

The ASAP event filing rate, using 2016 data as the baseline, and normalized per 10,000 flight hours were examined as part of the study. As discussed regarding the absolute ASAP reporting numbers, the same downward trend continued. The increase in ASAP reports in 2021 is not surprising as the flight count began to return to normal levels at the carrier.

As is the case with the overall number of ASAP reports, it will not be surprising to see the normalized level grow to approach the six-year average as the flight count rises to its previous level. Once flight activity has fully returned to normal levels, one would expect the number of reports submitted per 10,000 flight hours to level out (or maybe even decrease a bit) as the carrier's SMS matures.

The ASAP event filing rate normalized per 10,000 flights for the years 2016-2021 was also examined. As was the case with the overall number of ASAP reports submitted and the number of reports submitted normalized by 10,000 flight hours, a steady decrease occurred during the six-year period (2016-2021). Though the reduction in reports in 2020 is not surprising (given the reduction in flight activity), the rate of that decrease was notable.

Compared to the number of ASAP reports submitted in 2019, the rate dropped to almost half (tracking with the number of flights cut). Further research is warranted to understand the reasons behind such a dramatic drop in reporting during the pandemic. The carrier recognized this drop in reporting and looked more closely at their other routine assurance data (Flight Operations Quality Assurance (FOQA) data, Line Check results, Continuous LOSA, and the like). The carrier did not observe an increase in negative trends during the period of lower reporting.

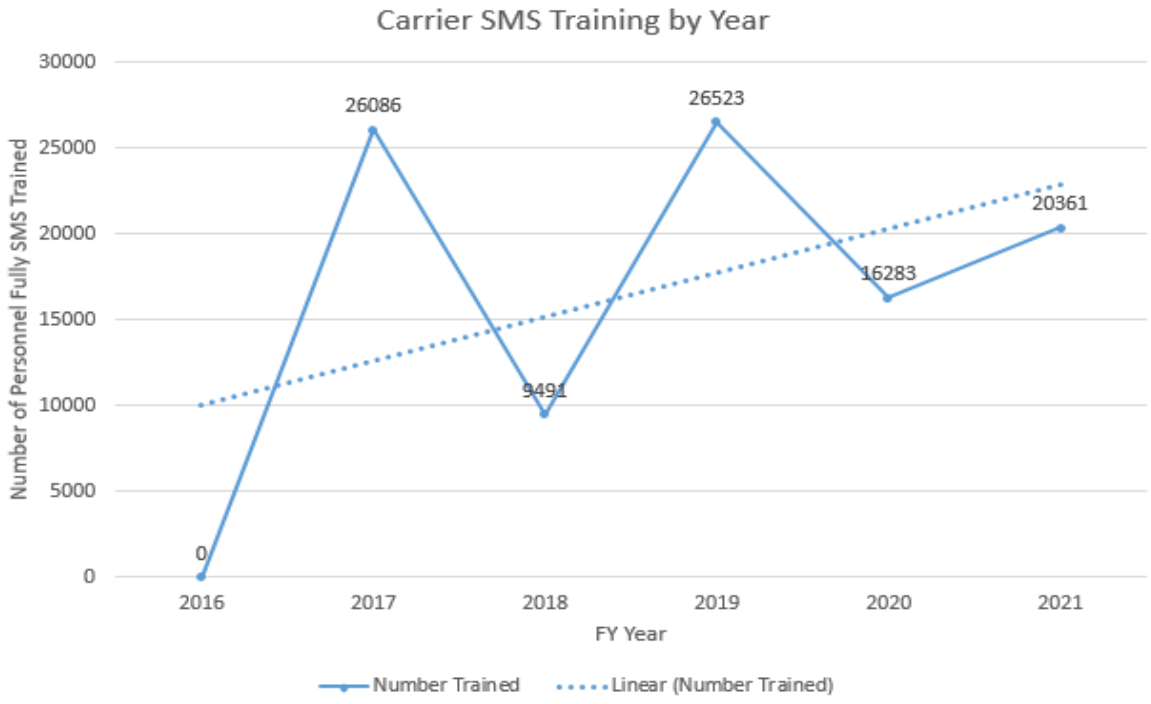
Carrier SMS Training (Factual Data)

A crucial part of an SMS is safety promotion and training. The carrier in this study has multiple levels of SMS training available, from an introductory course essentially for all employees, to tailored programs for managers and leaders who will perform Safety Risk Management (SRM) or accept risk. Generally speaking, the training

programs are administered via a Learning Management System (or LMS), and they are refreshed every two years. Figure 16 depicts the number of employees trained annually from 2016-2021. Note that the first peak in training was after full acceptance of the carrier's SMS by their FAA Certificate Management Office in 2017, and the training has peaks and valleys, with every second year being the more impactful part of the cycle.

Figure 16

SMS Training at the Carrier (2016-2021).



The smaller number of employees trained in 2021 was due to the decrease in personnel at the carrier due to early retirements and other incentive programs for employees to leave the company during the pandemic. The general trend line for SMS training by year is positive, and it is indicative of a healthy SMS at the carrier.

Carrier SMS New Hazards Identified (Factual Data)

The number of new hazards identified by the carrier during the period 2016-2021 was examined, with 2016 as the baseline. The number of new hazards showed a sharp decline year over year--this decline is not unexpected. As a carrier begins its journey down the SMS road, working from large systems to smaller ones, it is not unreasonable to expect that the number of new hazards would continue to decline. Unless there is a major change in the operations of a carrier (i.e., it takes on a new mission, a new aircraft, or dramatically changes another aspect of the enterprise), the number of new hazards should level off or decline. The findings suggest that a fully mature SMS might have years with no new hazards identified (if the operation remains status quo).

Carrier SMS New Operational Risk Record (ORR) Entries (Factual Data)

The number of new entries made into the carrier's Operational Risk Registry (ORR) by year for the period 2016-2021 (using 2016 data as the baseline) was also studied. The carrier used the ORR as the repository of all things risk—hazards, mitigation, SRM results, and risk acceptance. This single record-keeping system includes data that was contained in older, pre-SMS systems.

As was the case for new hazards identified in the previous example, it would be expected that the number of new ORR entries would decrease over time (if the operation was stable). As system analysis is completed, along with SRM and assurance plans, the carrier should move into oversight mode. The introduction of a new mission (like ETOPS - Extended Twin Operation Performance Standards), a new aircraft type, or a new process or procedure would require a new ORR entry. A change in an existing ORR entry simply requires an update (to include the results of the new SRM).

CHAPTER V

DISCUSSION, LIMITATIONS, AND CONCLUSIONS

This study was designed to build upon past research into the SMS construct, transformational safety leadership, self-efficacy, safety motivation, and safety outcomes (Adjekum, 2014, 2017; Adjekum et al., 2015, Robertson, 2016) in a collegiate aviation setting. SMS implementation at Part 121 or commercial carrier in the U.S is still relatively new, and the value of this research is the glimpse it provides into the implementation and maintenance of an SMS compliant system from inception through its relative childhood.

This research evaluates the efficacy of an objective method to assess SMS performance using a triangulation approach, as well as explores the practicality of using such a tool in a commercial setting. The concurrent triangulation mixed methods approach was utilized to address several research questions and develop others. The primary purpose of the study was the utilization of peer-reviewed and validated tools to assess a carrier's implementation and administration of its SMS, while exploring the potential to use this approach at other carriers.

Extant research in the field of SMS (Teske & Adjekum, 2021, 2022; Adjekum & Tous, 2020a, 2020b; Insley et al., 2020; Robertson, 2018; Adjekum & Jensen, 2016) has demonstrated its efficacy in the collegiate and other environments. This research helps further explore those relationships while embedding an additional question regarding

what was learned during the implementation of SMS at the carrier. The new information from the lessons learned should inform similar SMS implementation efforts in the future.

SMS Initiative Implementation

Despite several notable differences, the model proposed by Adjekum (2017) performed adequately and was useful in the novel setting of a Part 121 carrier. This research adds to the body of knowledge gained in using a previously validated approach in a new setting, that of a U.S. commercial carrier.

The use of a previously validated instrument with minor modifications for setting (as developed from CAPSCAS) saved a great deal of time and effort and allowed more efficient study at the Part 121 carrier. The similarities in the operations in both settings far outweigh the differences. Specific differences found around the constructs will be discussed in detail later in this paper. The quantitative instrument functioned satisfactorily for this study, but there were some gaps in the functionality of individual items which were unearthed during the CFA process.

The number of items that did not perform well was surprising, given the work done on the measures to date. The small sample size may have been a contributing factor to the low performance of a number of the items. However, after the exclusion of items as indicated during the CFA process, the overall model fit was vastly improved (Table 4 contains the goodness of fit indices for the final measurement model).

The results and findings of this study confirmed the quantitative and qualitative tools used herein performed adequately relatively to previous research. It will require further study to determine if the differences noted in the performance of the instruments

used were due to setting, population, sample size, or some other factor that could not be teased out under the current design.

The systematic review of the constructs in this study was similar to the approach taken by von Thaden and Gibbons (2008) and Chen and Chen (2014). This work must be accomplished during each implementation to determine the goodness of fit of the model (due to the relative paucity of similar studies in the literature, and the lack of longitudinal data from Part 121 carriers to further refine the model). Across multiple settings and implementations, differences can be found across departments, as well as different societal and/or safety cultures at a carrier (Thaden et al., 2006). Despite the differences that can emerge across settings, the consistent reliability and validity of the instruments used by Adjekum, Chen and Chen and Thaden and Gibbons are noteworthy. The results of this study reflect their efforts.

SMS Policy Implementation. The importance of a clear, concise safety policy as the cornerstone of successful SMS implementation cannot be overstated. In both the quantitative and qualitative portions of the study, respondent global perception of safety outcomes was linked to a clear safety policy. Additionally, interview data supported the premise that clear roles, responsibilities, and relationships under the SMS can lead to positive safety outcomes from the point of view of the respondents at the carrier.

In the quantitative portion of the study, SMS policy implementation had a significant direct and indirect effect on both safety outcomes whereas Adjekum (2017) saw a significant relationship with safety compliance, but not safety participation. The indirect effect points to the importance of safety motivation in the equation. Regarding safety motivation, Chen & Chen's (2014) study predicted a positive correlation between

pilot perceptions of the SMS practices within their airlines and motivation to perform related safety behaviors. The researchers also assumed safety motivation mediated the relationship between the selected antecedents and pilots' safety behaviors, so the direct and indirect effects of SMS practices on safety outcomes were hypothesized as follows: pilot perceptions of their airline SMS practices were positively associated with their safety motivation; pilots' perceptions of their airline SMS practices were positively associated with their safety compliance and safety participation; and pilots' safety motivation mediates the relationship between their perceptions of their airlines' SMS practices and safety behaviors--both compliance and participation (Chen & Chen, 2014). Adjekum carried the same view forward into his research, and like Chen & Chen, his study produces similar results regarding the role of safety motivation. Jian and Probst (2016) found that transformative leadership style versus passive leadership style in concert with various levels of safety motivation impacted SC and SP. This suggests that SMS policy implementation on its own may not be enough to encourage safety compliance and safety participation behavior.

Safety motivation is a player to encourage both safety outcomes. In the current research, the direct path was retained between SMSPol, SC, SP, and safety motivation (though the path between SMSPol and SM was not statistically significant, $p = .652$). The path between SMSPro and SM was significant and supported in the work of Adjekum (2017). Further research is warranted to determine if the performance of the instrument (the SM scale was reduced to two items after model fit), CR = 0.88 with a high degree of skewness (-2.990) and kurtosis (9.993), small sample size, or other factors might have led to the divergence in results versus prior studies.

The literature strongly suggests that safety policy implementation should originate from the highest echelons within the organization. There must be clear support from the operation and its leadership, as well (Teske & Adjekum, 2022; Cavazotte et al., 2021; Adjekum & Tous, 2020a; FAA, 2019). A core mission and value statement should encapsulate the safety policy, and the safety policy must be communicated widely across the organization (Stolzer et al., 2016; Wold & Laumann, 2015; ICAO, 2013).

The data derived from the survey results, interview analysis, and factual data indicate convergence at the carrier regarding leadership and SMS policy implementation.

SMS Process Engagement. Prior research has indicated that the acceptance of the key tenets of SMS policy by front-line personnel (i.e. SMS process engagement) is not always forthcoming but is required for effective SMS implementation (Adjekum, 2017; Robertson, 2016; Wold & Laumann, 2015). The respondents in this study indicated the importance of seeing the "buy-in" by leadership as a necessary condition for front-line acceptance.

In the quantitative portion of the study, respondent perception of SMS process engagement was very weakly related to safety compliance (but not safety participation--both results were the opposite of Adjekum's (2017) work). Additionally, the direct relationship between SMSPro and SM in this study was not significant ($p = .361$). In the final measurement model, the direct path between SMSPro and SP was not retained.

The SMSPro scale assesses how stakeholders perceive the policies defining conditions that might lead to potential punitive actions in the safety arena, safety reporting, reportable events, and the like. The positive relationship between SMSPro and SC suggests that a clear delineation of policy and expectations facilitates safety

compliance behavior. The lack of a relationship between SMSPro and SM and SP might be due to the carrier's mature safety culture (it has had a solid 50-year safety history) and its demonstrated safety reporting culture, in which there are professional individual goals for continuous improvement embraced by the line and management, alike. There is no formal requirement to participate in more safety promotion events, as these are all specified by contract and the carrier's advanced qualification program (aircrew training program).

In multiple discussions, respondents at the commercial carrier re-iterated the value of seeing their leaders promoting, then utilizing the SMS framework in the operation. The relationship between the perceived power distance between employees and leadership can vary across the culture in which a carrier operates, and it can directly impact employee satisfaction with leadership (Wei et al., 2017). Power distance can explain a moderating role both at the cultural and individual level, and when coupled with employee expectations, could be very influential in the perceived efficacy of leadership (Wei et al., 2016). The carrier under examination is notable for the low power distance relationship between senior leadership and front-line employees.

Teske and Adjekum (2022) found a positive correlation with a strong effect between the four key attributes of SMS (safety policy, safety risk management, safety assurance, and safety promotion) and mindful organizing. Both are positively correlated with positive safety outcomes. Though SMSPol and SMSPro items were both found in the survey used for Teske and Adjekum's (2022) study, it is not as important to cull out the results for each subset, but rather to recognize the close relationship between SMS and mindful organizing.

Adjekum and Tous (2020b) researched four management factors and resilient safety culture in high-reliability organizations: principles, policy, procedures, and practice. Policy had the highest predictive power and practices the weakest. The connection between leadership and the group of folks who set the principles and develop the policy was clear.

Wang (2018) examined the Aviation Divisions of the Ministry of National Defense (ADMND), Taiwan, Republic of China (ROC) to determine if their "SMS-like" system produced a safety culture appropriate to an SMS. Wang's (2018) work highlighted the importance of leadership engagement and how the tenets of SMSPro can impact the effectiveness of an SMS. Their inclusion of Just Culture in the discussion also was interesting, in that a number of the respondents in the study at hand said the U.S. implementation of SMS fell short by not emphasizing and/or facilitating the implementation of Just Culture at U.S. carriers at the same time as SMS. The carrier examined in this study and its multiple workgroups were continuing the discussions around Just Culture at the time of this study.

Additionally, the role of safety leadership has been shown to impact safety behaviors by other researchers (Neal et al., 2000; Neal et al., 2006; and Friewald, 2013), as well.

Though there were some differences found between this study and others, from a triangulation approach the carrier in the study does not appear to have gaps in its approach to SMSPro and its operation.

Triangulated Results of SMS Initiative

The results of this study indicate the carrier effectively utilized all available financial, technical/technological, and human resources needed to effectively implement and manage their nascent SMS. Themes that emerged included: the importance of the leader setting the tone; having a clear line of responsibility between risk and the accountable executive; the presence of a strong accountable executive; and the need for executives to guide the organization through SMS implementation.

Additionally, other recommendations for companies in the process of implementing an SMS included: a need for solid documentation; avoidance of over-complication; keeping SMS as part of the business; safety policy and promotion are key; having proactive processes and measures as part of the plan and have measures in mind.

The examination of factual data at the carrier corroborates the findings from the survey and the semi-structured interviews. Specifically, the SMS implementation at the carrier has provided both front-line employees and leadership with the necessary resources, tools, and measures to effectively adopt and execute an SMS. The carrier in this study had an effective safety program and a mature safety culture before the implementation of SMS.

The data from implementation to the current day is somewhat confounded by the occurrence of the Covid-19 pandemic (March 2020 through May 2021), which greatly impacted flight counts. However, a steadily increasing number of safety reports (as the number of operations grew), along with robust numbers of personnel trained in SMS, and continuous and appropriate use of the company's risk tracking systems all indicate congruence with the quantitative and qualitative measures in the study.

Implications for Theory

This study is an attempt to measure the dimensionality of the SMS initiative in a U.S. commercial air carrier operation. This study is an extension of work begun by Adjekum (2017) and others and may serve as an empirical framework for use at other commercial carriers (both pre and post SMS implementation) to positively influence the roll-out and sustained execution of an SMS. The results of this study re-affirm extant literature which states SMS policy should be clear, set goals and objectives, must be accessible to all employees, and must be part of the enterprise strategic plan (Stolzer et al., 2011).

Relationships between SMS Initiative and Other Study Variables

A central purpose of this research was the examination of the interplay between SMS initiative, self-efficacy, transformational safety leadership, safety motivation safety participation, safety compliance, and safety-related events. The results from the structural equation model and path analysis indicate the respondent perceptions about the SMS policy implementation generally had a significant (but weak) effect on their safety compliance and safety participation (except in the case of SMSPro and SP). The results reinforce the notion that an investment in the SMS initiative with the employee group and management team may enhance their perceptions regarding the operation and safety outcomes.

This result aligns with other research which confirms a positive relationship between SMS and safety culture in aviation organizations (Teske & Adjekum, 2021, 2022; Adjekum & Tous, 2020a, 2020b; Insley et al., 2020; Smith et al., 2020; Robertson, 2018; Adjekum & Jensen, 2016; Freiwald, 2013; Chen et al., 2014).

SMS Policy Implementation, Safety Motivation, Safety Compliance, and Safety Participation

This study validates a positive (but weak) path between SMSPol, SP, and SC. Additionally, a significant moderate pathway was found between safety motivation and safety compliance (β = .376, p < .001) and safety participation (β = .341, p < .001). In alignment with Adjekum's (2017) findings, the results corroborate Neal and Griffin's (2006) suggestion that SMS implementation could be a viable predictor of SC and SP. The results indicated that when participants understand the SMS policy and how the program is being implemented, they may be more motivated to get involved in safety-related activities. This finding reinforces the notion that a well-defined SMS policy is important to drive the entire SMS initiative (Stolzer, et al., 2008; ICAO, 2013).

Policy implication. Herzberg's *Two-Factor Theory* can help explain the connection between employee motivation and safety outcomes. Under Herzberg's model, motivation can be split between hygiene factors and motivation factors. Motivation factors achievement, recognition, and responsibility (Greenberg, 2013). A strong safety promotion campaign that empowers front-line workers to get involved, holds both leaders and employees responsible and recognizes those who are leading the SMS transition can have a positive impact on the SMS outcome. To energize the achievement and/or recognition element of Herzberg's model, management should ensure the Chief Pilots (or other leaders) routinely praise behaviors that led to a satisfactory safety outcome, including any incentives that the company might allow (reward points, etc.) that personnel can use for various items or programs of their choice.

SMS Process Engagement, Safety Motivation, Safety Compliance, and Safety Participation

This study validates a positive (but weak) path between SMSPro and SC. Additionally, a significant moderate pathway was found between safety motivation and safety compliance (β = .376, p < .001) and safety participation (β = .341, p < .001). Other researchers (Adjekum, 2017) found a significant path from SMSPro to SP. Vroom's Expectancy Theory can help explain the connection between SMSPro and SC. Given that personnel change their level of effort based upon the value of the reward they might receive and their perception of the link between effort and outcome (Vroom, 1964; Bandura, 1986). It is critical that leaders remain engaged and help employees clearly understand that their actions have consequences under the SMS, and if the link between effort and outcome can be clearly established, more positive safety outcomes will result.

Policy implication. Under Vroom's model, company officials should be clear in the design, implementation, and promotion of an SMS to address Vroom's expectancy, instrumentality, and valence concepts with the employee group (Vroom, 1964). Any reward offered has to be meaningful to the pilot and pilots have to clearly see the connection between action and reward.

Transformational Safety Leadership, Safety Motivation, Safety Compliance, and Safety Participation

The results of the final measurement model indicated significant direct and indirect effects of transformational safety leadership on safety participation (β = .232, p < .001). The direct effect between TSL and SP was .232, the indirect effect was .051 for a total effect of .283. There was no statistically significant path or effect between TSL and safety compliance (similar to Adjekum's (2017) study).

Additionally, there was also a significant moderate direct effect on safety motivation by transformational safety leadership ($\beta = .341$, $p < .05$). And as noted earlier, SM had a significant direct effect on both SP and SC. Thus, there was a positive effect of transformational safety leadership due to the mediation effect of safety motivation.

The connection between transformational safety leadership and safety participation is not surprising based on extant research. Bass and Avolio (1994) posit that transformational leadership motivates followers to improve performance by converting them, rather than simply gaining compliance. In the case of the carrier in question, the very active engagement by the leadership team (as discussed in the factual data examination) began the "conversion" process by motivating front-line employees to fully embrace the SMS.

The connection between leadership and safety-related outcomes has been well documented. Zohar (2002) posits that the role of leadership should be emphasized as a mechanism to improve safety. The significant results of the quantitative survey and the data gathered from the qualitative survey indicate the carrier under examination had an appropriate level of involvement from its leadership throughout the SMS implementation process. Additionally, the visible leadership involvement at the carrier was in keeping with Zohar's recommendations.

Kelloway, et al. (2006) found safety-specific transformational leadership had a positive effect on organizational safety, namely employee perception of safety consciousness and safety-related events. The factual data examined in the study captured the large amount of SMS training that took place at the carrier during the implementation

and sustainment of their SMS. The involvement of leadership in that training, as well as the very visible ongoing relationship of leadership with line-employees means there is little room for doubt regarding the importance leadership places on the carrier's SMS.

Bass and Riggio (2006) posit there are four key elements of TSL. Adjekum (2016) noted two were crucial to ensuring the connection between TSL and SP was realized: *individualized consideration* and *inspirational motivation*. The carrier in question is well known both in the industry and amongst its employees for scoring high marks in both elements. Given the strong connection between these elements and safety behaviors, carriers might reap not only safety-related benefits but many other benefits from exercising the principles of transformational safety leadership.

Policy implication. Research has suggested a wide range of benefits resulting from the successful implementation of transformational safety leadership. Faranhak et al. (2020) found team member attitude toward change and transformational leadership are important determinants of implementation success. Hussain et al. (2021) reported a high degree of transformational leadership can increase job satisfaction and organizational commitment. Other researchers, such as Normo et al. (2022), Cavazotte et al. (2021), Smith et al. (2020), Shen et al. (2017), Jian and Probst (2016), Clarke & Ward, 2006, and Barling et al., 2002) reported direct positive effects of transformational leadership on individual and/or organizational safety outcomes.

Operators should be reminded that communicating openly, reaching out individually to employees where they want to be met, and giving them a cause to rally around will lead to satisfactory safety results. The carrier under examination uses its in-person training programs across departments to ensure leadership has direct engagement

with line employees in a "safe space." When correctly deployed, leadership is using idealized influence, inspirational motivation, and intellectual stimulation by facilitating a conversation about current issues on the line, and potential improvements. Leaders at all carriers are encouraged to consider this approach.

Self-Efficacy, Safety Motivation, Safety Compliance, and Safety Participation

The final measurement model found self-efficacy and safety compliance were significantly but weakly related, (β = .157, p < .05). The direct effect between SE and SC was .157, the indirect effect was .092 for a total effect of .249. The relationship between SE and SP was non-significant. And finally, there was a strong direct effect between SE and SM (β = .244, p < .05). As mentioned earlier in the paper, there was also a strong direct effect between SM and SC and SP.

The results of this study support earlier research that indicated self-efficacy is a reliable predictor of safety-related work behavior for pilots (see Parasuraman et al., 1993; Prinzel, 2002). Thus, the weak to moderate total effect between SE and SC, and the stronger effect on SC and SP when moderated by SM is well-founded in theoretical research (Ślazyk-Sobol et al., 2021; Cayir and Ulupinar, 2021; and Ji et al., 2017).

Policy implication. As SMS continues to be rolled out**,** leadership should ensure that the program continues to recognize the connection between self-efficacy and safety behaviors. The carrier under examination utilized its training program (an Advanced Qualification Program or AQP, designed to incorporate near-real-time information from the operational environment into the training program in an SMS-like manner) to give pilots a chance to hone their skills at specified intervals. The AQP incorporates a completion standard so all crews will leave training with the requisite level of skill

required to operate safely in the specific environment in which the carrier operates. Thus, training has morphed from purely an evaluation to a training space with a line-oriented evaluation at its conclusion. Carriers are encouraged to utilize AQP (or other tactical programs designed to build self-efficacy) to the maximum extent possible.

Safety Compliance, Safety Participation, and Safety-Related Events

The relationship between safety compliance was related to safety participation with a strong, direct effect ($\beta = .590$, $p < .001$). The direct effect between SC and SP was .591, the indirect effect was .003 for a total effect of .594. This finding was aligned with Adjekum's (2017) prior research. The findings were also in line with Zohar's (2002) study that suggested a causal relationship between personnel safety performance indicators, such as compliance with safety regulations and safety-related events.

The path between SRE and SC was not significant (an opposite result of Adjekum's (2017) study). Additionally, the relationship between SP and SRE was moderate and significant, ($\beta = .310$, $p < .001$), again opposite of Adjekum's (2017) work. Thus, the hypothesis that safety-related events mediated the relationship between SC and SP was not supported.

Factual data was not available for direct evaluation of safety-related events. The examination of reporting data, and a thorough comb through of the qualitative interview data did not provide any indication of a level of safety-related events that was of concern to the safety leaders who participated in the study. Additionally, respondents generally reported satisfaction regarding the overall safety level of the organization.

The low incident rate in the U.S. Part 121 environment can lead to a sense of complacency in company leadership. The benefit of an SMS is the ongoing assurance

programs and the risk analysis and mitigation that goes into change management. Carriers should be cautioned to not allow the seemingly distal relationship between SP and SC to lull them into a sense that continuous improvement efforts on the flight deck and/or in the operation can be relaxed.

Demographic Effects

As part of the implementation of SMS within an organization, one should consider any unique challenges or opportunities due to the demographics of the employee and management group (von Thaden & Gibbons, 2008; Adjekum, 2014a). Factors such as nationality, age, gender, and/or others might impact the reception of SMS training and process execution. An ANOVA was conducted to examine differences in SC and SRE based on years at the company, age, and role.

Years at the company. Employee years at the company, SC and SRE were examined to detect any differences across between years at the company brackets. There was a statistically significant difference between the average SC score of personnel who have been at the company for greater than 25 years (M = 4.72, SD = .425) and those who have been at the company for greater than 20 years but less than 25 years (M = 4.31, SD = .653).

The slightly higher mean SC score for the greater than 25 to thirty-year group stands out slightly, possibly indicating a need for targeted training on SC for personnel in other year groups. The carrier reported a high level of selectivity during pilot hiring and it prides itself on a high level of standardization (based upon its AQP standards). Thus, most pilots arrive at the carrier with both a high level of experience and strong success

history. Even for these highly qualified aviators, years of repetitious flying could lead to complacency and normalization of deviance.

The carrier in the study had incorporated an entire model on "getting back to basics" to address the normalization of deviance in its AQP at the time of this writing. A closer examination of years at the company and SRE revealed no significant differences.

Age. An examination of SC versus age bracket and SRE versus age bracket both failed to reveal significant differences. The current study failed to reveal significant differences in respondent perception of SC across the various workgroups. The items included in the safety-related events scale are reported at least annually to the pilots in a steady-state environment, and the carrier reports completing targeted safety communications as required. The carrier reports consistency in this regard, so it is not surprising that there are no significant differences between groups regarding SRE. Additionally, the reporting level at the carrier is mature, so the general acceptance across all groups is not surprising.

Role. Significant results were detected between the respondent perception of safety-related events of First Officers (M = 2.67, SD = .363) and Check Airmen (M = 2.91, SD = .384). Since the factual SRE data was not obtained as part of the study, validating the perceptions of both groups is impossible. Check Airman (and Instructors) generally relayed a perception of the slightly high occurrence of safety-related events than a line pilot (First Officer or Captain).

This difference might be due to expectancy (as Check Airmen and Instructors deal more often with aggregate safety reports and safety updates than do line pilots) or events they experience while giving line training. The training role of the Check Airmen and

Instructors allows them to have a deeper insight into what is going on (especially in the realm of recent investigation outcomes). Thus, it is not surprising that Check Airmen and Instructors report a higher occurrence rate than do First Officers.

Gender. A t-test revealed a statistically significant difference in male and female respondents regarding safety compliance. Female perception of SC (M = 4.80, SD = .243) was higher than that of males (M = 4.44, SD = .609), with a medium-sized effect (Cohen's d = .626). The study also revealed a significant difference between the perception of male and female respondents and safety-related events.

Female perception of SRE (M = 2.98, SD = .171) was higher than that of males (M = 2.80, SD = .434), with a weak to moderate effect size (Cohen's d = .426). These results are similar to the results of Kearns and Aitken-Shirmer (2017) regarding gender differences and the perceived effectiveness of SMS and SMS training.

Additionally, Kao et al. (2021) found significant relationships between gender and safety compliance (females higher), safety participation (females higher), and injury rates (females lower) based on gender while studying mindfulness, safety performance, and safety culture in the oil industry. Further research is required to determine if the results with gender, age group, and/or years at the company hold with other samples.

First exposure to SMS. A t-test revealed no significant differences in SC and SP between those who had their first exposure to SMS at the carrier, and those who had it elsewhere. However, a significant difference was detected between those who had their first exposure to SMS at the carrier at their perception of SRE (M = 2.86, SD = .428), and those who had their first exposure to SMS elsewhere (M = 2.66, SD = .359). Cohen's d = .486, a weak to moderate effect. The carrier under investigation had just begun a hiring

cycle as this study was commencing, but no new hire pilots were not included in the study.

The data might indicate that a comprehensive SMS training program (to include risk identification, reporting, and SRM) for all personnel allows company personnel to accurately identify risk or the behaviors associated with SRE, but it may not totally overcome training received elsewhere. The carrier in this study provides such training. Further research is needed.

Conclusions

The purpose of this research was to use a convergent mixed methods data triangulation approach to evaluate the relationships between SMS initiative (SMS policy implementation and SMS process engagement), transformational safety leadership, self-efficacy, and safety performance parameters (safety compliance and safety participation) at a U.S Part 121 carrier.

A mediation analysis was also conducted using safety motivation as a mediator. Variations in the perceptions of research participants on study variables were collected and statistically significant differences were noted. The study was also designed to establish proactive operational safety benchmarks for continuous monitoring and improvements in SMS implementation at a U.S. commercial air carrier.

The respondents (n = 256) for the quantitative part of the study were from a U.S. Part 121 commercial carrier with an SMS approved by an FAA Certificate Management Office. The survey respondents who completed the 43-item survey included line pilots, check-airmen, instructors, and "other" flight operations subject matter experts at the carrier. The quantitative survey contained items to measure respondent perceptions of

study variables. Concurrently, semi-structured interviews were conducted with twelve middle managers and senior safety leadership personnel at the carrier to gather their opinions on the SMS initiative. Finally, factual data at the carrier over six years was examined to complete the concurrent-triangulation approach.

The outcome of this research provided both a quantitative measurement model for an objective evaluation of SMS effectiveness and the inter-relationships with other study variables at a Part 121 carrier. The qualitative portions of the research provided themes to provide a contextual understanding of the data gathered using the quantitative models. Finally, factual data from the company being examined was used to corroborate the findings of the other two phases of the work. The examination of the data, along with corporate artifacts and objective safety outcomes allowed the researcher to make holistic inferences regarding the efficacy of SMS implementation.

A final measurement model was proposed using Structural Equation Modeling – Path Analysis (SEM-PA) techniques. Five iterations were used to derive the best fit for a final measurement model using both modification indices and theoretical considerations. Multiple iterations were used to derive the best fit for the model. The best fit model was then used for hypothesis testing and validation of conclusions.

The results indicated SMS policy implementation had a significant direct and indirect effect on both safety outcomes (SC and SP). Safety motivation was essential in encouraging both safety outcomes. The direct path was retained between SMSPol, SC, SP, and safety motivation. The path between SMSPol and SM was significant. SMSPro had a very weak relationship with SC, but not SP.

This study validates a positive (but weak) path between SMSPol, SP, and SC. Additionally, a significant moderate relationship was found between safety motivation and safety compliance. This study validated a positive (but weak) path between SMSPro and SC. Additionally, a significant moderate pathway was found between safety motivation and safety compliance, and safety participation. The results of the final measurement model indicated significant direct and indirect effects of transformational safety leadership on safety participation.

Additionally, there was also a significant moderate direct effect on safety motivation by transformational safety leadership. And finally, the final measurement model found self-efficacy and safety compliance were significantly but weakly related. A significant direct and indirect effect was indicated between SE and SC. Overall findings from the triangulation of various data sources depicted a positive perception by respondents of the SMS initiative (SMSPro and SMSPol) at the carrier that was corroborated by factual safety performance data and interviews with middle managers and senior safety leaders.

An ANOVA indicated a statistically significant difference between the average SC score of personnel who have been at the company for greater than 25 years and those who have been at the company for greater than 20 years but less than 25 years. The difference may indicate a need to provide targeted safety training at certain points in a pilot's career. The carrier under examination had begun such training for all pilots regarding the normalization of deviance at the time of this study.

Significant results were also obtained between the respondent perception of safety-related events of Frist Officers and Check Airmen (with First Officers scoring

lower). It was suggested that this difference might be due to expectancy (as Check Airmen and Instructors deal more often with aggregate safety reports and safety updates than do line pilots). Thus, the Check Airmen and Instructors may have the latest information in their work setting before line pilots.

A t-test of means revealed a statistically significant difference in male and female respondents regarding safety compliance, with female respondents scoring higher than male respondents. The study also revealed a significant difference between the perception of male and female respondents on safety-related events. Female perception regarding the rate of SRE was higher than that of males.

Previous research had detected differences between men and women regarding perceptions of SMS effectiveness (Kearns & Aitkens-Shirmer, 2017) and mindfulness, safety participation, safety compliance, and injury in oil production (Kao et al., 2019). Finally, a significant difference was detected between those who had their first exposure to SMS at the carrier and their perception of SRE, with first exposure at the carrier employees reporting a perception of a higher rate of SRE than those who were exposed first to SMS elsewhere.

A thorough SMS training program for all personnel at the carrier in the study may have allowed rapid and thorough assimilation of the standard for SRE, it may not have overcome previous training at another company. Further research is required to determine if the results are due to gender, age group, years at the company, and/or first exposure to SMS hold with other samples and in other settings.

Overall, this study helped provide depth to the research regarding SMS implementation and steady-state execution at a commercial U.S. air carrier. This study

was designed to help industry leaders, regulators, and policymakers promulgate objective, data-driven policies that are also cost-effective in approach. That will ensure continuous improvement in safety for the flying public. Additionally, this study was also intended to help fill a gap in research as SMS becomes the benchmark for safety and reliability for high-reliability organizations globally.

Limitations

There are limitations in this study due to its design, its execution, technical aspects, and the researcher. This study gathered individuals' attitudes and perceptions, so there is some likelihood of a degree of response bias or social desirability bias in the results. It is assumed that the responses reflect the true attitudes of the participants at the time and place of administration.

Given the various power relationships of the investigator and the various respondents, bias may have occurred. Additionally, the researcher is knowledgeable in the field and also works in operations and is a participant in graduate school—all of these factors must be considered when examining the conclusions of the study and the underlying factors the researcher may unintentionally pass into the work.

The iterative nature of the model used in this study has the potential to leave out meaningful connections in an attempt to achieve the best fit between the measurement model, the structural model, and reality. The use of factor analysis (Confirmatory) and SEM-PA modification indices can influence the final outcome. Other technical issues might include a relatively small sample size, items as part of a construct that did not perform adequately (leading to a small number of items per construct). Further item analysis is warranted.

Finally, the concurrent approach was a snapshot at a U.S carrier emerging from the pandemic—the results might have been very different if done in a different time and place. Additionally, a very informative study across time (to gather longitudinal data) would add value to this study.

Recommendations for Future Research

This study helps set the benchmark for SMS implementation and execution at a U.S. 14 CFR Part 121 carrier. Additional research at other commercial carriers would add value to this work. More work is needed to determine if the safety performance metrics established in this study can be effectively used in a concurrent triangulation study to evaluate the current state of a carrier's SMS. Replication of this study using a longitudinal approach in both the commercial and collegiate environments will strengthen inferences and generalizability of findings in the populations of study. A further examination of the impact of gender, role, years at the company, and first exposure to SMS on key study variables is also warranted. Further work is also needed to determine if there are true differences in results between similar studies in a collegiate environment and a commercial environment.

APPENDICES

Appendix A
Semi-Structured Interview

The following questions will be posed to selected senior management personnel during the semi-structured interview in order to explore the leadership perspective on the health of the carrier's SMS and the carrier's current safety performance (Adjekum & Jensen, 2016):

1. Review consent terms – do you voluntarily consent to the terms of the study?
2. What role does leadership play in the safety policy implementation of the SMS program?
3. What are some of the benefits of the implementation of SMS at the carrier?
4. What are some of the challenges in the execution of SMS at the carrier?
5. What recommendations do you have for other carriers that are in the process of implementing SMS?
6. What are some of the measures used to determine how well your SMS is functioning?

Note: survey administrators should listen for tangents that might provide insight beyond the constructs discussed herein. There may be inter-relationships between key construct variables that emerge as part of the interviews.

Appendix B
Quantitative Survey Instrument

SMS Questionnaire

Demographics

Q2. What is your current role at the Airline?

Check Airman

Captain

First Officer

Instructor

None of the above

Q3. How many years have you worked at the Airline?

0 – 5 years

5+ - 10 years

10+ - 15 years

15+ - 20 years

20+ - 25 years

25+ - 30 years

30+ years

Q4. What is your age?

<= 25 years

25+ - 30 years

30+ - 35 years

35+ - 40 years

40+ - 45 years

45+ - 50 years

50+ - 55 years

55+ - 60 years

60+ years

Q5. Gender:

Female

Male

Prefer to not report

Q6. Your first exposure to Safety Management System (SMS) was at this airline?

True

False

SMS Policy Implementation (SMSPol)

The questions in this section use the following scale:

Strongly disagree (1)

Somewhat disagree (2)

Neither agree nor disagree (3)

Somewhat agree (4)

Strongly agree (5)

Q7. (SMSPol) The safety policy is signed and approved by the Accountable Executive (top level management) who demonstrates a commitment to safety through active and visible participation in the Safety Management System (SMS).

Q8. (SMSPol) Safety professionals with the appropriate skills, knowledge, and experience conduct SMS training.

Q9. (SMSPol) The results of safety performance review are used by the Accountable Executive (top level leadership) as input to the safety improvement processes.

Q10. (SMSPol) There is a process that provides for the capture of internal information including incidents, accidents, and other data relevant to SMS.

Q11. (SMSPol) Management allocates adequate resources for achieving the safety objectives and goals of the organization.

Q12. (SMSPol) There is a policy in place that provides immunity from disciplinary action for all personnel that report safety deficiencies, hazards, or occurrences (i.e., ASAP, SRS, etc.).

SMS Process Engagement (SMSPro)

The questions in this section use the following scale:

Strongly disagree (1)

Somewhat disagree (2)

Neither agree nor disagree (3)

Somewhat agree (4)

Strongly agree (5)

Q13. (SMSPro) Conditions under which punitive disciplinary action would be considered (e.g., illegal activity, negligence, or willful misconduct) are not clearly defined.

Q14. (SMSPro) Personnel are not informed on the primary contacts for aviation-related safety matters.

Q15. (SMSPro) The scope of the safety-related hazards that must be reported are not explained to personnel.

Q16. (SMSPro) Safety concerns reported through the safety reporting system are corrected in a timely manner.

Q17. (SMSPro) Knowing how and where to report safety concerns is easy.

Q18. (SMSPro) Safety reporting does not provide confidentiality for safety reports filed.

Self-efficacy (SE)

The questions in this section use the following scale:

Strongly disagree (1)

Somewhat disagree (2)

Neither agree nor disagree (3)

Somewhat agree (4)

Strongly agree (5)

Q19. (SE) I have the tools required to solve difficult problems.

Q20. (SE) It is easy for me to stick to my aims and accomplish the plan.

Q21. (SE) I am confident that I could deal efficiently with unexpected events.

Q22. (SE) I can remain calm when facing difficulties because I can rely on my coping abilities.

Safety Motivation (SM)

The questions in this section use the following scale:

Strongly disagree (1)

Somewhat disagree (2)

Neither agree nor disagree (3)

Somewhat agree (4)

Strongly agree (5)

Q23. (SM) It's worthwhile to maintain or improve personal safety.

Q24. (SM) It's important to maintain safety at all times.

Q25. (SM) It's important to reduce the risk of safety events in flight operations.

Safety Compliance (SC)

The questions in this section use the following scale:

Strongly disagree (1)

Somewhat disagree (2)

Neither agree nor disagree (3)

Somewhat agree (4)

Strongly agree (5)

Q26. (SC) I pay full attention to the pre-flight briefing when operating.

Q27. (SC) I follow correct safety procedures when operating.

Q28. (SC) I strive to ensure the highest level of safety when operating.

Safety Participation (SP)

The questions in this section use the following scale:

Strongly disagree (1)

Somewhat disagree (2)

Neither agree nor disagree (3)

Somewhat agree (4)

Strongly agree (5)

Q29. (SP) I promote the safety program within the organization.

Q30. (SP) I put in extra effort to improve flight safety.

Q31. (SP) I am an active proponent of flight safety with my fellow Pilots.

Transformational Safety Leadership (TSL)

The questions in this section use the following scale:

Strongly disagree (1)

Somewhat disagree (2)

Neither agree nor disagree (3)

Somewhat agree (4)

Strongly agree (5)

Q32. (TSL) Chief Pilots/Flight Ops Leadership go beyond self-interest for the good of the program.

Q33. (TSL) Chief Pilots/Flight Ops Leadership do not listen to my concerns.

Q34. (TSL) Chief Pilots/Flight Ops Leadership can be trusted to address obstacles in the operation.

Q35. (TSL) Chief Pilots/Flight Ops Leadership clearly define the steps needed to execute a safe operation.

Q36. (TSL) Chief Pilots/Flight Ops Leadership considers the ethical consequences of decisions.

Q37. (TSL) Chief Pilots/Flight Ops Leadership are disrespectful when handling errors by airmen.

Safety Related Events (SRE)

Please state to the best of your knowledge the frequency of events that have occurred in the operation in the previous year involving company pilots.

The questions in this section use the following scale:

Extremely rare (1)

Rare (2)

Occasional (3)

Frequent (4)

Very Frequent (5)

Q38. (SRE) Across the operation on a monthly basis, how often do company flights deviate from ATC instructions under normal flight conditions?

Q39. (SRE) Across the operation on a monthly basis, how often do company flights encounter close proximity to another aircraft requiring evasive action?

Q40. (SRE) Across the operation on a monthly basis, how often does an aircraft suffer a collision with fixed ground object during taxi?

Q41. (SRE) Across the operation on a monthly basis, how often are flight parameters exceeded requiring FDAP (flight data monitoring) trigger and event review?

Qualitative Questions

Q42. What are your opinions on the safety performance of the operation since the implementation of the SMS initiative?

Q43. How can the organization improve the SMS initiative?

Appendix C
CITI Training

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)

COMPLETION REPORT - PART 1 OF 2
COURSEWORK REQUIREMENTS*

* NOTE: Scores on this Requirements Report reflect quiz completions at the time all requirements for the course were met. See list below for details. See separate Transcript Report for more recent quiz scores, including those on optional (supplemental) course elements.

- **Name:** Robert Waltz (ID: 7754213)
- **Institution Affiliation:** University of North Dakota (ID: 421)
- **Institution Email:** robert.waltz@und.edu
- **Institution Unit:** Aviation
- **Phone:** 5125679168

- **Curriculum Group:** Human Research
- **Course Learner Group:** Group 2. Social / Behavioral Research Investigators and Key Personnel
- **Stage:** Stage 1 - Basic Course

- **Record ID:** 30038831
- **Completion Date:** 07-Sep-2019
- **Expiration Date:** 06-Sep-2022
- **Minimum Passing:** 80
- **Reported Score*:** 95

REQUIRED AND ELECTIVE MODULES ONLY	DATE COMPLETED	SCORE
Unanticipated Problems and Reporting Requirements in Social and Behavioral Research (ID: 14928)	13-Jan-2019	4/5 (80%)
Cultural Competence in Research (ID: 15166)	20-Jan-2019	4/5 (80%)
Populations in Research Requiring Additional Considerations and/or Protections (ID: 16680)	20-Jan-2019	5/5 (100%)
Consent and Cultural Competence (ID: 17263)	20-Jan-2019	5/5 (100%)
FERPA for Researchers (ID: 17410)	28-Jan-2019	4/5 (80%)
History and Ethical Principles - SBE (ID: 490)	28-Jan-2019	5/5 (100%)
Defining Research with Human Subjects - SBE (ID: 491)	28-Jan-2019	4/5 (80%)
The Federal Regulations - SBE (ID: 502)	28-Jan-2019	5/5 (100%)
Assessing Risk - SBE (ID: 503)	07-Sep-2019	5/5 (100%)
Informed Consent - SBE (ID: 504)	07-Sep-2019	5/5 (100%)
Privacy and Confidentiality - SBE (ID: 505)	07-Sep-2019	5/5 (100%)
Research with Prisoners - SBE (ID: 506)	07-Sep-2019	5/5 (100%)
Research in Public Elementary and Secondary Schools - SBE (ID: 508)	07-Sep-2019	5/5 (100%)
International Research - SBE (ID: 509)	07-Sep-2019	5/5 (100%)
Internet-Based Research - SBE (ID: 510)	07-Sep-2019	4/5 (80%)
Research with Children - SBE (ID: 507)	07-Sep-2019	5/5 (100%)
Research and HIPAA Privacy Protections (ID: 14)	07-Sep-2019	5/5 (100%)
Research with Persons who are Socially or Economically Disadvantaged (ID: 16539)	07-Sep-2019	5/5 (100%)
Research with Decisionally Impaired Subjects (ID: 16810)	07-Sep-2019	5/5 (100%)
Vulnerable Subjects - Research Involving Workers/Employees (ID: 483)	07-Sep-2019	4/4 (100%)

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid independent Learner.

Verify at: www.citiprogram.org/verify/?b33d7d8ce-fd1a-4674-87e4-02469649dbdb-30038831

Collaborative Institutional Training Initiative (CITI Program)
Email: support@citiprogram.org
Phone: 888-529-5929
Web: https://www.citiprogram.org

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)

COMPLETION REPORT - PART 2 OF 2
COURSEWORK TRANSCRIPT**

** NOTE: Scores on this Transcript Report reflect the most current quiz completions, including quizzes on optional (supplemental) elements of the course. See list below for details. See separate Requirements Report for the reported scores at the time all requirements for the course were met.

- **Name:** Robert Waltz (ID: 7754213)
- **Institution Affiliation:** University of North Dakota (ID: 421)
- **Institution Email:** robert.waltz@und.edu
- **Institution Unit:** Aviation
- **Phone:** 5125679168

- **Curriculum Group:** Human Research
- **Course Learner Group:** Group 2. Social / Behavioral Research Investigators and Key Personnel
- **Stage:** Stage 1 - Basic Course

- **Record ID:** 30038831
- **Report Date:** 07-Sep-2019
- **Current Score**:** 95

REQUIRED, ELECTIVE, AND SUPPLEMENTAL MODULES	MOST RECENT	SCORE
Defining Research with Human Subjects - SBE (ID: 491)	26-Jan-2019	4/5 (80%)
The Federal Regulations - SBE (ID: 502)	26-Jan-2019	5/5 (100%)
FERPA for Researchers (ID: 17410)	26-Jan-2019	4/5 (80%)
Consent and Cultural Competence (ID: 17263)	20-Jan-2019	5/5 (100%)
Assessing Risk - SBE (ID: 503)	07-Sep-2019	5/5 (100%)
Informed Consent - SBE (ID: 504)	07-Sep-2019	5/5 (100%)
Privacy and Confidentiality - SBE (ID: 505)	07-Sep-2019	5/5 (100%)
Research with Prisoners - SBE (ID: 506)	07-Sep-2019	5/5 (100%)
Research with Children - SBE (ID: 507)	07-Sep-2019	5/5 (100%)
Research in Public Elementary and Secondary Schools - SBE (ID: 508)	07-Sep-2019	5/5 (100%)
International Research - SBE (ID: 509)	07-Sep-2019	5/5 (100%)
Research and HIPAA Privacy Protections (ID: 14)	07-Sep-2019	5/5 (100%)
Internet-Based Research - SBE (ID: 510)	07-Sep-2019	4/5 (80%)
Unanticipated Problems and Reporting Requirements in Social and Behavioral Research (ID: 14928)	13-Jan-2019	4/5 (80%)
History and Ethical Principles - SBE (ID: 490)	26-Jan-2019	5/5 (100%)
Populations in Research Requiring Additional Considerations and/or Protections (ID: 16680)	20-Jan-2019	5/5 (100%)
Research with Persons who are Socially or Economically Disadvantaged (ID: 16539)	07-Sep-2019	5/5 (100%)
Research with Decisionally Impaired Subjects (ID: 16610)	07-Sep-2019	5/5 (100%)
Cultural Competence in Research (ID: 15166)	20-Jan-2019	4/5 (80%)
Vulnerable Subjects - Research Involving Workers/Employees (ID: 483)	07-Sep-2019	4/4 (100%)

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid independent Learner.

Verify at: www.citiprogram.org/verify/?k33d7d9ce-fd1a-4674-87e4-02409649db8c-30038831

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Appendix D
IRB Approval

THE UNIVERSITY OF NORTH DAKOTA
CONSENT TO PARTICIPATE IN RESEARCH

Project Title: AN EVALUATION OF THE RELATIONSHIPS BETWEEN SAFETY MANAGEMENT SYSTEMS (SMS), TRANSFORMATIONAL SAFETY LEADERSHIP, SELF-EFFICACY, AND SAFETY PERFORMANCE METRICS IN A 14 CODE OF FEDERAL REGULATION (CFR) PART 121 AIRLINE: A MEDIATION ANALYSIS

Principal Investigator:	Robert "Bob" Waltz
Phone/Email Address:	Bob Waltz; 512.567.9168 / robert.waltz@und.edu
Department:	Aerospace Science
Research Advisor:	Daniel Kwasi Adjekum, Ph.D., CSP
Research Advisor Phone/Email Address:	701-777-6689 / daniel.adjekum@ndus.edu

What should I know about this research?

- Someone will explain this research to you.
- Taking part in this research is voluntary. Whether you take part is up to you.
- If you don't take part, it won't be held against you.
- You can take part now and later drop out, and it won't be held against you
- If you don't understand, ask questions.
- Ask all the questions you want before you decide.

How long will I be in this research?

We expect that your participation in this research will last approximately 30 minutes (taking the interview un-interrupted).

Why is this research being done?
The purpose of this research is to evaluate the effectiveness of the implementation of Safety Management System (SMS) at a U.S. Part 121 Carrier. Data will be gathered from managers and leaders who are involved in the administration of the SMS at the carrier. The themes which emerge from this research will be examined in relation to de-identified company safety artifacts. This research is meant to gauge the effectiveness of a carrier' s SMS, as well as serve as part of a holistic look at SMS implementation at a major air carrier which might highlight areas that are working well, as well as areas that might need attention.

What happens to me if I agree to take part in this research?

Approval Date: 10/28/2021

Expiration Date: 10/27/2022

University of North Dakota IRB

Date:_____
Subject Initials:_____

If you decide to take part in this research study, you will be given an opportunity to discuss this consent document before starting your interview. If you do not consent or wish to participate, you will be excused from the study with no consequences.

The interview session will be conducted via Microsoft Teams®, and will involve five short questions regarding your perceptions of SMS at your company. A transcript of your responses will be provided to you for review, then your de-identified comments will included in a composite analysis to identify common themes and recommendations.

Could being in this research hurt me?
There are no risks participating in this research beyond those experienced in everyday life.

Will being in this research benefit me?
It is not expected that you will personally or financially benefit from the research. However, you may choose to be part of the shared responsibility for safety in your organization by taking part in this study.

The study will provide data and tools for evaluation of the current state of a company's SMS, to include highlighting areas that may need attention. The study specifically examines the relationship between SMS implementation and function, safety leadership, and safety outcomes. This work will hopefully not only benefit your organization, but other organizations of similar complexity and scale.

How many people will participate in this research?
Approximately twelve fellow SMS managers/leaders will be invited to take part in this portion of the study.

What other choices do I have besides taking part in this research?
The alternative choice is to not participate in the study.

Will it cost me money to take part in this research?
You will not have any costs for being in this research study.

Will I be paid for taking part in this research?
There will be no financial incentive for taking part in this survey.

Who is funding this research?
There is no funding being provided for this research.

What happens to information collected for this research?
Your information may be shared for oversight purposes with:
- The Institutional Review Board (IRB) that reviewed this research

Approval Date: 10/28/2021

Expiration Date: 10/27/2022

University of North Dakota IRB

Date:_____
Subject Initials:_____

- The Research Advisor and Committee

We may publish the results of this research. However, we will keep your name and other identifying information confidential. We protect your information from disclosure to others to the extent required by law. We cannot promise complete secrecy.

The interview does not ask for any information that could connect respondent with response. After transcription, the respondent will have an opportunity to review their responses before data coding. Data coding will be conducted by the researcher, and it facilitates the use of the information gathered in the aggregate. If this research is published, no information that would identify the participants will be included. All materials will be treated confidentially and stored on a secure server through the data reduction process. After coding and analysis, all recordings will be destroyed. All other data will be retained in accordance with UND IRB policy. Data collected in this research will not be used or distributed for future research studies, even if identifiers are removed.

What if I agree to be in the research and then change my mind?
If you decide to leave the study early, we will stop the interview. You may skip any questions, if desired. If you would like to opt out altogether, you may do so with no adverse consequence. You may contact the principal investigator using the email address and telephone number provided in this consent statement, if desired.

Who can answer my questions about this research?
If you have questions, concerns, or complaints, or think this research has hurt you or made you sick, talk to the PI of the research team at the phone number listed above on the first page.

This research is being overseen by an Institutional Review Board ("IRB"). An IRB is a group of people who perform independent review of research studies. You may talk to them at 701.777.4279 or UND.irb@UND.edu if:

- You have questions, concerns, or complaints that are not being answered by the research team.
- You are not getting answers from the research team.
- You cannot reach the research team.
- You want to talk to someone else about the research.
- You have questions about your rights as a research subject.
- You may also visit the UND IRB website for more information about being a research subject: http://und.edu/research/resources/human-subjects/research-participants.html

Your signature documents your consent to take part in this study. You will receive a copy of this form.

Approval Date: 10/28/2021

Expiration Date: 10/27/2022

University of North Dakota IRB

Date:_____
Subject Initials:_____

Subject's Name: _____

_____ _____
Signature of Subject Date

I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative.

_____ _____
Signature of Person Who Obtained Consent Date

Approval Date: 10/28/2021

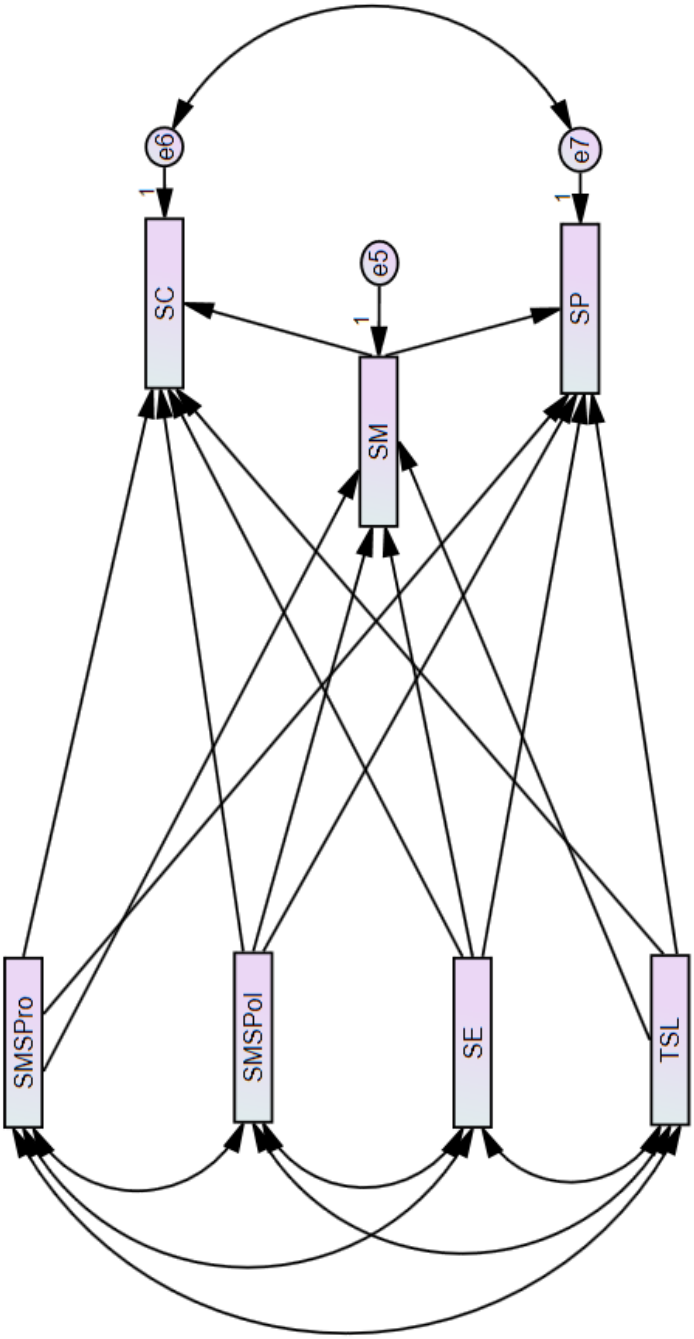
Expiration Date: 10/27/2022

University of North Dakota IRB

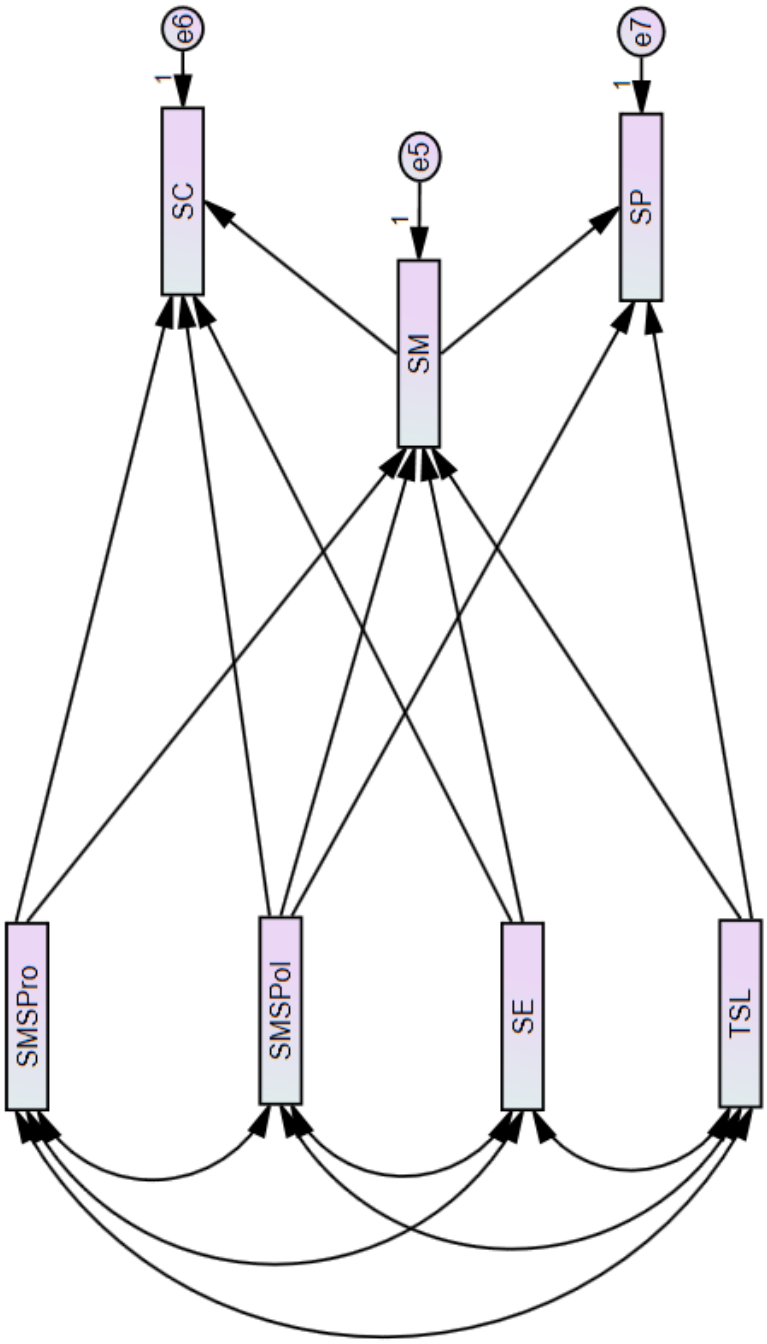
Date: _____
Subject Initials: _____

Appendix E

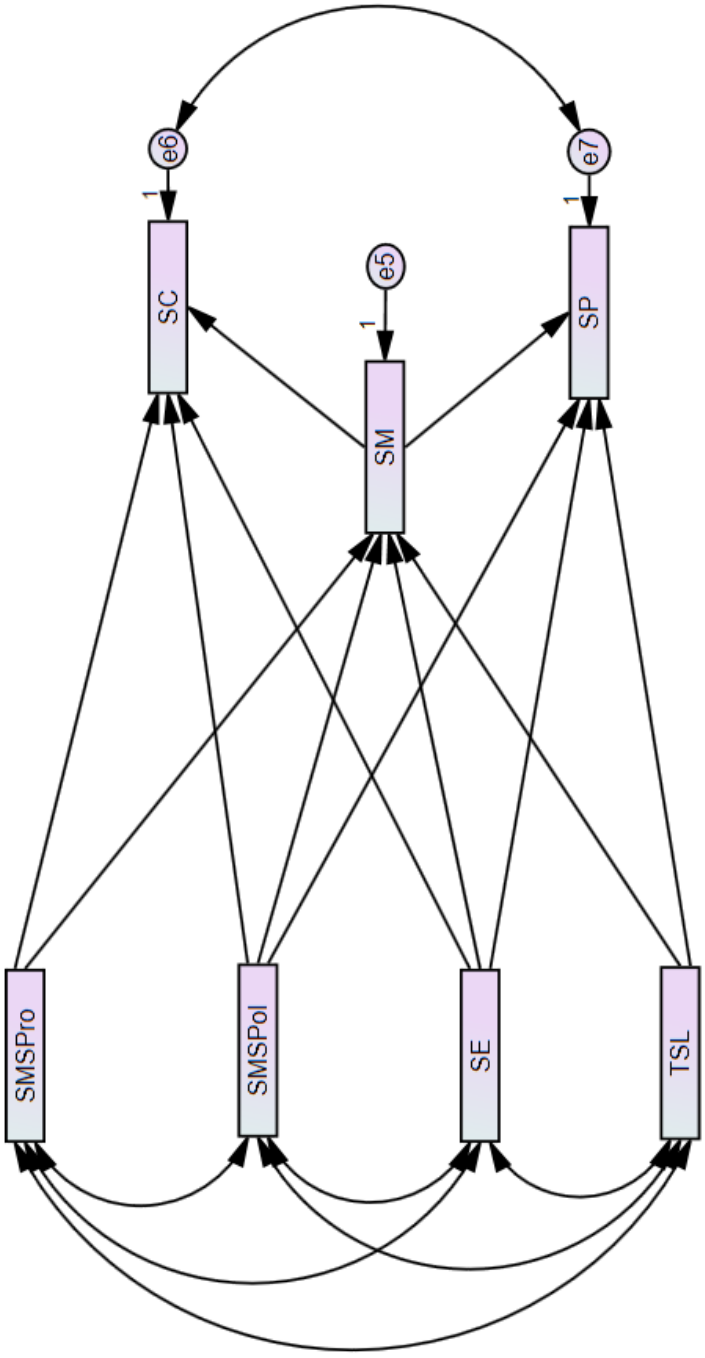
The Fully Mediated Structural Model with Covariance Between Error Terms



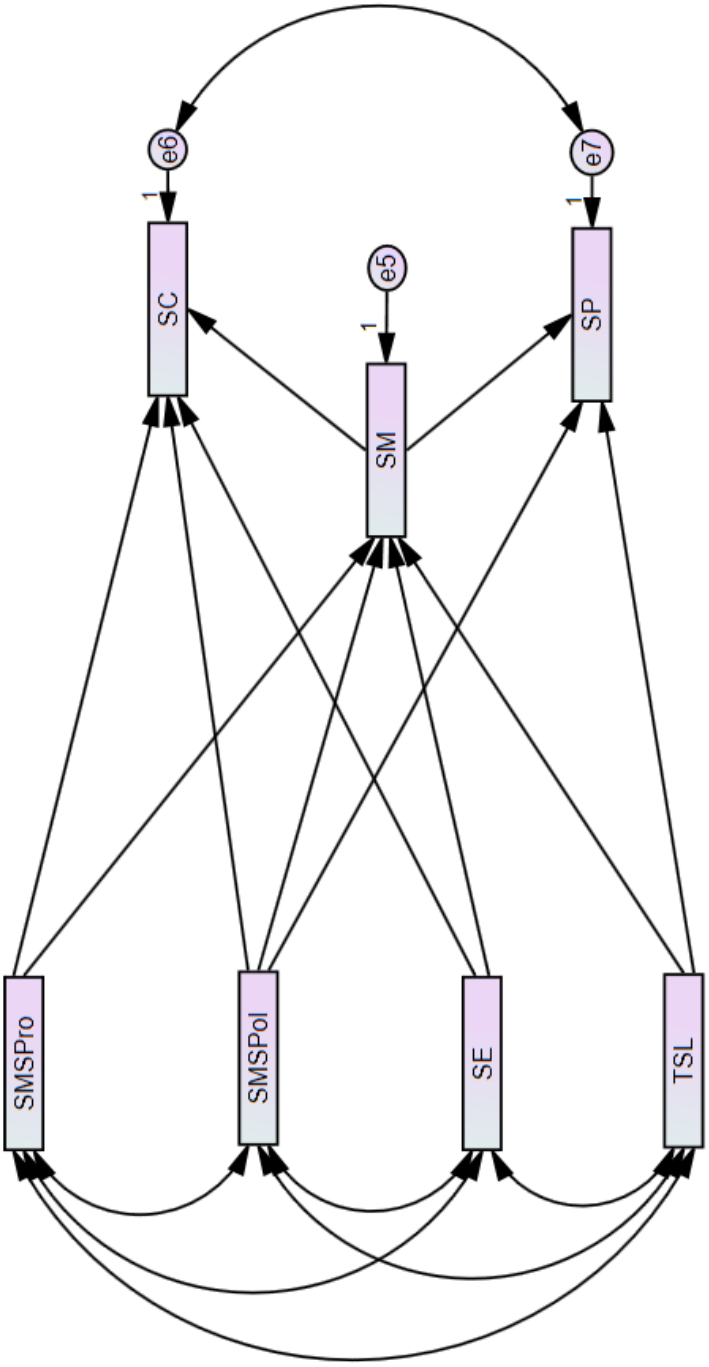
Appendix F
Model II: Covariance Between *e*6/*e*7 Removed



Appendix G
Model III



Appendix H
Model IV



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