Spring 5-13-2023

USING IMAGERY PRACTICE TO IMPROVE AIRLINE PILOT SITUATIONAL AWARENESS

Brian Christopher Sajdak

USING IMAGERY PRACTICE TO IMPROVE AIRLINE PILOT SITUATIONAL AWARENESS

by

Brian Christopher Sajdak

A Dissertation
Submitted to the Graduate School,
the College of Business and Economic Development
and the School of Leadership
at The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

Approved by:

Dr. H. Quincy Brown, Committee Chair
Dr. Heather M. Annulis
Dr. Jonathan Beedle
Dr. Mary Funk
Dr. Dale Lunsford

May 2023

Published by the Graduate School

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

ABSTRACT

Pilot error remains the primary cause of airline airplane accidents (Federal Aviation Administration, n.d.). Airline pilots have relied on Crew Resource Management and Threat Error Management to reduce or eliminate errors (Helmreich & Foushee, 2019). Unfortunately, the worldwide accident rate continues to increase (International Air Transport Association, 2021), demonstrating the need for further research into improving aviation safety. Current regulations do not require imagery training for airline pilots to improve situational awareness (Federal Aviation Administration, 2017a). Athletes and other professionals, such as musicians and medical professionals, use imagery to improve performance (Munzert et al., 2009). Imagery practice may improve the situational awareness of airline pilots. This study examined the relationship between imagery practice and airline pilot situational awareness. The researcher used an experimental posttest design with a group of airline pilots that received imagery training and a practice period. The data analysis answered the research questions and objectives using data provided by the participants who completed an interactive video survey.

The researcher compared the survey results with airline pilots without imagery practice, measuring Endsley's (1995) three levels of situational awareness, including perception, comprehension, and projection. The study's results produced three findings that emphasize the effects of the research. Pilots who practiced imagery more often had higher levels of situational awareness during the video survey than pilots who practiced less. Although there was an improvement in the group that practiced imaging a flight, further research may improve the effectiveness of imagery practice. More experienced pilots participated in the study compared to less experienced pilots. Further research regarding safety training experience and situational awareness could add to the findings of this study, along with Wang et al. (2021) findings regarding pilots using personal attributes such as emotional intelligence that replace inadequate training to maintain situational awareness. *Keywords*: imagery, situational awareness, surprise, crew resource management, threat error management

ACKNOWLEDGMENTS

I want to thank the faculty and staff within the Department of Human Capital Development. I especially thank my committee chair, Dr. H. Quincy Brown, and committee members, Dr. Heather M. Annulis, Dr. Jonathan Beedle, Dr. Mary Funk, and Dr. Dale Lunsford, for their tireless commitment to student success throughout my experience in the program.

Acknowledgment is not enough for my family. My wife, Laura, and my two sons, Geir and Thaddeus, sacrifice many days and nights to allow me to succeed when I challenge myself to continue learning. I cannot thank them enough.

To my classmates, especially my HCD cohort, I thank you for the opportunity to learn from you all. The drive of the group was more significant than any individual. It does take a team to produce success, and the high-performing individuals formed a bond I will never forget. Thank you, all.

DEDICATION

This dissertation is dedicated to

all pilots who have lost their lives, that we learn from, to be safer.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
CAB	Civil Aeronautics Board
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
FAA	Federal Aviation Administration
fMRI	Functional Magnetic Resonance Imaging
FSC	Full Service Carrier
HFACS	Human Factor Analysis and Classification System
LCC	Low Cost Carrier
LMS	Learning Management System
LOSA	Line Operations Safety Audit
MEG	Magnetoencephalography
MG-M	Motivational General Mastery
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
PET	Position Emission Tomography
PETTLEP	Physical, Environment, Task, Timing, Learning, Emotion, Perspective
SA	Situational Awareness

SAGAT	Situational Awareness Global Assessment Technique
TEM	Threat Error Management
TMS	Transcranial Magnetic Stimulation

CHAPTER I – INTRODUCTION

According to the Federal Aviation Administration Human Factors (n.d.), nearly three-quarters of all aircraft accidents are attributable to human error. Along with federal agencies and independent safety organizations such as the Flight Safety Foundation, Air Transport Association, and the International Air Transport Association, the airline industry strives to improve global aviation safety (Flight Safety Foundation, n.d.). Commercial flights operate under strict government regulations to ensure safety for the general public (Federal Aviation Administration, 2022a). Despite extensive safety precautions, companies continue to experience aircraft accidents (Aviation Safety Network, 2022). Although high-profile aircraft accidents have occurred in recent years, the airline industry experienced very few incidents related to mechanical failure (Aviation Safety Network, 2022). Accidents are, instead, attributable to human error (Federal Aviation Administration Human Factors, n.d.). Airlines spend time and resources to train airline pilots to eliminate as much human error as possible (U.S. Bureau of Labor Statistics, 2022); however, airline training programs do not include imagery training (Federal Aviation Administration, 2017a).

For decades, professional athletes have used imagery training to enhance performance under stressful conditions (Onestak, 1991). *Motor imagery* training includes visual imagery and kinesthetic imagery awareness (Chholak et al., 2019). Yu et al. (2016) define *visual imagery* as visualizing successful performance in either the first or third-person perspective without any movement. *Kinesthetic imagery* emphasizes the sensations of physical movements through some form of action while visualizing (Yu et al., 2016). This study reviews research in the field of imagery training. The study explores whether improving airline pilots' situational awareness (SA) reduces human error.

Chapter I explains the background of this quantitative research study, including reactions to the most recent airline accidents involving surprise events and current training settings for airline pilots. The chapter includes a statement of the problem, the purpose of the study, and the research objectives. A theoretical framework builds a visual picture for the basis of the study, leading to the significance of the study with limitations, delimitations, and assumptions. This chapter also includes a list of definitions to explain aviation and airline terms and helpful imagery vocabulary to understand the study.

Background of the Study

In 2009 a tragic airplane accident in Buffalo, New York, forced the FAA to reexamine the minimum level of knowledge and experience required by airline pilots (NTSB, 2010). The National Transportation Safety Board (NTSB) Accident Report listed probable causes of the accident, including the captain's inability to manage the flight and the pilot monitor's failure to identify the errors of the pilot flying the airplane (NTSB, 2010).

Airline pilots fly an average of 75 hours per month (The U.S. Bureau of Labor Statistics, 2022). A typical flight crew for transport category airplanes requires a minimum of two pilots, the captain and the first officer (Federal Aviation Administration, 1993). The captain represents the person of record with authority and responsibility to operate an airplane safely with the intention of flight (Federal Aviation Administration, 2017b). The first officer assists the captain with assigned duties to accomplish a safe flight (Federal Aviation Administration, 2017b). Longer international flights can include up to two relief flight officers (National Archives, 2022a).

Typically, the captain has more experience than the other pilots on the flight deck since most airlines operate on a seniority model (Lee & Singer, 2014). The captain maintains responsibility for a flight's safe and legal outcome (National Archives, 2022a). The captain in the 2009 accident in Buffalo had 3,379 total flight hours with 111 hours of flight experience on the accident airplane type, the Bombardier Q400 (NTSB, 2010). The First Officer had 2,244 total flight hours with 774 hours of flight experience on the accident airplane type (NTSB, 2010).

Total hours represent the experience level of a pilot. The FAA requires a minimum of 1,250 flight hours for pilots who graduated from an approved school or 1,500 for non-approved programs to work for an airline (National Archives, 2022b). Some higher education institutions operate as a Certified Training Program, allowing pilots to obtain a restricted Air Transport Certificate at a lower experience level measured in flight hours (Federal Aviation Administration, 2020a). A captain must complete 1,000 hours as a first officer before upgrading to captain (National Archives, 2022b). The pilots' experience level in the Buffalo accident was low, considering airline pilots fly an average of 75 flight hours per month. The NTSB (2010) report re-emphasized previously issued recommendations that training programs should include developing skills necessary to monitor and evaluate human error (NTSB, 2010).

Current Recommendations for Training Pilot Situational Awareness

The training recommendations of the 2010 NTSB report have similarities with past reports. In 1994, the NTSB acknowledged the pilot's need for comprehensive crew resource management training, with 31 of 37 accidents between 1978 and 1990 reporting inadequate pilot cross-checking and monitoring (NTSB, 1994). In 1994, the NTSB recommended that the airlines not operating under the Advanced Qualification Program (AQP) should train airline pilots in the simulator under realistic conditions, using non-flying monitoring, and challenging errors. An Advanced Qualification Program at an airline represents a training methodology that uses a proficiency-based model to train and evaluate airline pilots (Federal Aviation Administration, 2017a). Each airline submits for approval to the Federal Aviation Administration (FAA) a detailed job task analysis and innovative methods to train airline pilots to achieve maximum performance (Federal Aviation Administration, 2017a). The repeating themes throughout these NTSB reports emphasize the need for improved training methodologies.

Practical airline pilot flight training is essential for the safe operations of air commerce (U.S. Bureau of Labor Statistics, 2022). Before holding an Air Transport Pilot certificate, pilots require minimum training and flight hours (Federal Aviation Administration, 2013). The FAA sets training standards and minimum qualifications for airline pilots, including knowledge testing and practical testing in airplanes (Federal Aviation Administration, 2019). Airline pilot training provides pilots with technical proficiency skills (cerebral knowledge) and physical capabilities based on trained responses to scenarios within a familiar context (Casner et al., 2012). Simulation training focuses on skills, knowledge, and ability in a simulated setting, and training continues in real-time during flights (Federal Aviation Administration, 2017a).

Programs created since 2010 include the safety recommendations from the NTSB (Federal Aviation Administration, 2020b). Leadership, Command, and Mentoring

Programs, created from recommendations made over twelve years ago, represent an example of a current safety program (NTSB, 2010). Airlines actively deploy training programs to meet mandatory compliance by April 27, 2023 (Federal Aviation Administration, 2020b). The training program focuses on *soft skills* to supplement the technical skills of procedures and maneuvers (Federal Aviation Administration, 2020b). The program recommends discussing critical issues from the NTSB (2010) during an airline pilot's initial and recurrent training.

Current Airline Training Practices

New hires or *airline* pilots flying a different aircraft type for the first time at an organization must receive initial training in the airplane (Federal Aviation Administration, 2013). The FAA AQP training includes systems, procedures, maneuvers, and operations training (Federal Aviation Administration, 2017a). Recurrent training requires a*n airline* pilot to demonstrate skills learned in initial training and current issues that the organization or the FAA determines are crucial to flight safety (Federal Aviation Administration, 2017a). The training occurs using a variety of learning tools.

Airlines utilize many training interventions (Federal Aviation Administration, 2017a). For example, *airline* pilots demonstrate skills and abilities in full-motion simulators, static flight training devices, procedures trainers, and flight deck mock-ups (Federal Aviation Administration, 2017a). Learning Management Systems (LMS) curate instruction and provide operating manual information and procedures for the airplane (Khoualdi & Algamdi, 2019). Some airlines use Flight Management Systems (FMS) applications on tablet computers to train *airline* pilots in managing navigation and communication systems (Klein et al., 2009). The sophisticated simulation machines and training tools focus on individual and *team* skills through well-trained instructors (Myers et al., 2018). Still, the Federal Aviation Administration (2017a) does not require imagery practice (visual or kinesthetic) where *airline* pilots would close their eyes and "see" themselves throughout the flight maintaining SA.

The Crew Resource Management (CRM) concept and Threat Error Management (TEM) model exist in the aviation industry to improve safety (Helmreich & Foushee, 2019). TEM defines what *airline* pilots do *to deal with threats and errors*, and CRM explains how *airline* pilots *communicate threats and errors* (Helmreich & Foushee, 2019). After studying multiple crashes, NASA psychologists created the term CRM in 1979 (Helmreich, Merritt, & Wilhelm, 1999). CRM matured in the early 1980s when training programs focused on correcting individual attitudes and management training approaches (Helmreich, Merritt, & Wilhelm, 1999). CRM training concepts evolved to reduce human error frequency and severity in airplanes (Helmreich, Merritt, & Wilhelm, 1999). Researchers admit that CRM does not reach all *airline* pilots, and some reject the training and practice benefits (İnan, 2018).

CRM now focuses on *airline* pilots' behaviors when responding to threats (Helmreich, Merritt, & Wilhelm, 1999). Lauber (1984) defines CRM as a *team* using all available resources to achieve a safe, legal, and efficient flight. CRM behaviors include communication and decision-making, team formation and leadership management tasking, situation awareness and workload management, technical skills and knowledge (Martin, 2019). The evolution of CRM behaviors led to an additional model to supplement CRM concepts called the Threat and Error Management Model (Federal Aviation Administration LOSA, n.d.).

The University of Texas developed early CRM concepts using a Line Operations Safety Audit (LOSA) for airlines that reveal actionable data to reduce *airline* pilot errors (Federal Aviation Administration LOSA, n.d.). The study moved the aviation industry towards systems thinking about human factors errors (Federal Aviation Administration LOSA, n.d.). Line Operations Safety Audit observers sitting in commercial airplane jumpseats began recording human errors made by *airline* pilots to understand whether CRM behaviors would become errors (Federal Aviation Administration LOSA, n.d.). In 1997, the University of Texas and Continental Airlines conducted a LOSA study to create the framework of what has become the TEM model (Federal Aviation Administration LOSA, n.d.). The researchers studied the errors from a systems perspective and determined behavioral responses (Federal Aviation Administration LOSA, n.d.). They concluded that *airline* pilots make behavioral responses to threats and errors (Federal Aviation Administration LOSA history, n.d.).

Helmreich, Klinect, & Wilhelm (1999) developed the TEM model at the University of Texas to organize a systematized process for pilots. *Airline pilots use t*he TEM model tool *t*o determine external and internal threats during a flight (Helmreich, Klinect, & Wilhelm, 1999). Within the TEM model, threats are identified through awareness, meaning the individual or *team* determines a threat exists as part of the flight. Then errors are avoided by utilizing CRM behaviors (Helmreich, Klinect, & Wilhelm, 1999). If *pilots do not* manage *a threat* by either changing the plan or waiting until the threat no longer exists, the threat could become an error (Helmreich, Klinect, & Wilhelm, 1999). *Airline p*ilots manage the error with CRM behaviors allowing pilots to recover to a safe flight condition (Helmreich, Klinect, & Wilhelm, 1999). Mismanaged threats and errors can lead to incidents and accidents (Helmreich, Klinect, & Wilhelm, 1999).

Even with *teams* using CRM behaviors to respond to threats and errors, pilot errors typically account for the primary cause of airplane accidents (Federal Aviation Administration Human Factors, n.d.). Reason's (1990) Swiss Cheese model explains that a productive safety system has many levels, the *airline* pilot being the last. Each level can break down, giving the *airline* pilots the final opportunity to make the flight safe. Wiegmann and Shappell (2003) developed the Human Factors Analysis and Classification System (HFACS) to investigate the latent and active errors that combine to cause an accident. Wiegmann and Shappell (2003) contend that pilot human factors errors are skill-based, decision-making, and perceptual problems that imagery training may correct.

Imagery Training for Pilots

Imagery, also known as mental practice, has been used by many individuals to enhance performance by visually repeating a behavior (Jackson et al., 2001). During a study of elite athletes who rely on automatic behaviors (like putting in golf), Kacperski et al. (2016) found imagery helpful on competition day. Lotze (2013) explains how musicians utilize mental imagery's visual, motor, somatosensory, and auditory components to improve their performances. Research demonstrates that long-term memory stores help maintain SA in uncertain events (Endsley, 1995). Pilots remember close-call experiences from previous flights to improve their performance during the current flight (Madsen et al., 2016).

Imagery training represents an individual's metacognitive skill, meaning they can consider how to improve their thinking skills unrelated to interactions with others (Pearson et al., 2011). Hammond et al. (2012) found that athletes improved individual golfing performance using Motivational General-Mastery (MG-M) imagery training. MG-M imagery focuses on individuals overcoming a problematic situation while imagining being in control (Hall et al., 1998). When the pilot's ideal reaction to a situation matches their actual behavior, the pilot has SA (Adams & Pew, 1990). Pilots must maintain SA to avoid errors and keep the airplane safe (Adams & Pew, 1990); however, airline pilots experience significant challenges in maintaining SA (Federal Aviation Administration, 2017b).

Situational Awareness For Pilots

Early research in pilot SA focused on the individual's cognitive process (Prince & Salas et al., 2017). Although CRM was historically a team concept, Foushee and Helmreich (1988) studied the individual's input factors. Endsley (1995) focused on individual and team SA and developed three levels of SA. Endsley's (1995) three SA levels are level one perception, level two comprehension, and level three projection. Situational awareness perception draws on the person knowing what has happened (Endsley, 1995). Situational awareness comprehension understands, through awareness, the current state mental model (Endsley, 1995). Situational awareness projection forecasts what will happen due to the conditions (Endsley, 1995). During previous studies, Endsley (1995) treats SA as a separate but causal construct of decision-making. A person with poor SA may cause an accident regardless of decision-making ability (Endsley, 1995). Therefore improved SA can reduce decision-making mistakes.

However, no change or improvement to SA will cause the same human error results (NTSB, 2010).

Norman (1981) explains a mistake as an error associated with losing SA, meaning the loss of SA derives from the individual forming an incorrect intention and performing the wrong action or process. Pilots making mistakes in an airplane relates to the inability of human-centric processes (focusing on tasks, activities, and human skills) to connect accurately with the airplane's machinery (Wiegmann & Shappell, 2003). SA loss continues as a problem in the airline industry (NTSB, 2010). Imagery training could determine whether visualization improves the airline pilot's SA (Jentsch et al., 1997).

In 2017, Chen et al. integrated neuroscience, psychology, and social sciences theorizing that visualization connected human-centric processes to machine-centric processes. Tokumaru et al. (2003) tested imagery flight training, measuring electroencephalogram (EEG) in novice pilots and fighter pilots. The research team found cortical stimulation and powerful vividness in the fighter pilot group, suggesting that imagery research may be helpful to airline pilots (Neuper et al., 2005; Tokumaru et al., 2003).

Statement of the Problem

Airline pilots monitor and manage the systems and operations on the flight deck to reduce or eliminate pilot errors (Federal Aviation Administration, 2017a). Improperly trained airline pilots who lose SA while monitoring for errors can lead to an undesired aircraft state and, eventually, an accident (Federal Aviation Administration, 1996; Jones & Endsley, 1996). NTSB investigations, such as the Colgan Air Flight 3407 (NTSB, 2010) accident, and other accidents like two fuel starvation accidents, United Airlines

Flight 173 in 1978 (NTSB, 1979) and Avianca Airlines Flight 52 in 1991 (NTSB, 1991), due to loss of situational awareness in monitoring, demonstrate that human errors with tragic results have continued for decades. A few possible consequences of an airplane accident are loss of life, destroyed families, damage to property, and liability to the airline. In order to prevent accidents caused by pilot errors, changes need to be made to current airline pilot SA training to reduce or eliminate errors (NTSB, 2010). If the current airline pilot training methodology to improve SA remains the same, accidents and losses will continue to plague the industry.

Purpose of the Study

This study aims to determine the relationship between imagery practice and situational awareness for airline pilots. The study examines the effects of imagery on three levels of SA, including perception, comprehension, and projection. Finally, the data analysis may prompt regulators and airlines to include imagery practice in existing training plans.

Research Objectives

Understanding how imagery practice improves airline pilots' SA requires posing relatable questions. Clearly stated research questions help the researcher use the appropriate test and analyze the results (Meltzoff & Cooper, 2018). The following research questions will address SA and imagery: Does the practice of imagery improve airline pilot situational awareness? Do airline pilots who receive imagery training and practice improve situational awareness perception, comprehension, or projection?

This study answers the research questions through three types of research objectives: descriptive, relationship, and comparison objectives (Meltzoff & Cooper, 2018). The research objectives parallel the problem by focusing on improving airline pilot SA through imagery training and practice. The research objectives that guide this study include:

RO1 – Describe the participants in the study, including years of flying experience, type of flying experience (civilian/military/combination), total flight hours, and age.

RO2 – Determine the relationship between imagery practice and airline pilot situational perception.

RO3 – Determine the relationship between imagery practice and airline pilot situational comprehension.

RO4 – Determine the relationship between imagery practice and airline pilot situational projection.

RO5 – Compare the difference in situational awareness for the airline pilots with imagery practice and those without imagery practice.

Conceptual Framework

The conceptual framework for this experimental quantitative study roots in a grounded theory of causal inference. Shadish et al. (2002) describe two kinds of generalized causal inference: generalizations regarding the constructs and generalizations regarding the measurement variables. Generalized causal inference focuses on the translation of imagery for airline pilots in this study to follow-on studies under different settings and locations that should produce similar results (Shadish et al., 2002). To meet the stringent requirements to generalize, the conceptual framework in Figure 1 depicts the study's constructs, variables, and theories.

Swanson and Holton (2009) describe human resource development as a three-legged stool that includes economic, systems, and psychology theories as foundational in performing as an organization, process, team, and individual with ethics underlying the theories. Regarding economic theories, organizations are in business to earn a profit and provide value to shareholders (Swanson & Holton, 2009). If human error rates decrease, investment in imagery training could provide a substantial return on a minimal investment (Jentsch et al., 1997). Airlines rely on many safety systems that parallel systems theory. Systems contain the processes that connect to other subsystems throughout the organization to plan for the future or maintain performance during stable and chaotic seasons (Swanson & Holton, 2009). In the psychology "leg" of the human resource development stool, cognitive, Gestalt, and behaviorism bring together human performance's individual and organizational importance (Swanson & Holton, 2009). Cognitive load theory explains how humans gain and process information through working and long-term memory (Kirschner et al., 2018). The conceptual framework demonstrates the integration of human capital theory with imagery theory to explain the study.

Kosslyn (1981) describes imagery theory as processing information through data structures, including how individuals organize information and format content. A link exists between situational awareness and pilot errors in complex systems (Salas et al., 1999). Kinesthetic and mental imagery practice should increase SA and reduce pilot monitoring errors (Jentsch et al., 1997). Increased SA in airplane procedures reduces risk (Endsley & Robertson, 2000). Decreased risk should lead to fewer airplane incidents

(You et al., 2013). This study uses imagery to determine whether an increase in SA reduces error incidents.

This study's conceptual framework (Figure 1) depicts the application of imagery training in tandem with the current aviation CRM concepts used in the TEM model. The study's foundation details the economic, system, and psychological theory that Swanson and Holton (2009) state supports the individual, team, process, and organization goals—in this case, for a safe airline. Mental imagery exercises creating, generating, inspecting, maintaining, and manipulating an image in the mind's eye (Sima et al., 2013). In the present study, the treatment group receiving the imagery training and practicing imagery over the three weeks will apply spatial images, known as object maps, to the flight plan.

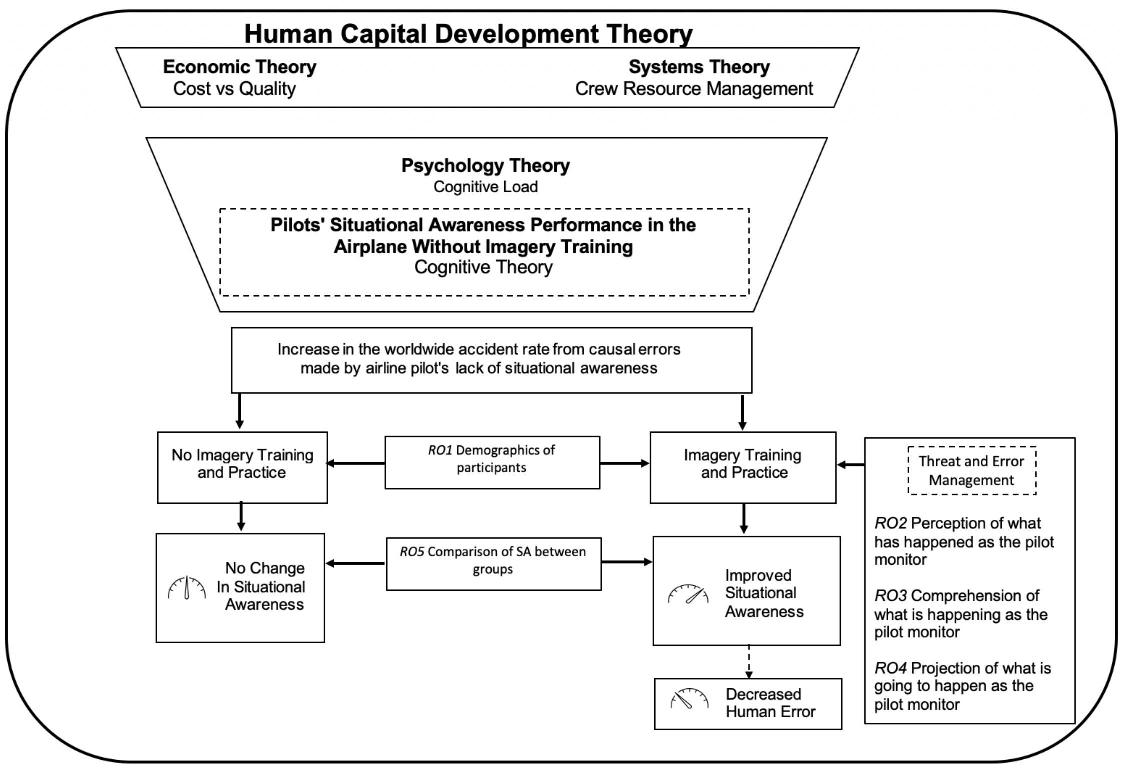


Figure 1. Conceptual Framework

Object maps exist in human brains' properties–processing subsystem (Kosslyn, 1994). The control group will not receive training. Both the treatment and control group participants will complete a survey that measures SA. The treatment group survey will also collect data, including the number of flights completed and the number of times practicing imagery throughout the study. The study's results provide data for further research and future aviation training.

Significance of the Study

U.S. airline accident rates with fatalities remain low (Boeing Statistics, 2021). Commercial aviation in the United States has decreased the number of measured fatalities by 95% during the past two decades (Federal Aviation Administration, 2018). The U.S. Bureau of Transportation Statistics (n.d.) reports that the U.S. Air Carriers had an accident rate of .157 per 100,000 flight hours. When accident rates are low, investigators' complexity in determining the cause of an accident increases (Haunschild & Sullivan, 2002). Haunschild and Sullivan (2002) report complexities with accident investigation from accident heterogeneity due to increased regulations and training. With advanced technology, predicting an accident has become more complex (Haunschild & Sullivan, 2002). Haunschild and Sullivan (2002) suggest that increasing system variety for reducing errors, including individual diversity of experience in specialist jobs like flying, can benefit safety. A solution could include imagery training. Accident rates are one way to determine airline safety (International Air Transport Association, 2021). Investment in safety programs can also provide insight into airline safety.

Low accident rates have not slowed investment in reducing accident rates to zero. The aviation industry uses federally-sponsored programs such as voluntary reporting systems and analysis and sharing programs to maintain low accident rates (Federal Aviation Administration, 2018). An increase in airline safety expenditures resulted in a 9.34% decrease in the airline's average accident rate (Wang et al., 2013). Commercial Airlines and regulators have added technology, such as Traffic Collision and Avoidance Systems, to prevent identical accidents (Federal Aviation Administration, 2011). Although automated flight decks continue to advance, airline pilots consistently make the same human errors by losing SA (NTSB, 2010).

A reduction in both the accident rate and fatalities in the United States over an extended period still finds SA pilot monitoring errors attributed to most accidents (Federal Aviation Administration, n.d.). Although domestic accident rates are low, the International Air Transport Association stated that the overall worldwide 5-year accident rate increased from 2016 to 2020 (International Air Transport Association, 2021). That means the current training and investments are not improving the accident rate globally.

This study adds data to the current accident prevention methods by applying imagery training, which Pearson et al. (2011) assert improves performance. A positive impact on perception occurs when an image improves and becomes more vivid (Pearson et al., 2011). The improved performance may translate to the aviation industry reducing human error. Imagery training could reduce future airline investments by improving SA and reducing human error (Federal Aviation Administration, 2004). The potential return on investment for the training costs exists with improved SA during surprise events.

Airlines will continue to invest in airplane automation without studying the correlation between imagery practice and improved SA during surprise events (NTSB, 2010). Airlines will also improve other forms of traditional CRM training without imagery training based on the NTSB (1994, 2010) safety report recommendations. Taking a different approach by using techniques of imagery training from well-established and researched areas that use imagery training may be the answer that airlines seek to improve performance (Cumming & Ramsey, 2008).

Delimitations

The delimitations of this study set the boundaries within aviation that the imagery practice will research. The U.S. Bureau of Labor Statistics (2021) estimated that airlines employed approximately 81,310 airline pilots in the United States in 2021. Mazareanu (2019) estimates that there are 333,000 airline pilots worldwide. The study will be limited to airline pilots with membership in the Airline Pilots Association at a U.S.-based cargo airline. Although English remains the international language for aviation, there may be language barriers for those airline pilots who do not speak English as their primary language. Using a U.S. airline pilot group sample will ensure English as a primary language.

The sample population requires all participants to hold the U.S. Air Transport Pilots certificate and actively fly. Once issued, an Airline Transport Pilot certificate remains a lifetime license, so participants of the study must be actively flying at the time of the study and not retired pilots who may have been out of the industry and lack the most current CRM skills. The airline pilots cannot be in training for a different airplane during the three-week study period. Training for a different airplane may not allow airline pilots enough time to practice imagery. It will not allow them to fly in the airplane since training is conducted mainly in simulators.

The study requires participants to access a computer or tablet device with an internet connection to complete the training and surveys. The treatment group participants must fly at least three flights within the three-week study period to practice imagery and consolidate the information. The participant's perspective for the study simulates the role of pilot monitoring. The pilot monitoring monitors the flight but without moving the flight controls (Federal Aviation Administration, 2015a). This study excludes the SA of the pilot moving the flight controls. In order to focus primarily on monitoring, the choice to exclude the pilot flying can focus the participant on the intended skillset.

Assumptions

The study assumes that the Airline Pilots Association's sample population represents typical airline pilot behaviors. The study also assumes that the participants will follow the treatment and practice period detailed in the instructions. Professional airline pilots expect the profession that participants would give an effort commensurate with the responsibility bestowed upon each airline pilot in the industry to answer the posttest accurately and honestly. Lastly, the study assumes that the research and data collected from previous studies, such as Endsley's (1995) Situational Awareness Global Assessment Technique (SAGAT), provided accurate results.

Definitions of Terms

The definition of terms for this study will be helpful in explaining specific terms related to aviation and imagery. The following list defines terms associated with this study:

1. *Active Errors* – Errors made by the pilots directly responsible for the event (Wiegmann & Shappell, 2003).
2. *Airline Transport Pilot certificate (ATP)* – The pilot certificate required to fly large part 25 certified air transport airplanes. The highest level of aviation license an individual pilot can attain (Federal Aviation Administration, 2019).
3. *Airplane Accident* – An occurrence involving an airplane with persons on board with the intent to fly that suffers substantial damage, death, or serious injury (National Archives, 2022c).
4. *Airplane Incident* – An operation involving an airplane, not meeting the definition of an accident, where the actions affect the safety of operations (National Archives, 2022c).
5. *Crew Resource Management (CRM)* – The effective use of all flight crew resources to provide safe results through behaviors that mitigate threats and reduce errors (Federal Aviation Administration, 2004).
6. *Error Troika* – Avoiding and mitigating errors while working as a team (Helmreich, Merritt, & Wilhelm, 1999).
7. *Federal Aviation Administration (FAA)* – A U.S. Department of Transportation division responsible for regulating and implementing safety rules and promoting aviation in the United States. (Federal Aviation Administration, n.d.).
8. *FAA Advanced Qualification Program* – An FAA-approved training guideline that sets standards for an airline to design and develop a specific training

program based on the individual airline's needs (Federal Aviation Administration, 2017a).

9. *Human Factors Analysis and Classification System HFACS* – A system that defines the active and latent failure levels in aviation that lead to an accident (Wiegmann & Shappell, 2003).
10. *Imagery* – Images are created through a mental process utilizing imagination (Mizuguchi et al., 2017).
11. *Imagery Training* – The practice of learning and using mental imagery to enhance individual performance by visually repeating a behavior (Jackson et al., 2001).
12. *Kinesthetic Imagery* – A cognitive creation of mental depiction while physically moving through the movements without performing the action for which the individual practices the movements (Ridderinkhof & Brass, 2015).
13. *Latent errors* – Errors that are undetected or dormant until they adversely affect the unsuspected pilots (Wiegmann & Shappell, 2003).
14. *Line Operations Safety Audit* – An assessment of human factors threat and error management through documenting behavioral markers (Federal Aviation Administration LOSA, n.d.).
15. *Mental Imagery* – A cognitive creation of a mental depiction of an object or process within a person's imagination or memory not present (Roumbou, 2017).
16. *Mental Model* – Human interaction within a cognitive structure where humans create meaningful patterns (Reynolds, 2009)

17. *National Transportation Safety Board (NTSB)* – The inspection agency of the United States government that investigates airplane accidents and makes safety recommendations (NTSB, n.d.).
18. *Pilot Flying* – The pilot on the flight deck responsible for managing the flight path and energy of the airplane (Federal Aviation Administration, 2015a).
19. *Pilot monitoring* – The pilot not physically moving the flight controls yet responsible for backing up the actions of the pilot flying the airplane in a multi-crew airplane (Federal Aviation Administration, 2015a).
20. *Reason's Swiss Cheese Model* – Breakdown of a productive system's organizational influences, supervision, preconditions of safety, and unsafe acts that lead to an accident (Reason, 1990).
21. *Situational Awareness* – The accurate perception of past activities, present situation, and future possibilities that affect the safety of the airplane (Endsley & Robertson, 2000).
22. *Threat Error Management (TEM)* – A safety concept or model of human performance to address threats and errors when operating an airplane in a team environment (Helmreich, Klinect, & Wilhelm, 1999).

Organization of the Study

The study's organization includes a literature review, the research methodology, research results, research analysis, discussions, and a summative conclusion. Chapter Two provides a literary review of aviation safety history, then narrows to discuss the conflict between airline profitability and training costs and the evolution of CRM and TEM while understanding SA. Chapter Two also explains the differences between the multi-pilot and individual mental models and how imagery can improve pilot SA. Chapter Three describes this study's research process, including the quantitative research methodology. The research design integrates the variables, sample and population, instrumentation, data collection plan, data analysis and display plan, and limitations.

Summary

Airline history demonstrates a need to identify and resolve issues for flight safety (NTSB, n.d.). Airplane technology has become more complex (Haunschild & Sullivan, 2002), causing airline pilot training requirements to grow (NTSB, 2010). Although accident rates remain low, every accident has devastating consequences for the community and airline involved.

Until the industry sustains zero accidents annually, new research with new ideas remains essential to improve SA and reduce pilot monitoring errors (Federal Aviation Administration Human Factors, n.d.). This study will determine the relationship between imagery practice and airline pilot SA. The study uses historical research in SA and current training information in CRM utilizing TEM to anchor the research.

CHAPTER II – LITERATURE REVIEW

The aviation industry has relied on data as a significant source to maintain safe, reliable service (Flight Safety Foundation, n.d.). The literature review will provide a background into the general safety within the airline industry and the conflict between training costs and profitability. The review will then describe human factor errors through CRM, SA, surprise events, TEM, and airline safety systems. The literature review's focus then turns to individual performance improvement using imagery. Finally, the review will connect imagery to aviation and individual mental models of airline pilots. The review demonstrates the need for the study.

This study remains rooted in human capital development through the airline industry's economic, system, and psychological components to improve an airline organization's performance through working groups and individual employees (Swanson & Holton, 2009). This study examines sustainable resource theory, which Swanson and Holton (2009) describe as the struggle employees endure when resources are scarce. The research will demonstrate CRM and TEM's connection to the airline safety system and applies Swanson and Holton's (2009) general description of systems theory. The researcher will also show how SA and imagery rely on Swanson and Holton's (2009) interpretation of Gestalt psychological theory and cognitive psychology. Finally, the researcher will help the reader understand how incorporating imagery training could significantly contribute to aviation safety.

Historical Changes to Aviation Safety

Safety has always been an inherent risk in air transportation (Flight Safety Foundation, n.d.). However, risks to airline organizations have changed (Flight Safety

Foundation, n.d.). This literature review explains the airline industry history as actions and attitudes from the pre-jet age and jet age to deregulation, post-deregulation to September 11, 2001, through post-September 11, 2001. Some may argue that the COVID-19 pandemic may be another segment that will change aviation's trajectory (Xuan et al., 2021). However, the history books have not yet written on the effects and changes to airline passenger safety regarding health, so the researcher will reserve adding post-pandemic aviation industry accounts.

Pre-Jet Age

Early aviation required significant capital to purchase and operate airplanes (Bilstein, 1969). The airline transportation industry's early days started with the need for additional revenue that passenger travel provided to airmail carriers (Johnson, 2018). The Air Mail Act of 1925, the Air Commerce Act of 1926, the Foreign Air Mail Act of 1928, and the Watres Act demonstrate a need for regulation as aviation's infancy caused struggling companies to look for ways to succeed (Van der Linden, 2002). Since most technologies were brand new and tremendous upstart costs were a reality, safety was a lower priority than financial success and excessive marketing (Popp, 2016). Airline safety was unknown nationally in the young industry due to poorly documented airplane accident recordkeeping, technology challenges, and tremendous growth (Federal Aviation Administration, n.d.).

Early 20th-century inventors built many different airplane types as the industry learned how to control powered flight (Van Vleck, 2013). Individuals creating new airplanes and innovating ways to move mail and people with no central repository for information, including accident data, made it challenging to improve safety (Van Vleck, 2013). New instrumentation, such as gyroscopes, navigation, and communication equipment, was added to airplanes to improve safety (Bradley, 1994). Even with new technology, accidents were frequent (Popp, 2016). The fearful flying public demanded that commercial aviation provide a safe operating environment (Popp, 2016). In 1938, the United States established the Civil Aeronautics Authority (CAA), which conducted investigations to determine accident causation and reduce airplane accidents (Federal Aviation Administration, n.d.). Growth in passenger and mail transportation continued, driving further regulations by the CAA to improve safety (Federal Aviation Administration, n.d.).

The U.S. government created the Civil Aeronautics Board (CAB) to regulate competition through a route approval system (Gormly, 2015). The CAB was responsible for growing the domestic routes and establishing airline fare prices to make it possible for airlines to have some predictability in revenue (Gormly, 2015). Domestically, commercial air travel increased, although there were competitive issues due to decreasing international market share (Gormly, 2015). Airlines were still figuring out the competition as airlines transitioned to jet airplanes.

Jet Age to Deregulation

As airlines moved to more technologically advanced and faster airplanes, passenger and flight crew risk increased (Morrison & Winston, 1989). In 1940 the first flight engineer was added to improve safety; this meant having a third pilot in the flight deck to manage systems on the airplane (Boeing History, 2021) while the other two pilots flew the airplane (Fraher, 2019). Safety was still not the top priority for airlines – the accident rate remained high when the jet age began (Boeing Statistics, 2021).

According to Boeing's annual safety records, adding jet airplanes to their fleets brought high aviation accident rates (Boeing Statistics, 2021). Boeing safety records are published yearly regarding commercial airplane safety worldwide (Boeing Statistics, 2021). In 1959 the annual fatal accident rate was over 40 per million departures (Boeing Statistics, 2021). The commercial jet age began in the late 1950s as the market introduced the DeHavilland Comet (Walker, 2017), Boeing 707, and Douglas DC-8 (Federal Aviation Administration, 2021). Although the federal government highly regulated the industry, the accident rate was unacceptable (Boeing Statistics, 2021). Changes in aircraft and regulations produced a lower fatal accident rate of approximately 1 per million departures by the 1970s (Boeing Statistics, 2021). Then, in 1978, the U.S. government deregulated the airline industry.

Post Deregulation to September 11, 2001

Airline deregulation facilitated the onslaught of airline startups, changing the competitive landscape and airline business models (Morrison & Winston, 1989). New airlines had lower costs due to higher load factors (a higher percentage of passengers occupying seats) to offset the startup costs and substantial capital needed for operations (Baltagi et al., 1995). During deregulation, each startup airline had lower perceived safety within public opinion, even though the FAA regulated pilot certification and airline operations (Adrangi et al., 1997). Some industry experts thought the reduced ticket prices would force airlines to cut safety expenditures and utilize inadequately trained airline pilots flying expanded schedules (Adrangi et al. 1997). However, Adrangi et al. (1997) refuted public opinion finding that airline safety did not diminish but improved.

Airline industry deregulation removed the federal control over routes, fares, and the number of new airlines entering the market; however, it left the FAA's regulatory aspect intact (Cannon, 1978). The FAA regulations require airlines to train pilots within specific standards (Federal Aviation Administration, 2022a). Airplane and simulator training allowed airline pilots to learn to fly in new airplanes or positions for the first time with paying passengers or freight onboard (Federal Aviation Administration, 2021). Airline training costs included sophisticated simulators developed over the years, which started in February 1970 (Federal Aviation Administration, 2021). A critical accident occurred in 1978, around the time of deregulation, making the industry aware of the incident caused by human factor errors (NTSB, 1979).

Although regulators required cockpit voice recorders (CVR) in the flight deck years before this accident (Federal Aviation Administration, 2021) for accident investigations, airlines did not use the information to evaluate and train airline pilots (Walker, 2017). In 1978, a United Airlines Douglas DC-8 crashed, killing ten people on board (NTSB, 1979). The airplane ran out of fuel due to the pilots' lack of judgment and communication about the low fuel state (NTSB, 1979). Experts also concluded that the accident's cause indicated that the landing gear was not in the down and locked position, although the gear was down and locked (NTSB, 1979). This accident changed the way airline pilots trained, and in the 1980s, airlines incorporated accident risks and human errors into training (Wagener & Ison, 2014).

In 1981, United Airlines began a Cockpit Resource Management program (Flight Safety Foundation, 2014). The CRM program became mandatory for all airline pilots by 1989 (Federal Aviation Administration, 1993). The airlines improved the accident rate from the 1980s until September 11, 2001, to less than five fatal accidents per million departures, despite increased flights and busier airspace (Boeing Statistics, 2021). Airlines continued to purchase more advanced flight deck airplanes, including airplanes that have Flight Management Systems (Fennell et al., 2004). Advanced flight deck airplanes intend to provide more SA to airline pilots by decreasing the workload in specific flight regimes (Casner & Schooler, 2013). The industry focused on improving human factors with automation and less on flying skills (Casner & Schooler, 2013). However, once the events of September 11, 2001, occurred, the industry safety focus changed again.

Post-September 11, 2001

On September 11, 2001, terrorists took control of four U.S. airplanes and crashed them into specific targets. The terrorists crashed two planes into the World Trade Center in New York, New York, and one airplane into the Pentagon in Washington, D.C. The fourth airplane crashed into a field in Shanksville, Pennsylvania. Post-September 11, 2001, the aviation industry sought changes, finding it essential to improve airline pilot training, flight deck security, and passenger safety (Hollings, 2001). Airlines also needed significant investments to fortify the flight deck door (Federal Aviation Administration, 2008). Security and airline screening added further costs to aviation operations (Hollings, 2001). With these additional security features, the airline industry continued to find ways to reduce costs.

Airline Performance in the Air and Financially

In a longitudinal study, Tsikriktsis (2007) posited that operational performance, meaning on-time service, relates to profitability. Tsikriktsis (2007) also explored correlations between low-cost carriers flying point-to-point routes, full-service airlines, and profitability. Tsikriktsis confirmed that capacity and utilization significantly impact profitability when flying point-to-point and full-service, hub-and-spoke models. Tsikriktsis stated that focused airlines outperform in profitability. Since high on-time performance equates to improved profitability, safety often takes a lower priority than reliability.

Buckley et al. (1988) found that airlines measured success as competitive performance, competitive potential, and management process. Chang and Yeh (2004) expanded on Buckley et al.'s work by applying it to aviation, where performance ties to the safety effort outcome, capability to improve potential performance, and management potential to achieve performance. Chang and Yeh (2004) created an overall airline and individual safety scores index. The researchers provided methods for increasing safety to improve performance. For example, optimized maintenance procedures, which can save money and increase operation hours, provide management with higher on-time departure performance (Öhman et al., 2020). Because the safety index's score measures performance, separating the two inter-dependent variables, safety and performance, can be tricky since other factors may cause the results (Öhman et al., 2020).

Aviation does not disconnect the connection between safety and public perception. Squalli and Saad (2006) assessed airplane safety reputation and the impact on the population's willingness to fly. They found that public perception of an unsafe airplane reduces passenger enplanement when some accidents or incidents lead to severe injuries or fatalities. Enormous cost pressures, operational efficiencies related to safety, and public perception significantly demonstrate the need for reducing human errors on the flight deck. Financial pressures force many organizations to find less expensive safety training alternatives.

The Conflict Between Training Costs and Profitability

Airlines have large budgets and significant expenses (Alan & Lapré, 2018). Changes in the business model due to deregulation, low-cost carriers, code-sharing agreements, open skies agreements, world events, and regulations increase the business decision complexity (Alan & Lapré, 2018). Airline leadership monitors budgets to decide how much to spend on a principal expense like safety training.

Defining Costs That Can Affect Spending on Training

Airlines have many expenses required to run a safe and on-time operation. International Air Transport Association Airline Cost Management Group (2021) divides expenditures into flight operating expenses, ground operating expenses, and system operating expenses. Labor and fuel are the two most significant flight operating expenses (A4A, 2021). Airline pilot training and safety programs are transport-related expenses, which were the third-largest expense for airlines for the third quarter of 2021 (A4A, 2021). Considerable expenses require airlines to have a system to determine exact costs and prioritize spending.

Service industry airlines rely on strategies for obtaining cost estimates (Banker & Johnston, 1993). Operations-based cost drivers were significant due to the sizeable service-centered aviation industry mindset when airline deregulation began (Banker & Johnston, 1993). Table 1 shows labor, fuel, and transport-related expenses representing over 60% of all expenses. The substantial price tag for airplanes as a fixed cost demonstrates the importance budget management programs play for other expenses.

Table 1 *Airline Expenses Presented by Percentage*

Required items	% of Operating Expense
Labor	33.1%
Fuel	16.3%
Aircraft rents and ownership	7.4%
Non-aircraft rents and ownership	6.0%
Professional services	8.4%
Food and beverage	1.5%
Landing fees	2.6%
Maintenance material	1.7%
Aircraft insurance	0.1%
Non-aircraft insurance	0.2%
Passenger commissions	0.5%
Communication	0.7%
Advertising and promotion	0.5%
Utilities and office supplies	0.6%
Transport–related expenses	11.5%
Employee business expenses	2.0%
Other operating expenses	6.8%

Note. Adapted from A4A. (2021). "A4A U.S. Passenger Airline Cost Index (PACI)," by Airlines for America. https://www.airlines.org/dataset/a4a-quarterly-passenger-airline-cost-index-u-s-passenger-airlines/.Copyright 2022 by Airlines for America.

Other significant expenses, such as airplane rent, ownership, and additional non-aircraft rent and ownership, are fixed costs that cannot vary significantly (A4A, 2021). Boeing's retail price for its narrow-body airplane ranges from $89.1 to $134.9 million (Boeing, n.d.). The Boeing widebody retail price ranges from $271.9 to $442.2 million (Boeing, n.d.). All other fixed costs for ground and system operating expenses are much smaller and do not influence profit margins as much as the enormous fixed costs related to flying (A4A, 2021). All airlines have similar expenses for airplanes; however, deregulation changed the business model for many airlines.

How Deregulation Increased External Pressure on Airline Revenue

Airline deregulation turned the industry upside down. The Airline Deregulation Act of 1978 eliminated governmental control over routes, pricing, and new competition to the U.S. air system without harming safety (Howard, 1978). Before deregulation, the U.S. government set route pricing, assigned routes to airlines, and limited the number of new airlines entering the market (Rose, 2012). Although airline deregulation intended to improve the airline industry, liberalization presented new challenges (Ginieis et al., 2020).

Challenges for airlines post-deregulation increased financial pressures on airlines. In 2009, Goetz and Vowles described deregulation as the good, the bad, and the ugly. Previously, airline governmental regulations kept the industry stable by limiting competition and unfair pricing (Brown, 2014). After deregulation, Rose (2012) reported that its benefits included increased routes and passenger volumes, lower ticket prices, and more non-stop flights conflicting with more powerful hubs and longer delays. Deregulation expanded routes, lowered fares, and increased carrier efficiencies while maintaining high safety levels (Goetz & Vowles, 2009). Deregulation caused high employee turnover due to acquisitions, mergers, and bankruptcies (Goetz &Vowles, 2009). A significant period from 2000 to 2008 saw many bankruptcies, extensive layoffs, pension programs terminated, and union contract renegotiations (Goetz & Vowles, 2009). The onset of new financial pressures caused by increased competition, which essentially connected training costs to profitability, was amplified during unprofitable periods (Goetz & Vowles, 2009).

Industry Financial Pressures From Low Costs Carriers

Deregulation brought new competition from Low-Cost Carriers (LCC) that put financial pressure on all airlines (Dinler & Rankin, 2018). Full-Service Carriers (FSC) used a hub and spoke system, while LCC airlines initially served secondary markets point-to-point (Pels, 2008). LCC's models limit expenses by having a no-frills customer experience (Dinler & Rankin, 2018). LCC and FSC airlines now undercut fares to gain market share using a newly-formed clearinghouse, the Airline Tariff Publishing Company (Button, 2015).

In the 1980s, some LCCs reduced costs by increasing productivity (Barkin et al., 1995). For example, Southwest airlines negotiated an agreement with their airline pilot union, allowing their pilots to make a similar income to other airlines flying but requiring more flights (Barkin et al., 1995). Wages at LCCs are typically lower than at most FSC airlines (Hunter, 2006). Motivation to work harder through increased productivity at lower wages comes from a less highly structured culture that builds a family atmosphere or team approach (Hunter, 2006).

LCCs may consider whether they need to motivate workers differently. Hunter (2006) found that LCCs have more worker flexibility in schedule and a cooperative approach, while FSCs employ more mechanized and highly-skilled, specialized workers, leading to human capital development. Both LCC and FSC airlines seek to maintain customer loyalty.

Brand loyalty and repeat business are critical to LCCs competing with FSCs (Forgas et al., 2010). Airlines define brand loyalty components as satisfaction level, trust, and perceived value (Forgas et al., 2010). LCCs want to create a customer experience that has a satisfaction level to build brand loyalty (Forgas et al., 2010). LCCs want customers to trust airline reliability and integrity to reduce transaction costs (Forgas et al., 2010). The perceived positive value should establish brand loyalty (Forgas et al., 2010). These three components for LCCs take market share from the FSCs and pressure financial health.

How Full-Service Carriers Reduce Internal Costs

FSC airlines needed efficiencies to compete with the 47 new airlines that entered service in 1984 (Rose, 2012). FSC passenger programs such as frequent flyers and airport lounges provided a quality experience over LCCs and increased passenger loyalty (Pels, 2008). Large hubs that connected many cities also offered route flexibility, giving FSCs a competitive advantage (Button, 2015).

FSCs designed large hubs that included code-sharing partners (Shen, 2017). Code sharing allows an airline to sell a ticket on a partner airline and keep a small profit of around eight percent of the ticket price as a commission. Shen (2017) explains code sharing as either vertical, where multiple airlines fly the route selling tickets, or horizontal, where only one airline flies the route selling tickets. Maloo and Darrow (2001) found that code sharing reduced the excess unfilled seat supply, increasing airlines' profits. Code-sharing also led to increased market power (Shen, 2017). FSC airlines' larger and higher capacity airplanes with fewer unfilled seats, called a higher load factor, cut directly into LCC airlines' business models (Maloo & Darrow, 2001). The higher load factor relieved some FSC financial pressure, and ideas to fill more seats, airplane size, and type varied across different regions (Maloo & Darrow, 2001).

Despite attempts to improve service quality to hold market share, some areas like the Midwest were known for poor customer service experiences in the early 2000s (Goetz & Vowles, 2009). Service failures lead to higher costs for the airline through immediate costs to accommodate passengers and long-term reputation damage (Alan & Lapré, 2018). FSC airlines also consolidated in the 1980s to gain market share (Goetz & Vowles, 2009). Attempts to maintain market share through improved customer service adversely affected FSC's profits.

In the early 2000s, economic conditions caused by historical world events forced downturns in airline financial health (Goetz & Vowles, 2009). The industry saw losses from the terrorist attacks and conflicts in the Middle East, sharp fuel price increases (Goetz & Vowles, 2009), and restricted travel due to the COVID-19 pandemic in the early 2020s (Xuan et al., 2021). Market and industry catastrophes continually add financial decision-making pressures on airline leaders, which can affect decisions on training costs (Fraher, 2019).

Cost Savings Associated Directly With Airline Pilots

Although airlines used various tactics to restrict costs and increase revenue, they ultimately turned towards pilot–specific methods for cost savings. The financial pressures began affecting union contract negotiations (Walsh, 1988). Under new agreements, airline pilots succumb to expert de-professionalization through increasing managerial control and productivity while receiving reduced financial compensation (Fraher, 2019). Fraher (2019) uses the term *quasi-professional experts* to describe de-professionalized pilots. Airline pilots' relationships with their employers eroded due to these pay differences.

Some airlines created a concessionary two-tier compensation package for airline pilots to reduce long-term labor costs (Walsh, 1988). A "B–scale" agreement pays one airline pilot on the flight deck a different rate and has different benefits than the other airline pilot on the flight deck (Cimini, 1990). The union contract negotiations provided additional cost savings to the airline at the pilots' expense (Walsh, 1988). After achieving cost savings through airline pilot pay, airlines began looking for additional pilot training cuts.

Airline pilots saw airlines design training programs with reduced footprints, requiring more learning with fewer training days. Fraher (2019) studied airline pilot attitudes post-9/11 and found that airline pilots began perceiving the training as shortcuts and felt that testing was not up to the safety standards. For example, over the last several years, the Boeing 737 Max airplane accidents revealed that the manufacturer, trying to sell airplanes at a competitive price to cost-sensitive airlines, did not recommend special training for the 737 Max (MacArthur, 2020). Two accidents within a short period prompted the parking of all 737 Max airplanes and required a software system change and proper training for airline pilots (Herkert et al., 2020). The initial training recommended by the FAA did not include the most practical method to train an airline pilot outside the airplane by not utilizing simulation training (Herkert et al., 2020). Boeing's cost containment efforts fell apart when the FAA required simulator training (MacArthur, 2020). Training costs conflict with profitability with the need to constantly improve training without adding or even reducing costs to the airline.

Human Factors Errors and CRM Development

Pressure to reduce training costs exist in the airline industry, where human error leads to the cause of accidents (Wiegmann & Shappell, 2003). Airlines, researchers, and the FAA have searched for ways to solve human factors errors for decades. Human factors theories developed from airplane accident investigations starting with Heinrich's Domino Theory (DeCamp & Herskovitz, 2015).

Human Factors Theory and Models

Heinrich's (1959) Domino Theory states that as issues occur, they lead to the next issue, similar to dominos falling over until reaching the accident. Heinrich (1959) explains the dominos as five stages: social environment and ancestry, personal faults, unsafe acts or conditions, accidents, and injuries. Removing a domino discontinues the chance of an accident (Heinrich, 1959). The Domino Theory single chain of events style was not descriptive enough for accident investigators (DeCamp & Herskovitz, 2015). In the 1980s, Ferrell's Human Factor model superseded the Domino Theory, which views aviation not as a single chain but as having multiple causes that can lead to an accident (DeCamp & Herskovitz, 2015).

Airplane operations are a complex system where many decisions make it difficult to determine the root cause of human error (Kelly & Efthymiou, 2019). Ferrell's Human Factor model determines accident causation by looking at overload, incompatible and improper activities (DeCamp & Herskovitz, 2015). Ferrell's model was refined further by Peterson's model, which separated incompatible activities and overload from errors (DeCamp & Herskovitz, 2015). Peterson's model assigned situational decision, unconscious desire, and perceived low chance as three possible reasons for errors (DeCamp & Herskovitz, 2015). Ferrell's and Peterson's models gave way to Reason's Swiss Cheese models (DeCamp & Herskovitz, 2015).

Reason's (1990) Swiss Cheese model explains how hazards can get through a process's multiple layers in the complex aviation safety system, and these "holes" that the hazards get through lead to an accident, incident, or loss (see Figure 2). The analogy of holes, like those in Swiss Cheese, provides a mental image of where hazards get through the holes. These system failures are hazards that lead to loss (Reason, 1990). Reason's (1990) accident causation model assumes that the holes in a productive system's layers align, causing it to break down.

Using the logic of Reason's Swiss Cheese model, Wiegmann and Shappell (2003) assert that a productive system includes decision-makers, line management, preconditions, and productive activities with a feedback loop. Failed or absent defenses break down the productive system, where each layer has a hole for the hazard to proceed through (Wiegmann & Shappell, 2003). The broken productive system defense fails, and accidents occur (Wiegmann & Shappell, 2003). To apply Reason's Swiss Cheese model, Wiegmann and Shappell (2003) created the Human Factor Analysis and Classification

System model (HFACS). The HFACS model created a classification system for accident information (Wiegmann & Shappell, 2003).

The Human Factors Analysis and Classification System

The HFACS enhances traditional aviation accident investigation techniques by providing an accident's causal factors (Kelly & Efthymiou, 2019). Other high-risk areas used the HFACS, such as Naval and Air Force operations (Miranda, 2018) and the surgical healthcare industry (Cohen et al., 2018). Starting with the accident and working backward, investigators determine the underlying reasons, or holes, that caused the accident (Wiegmann & Shappell, 2003).

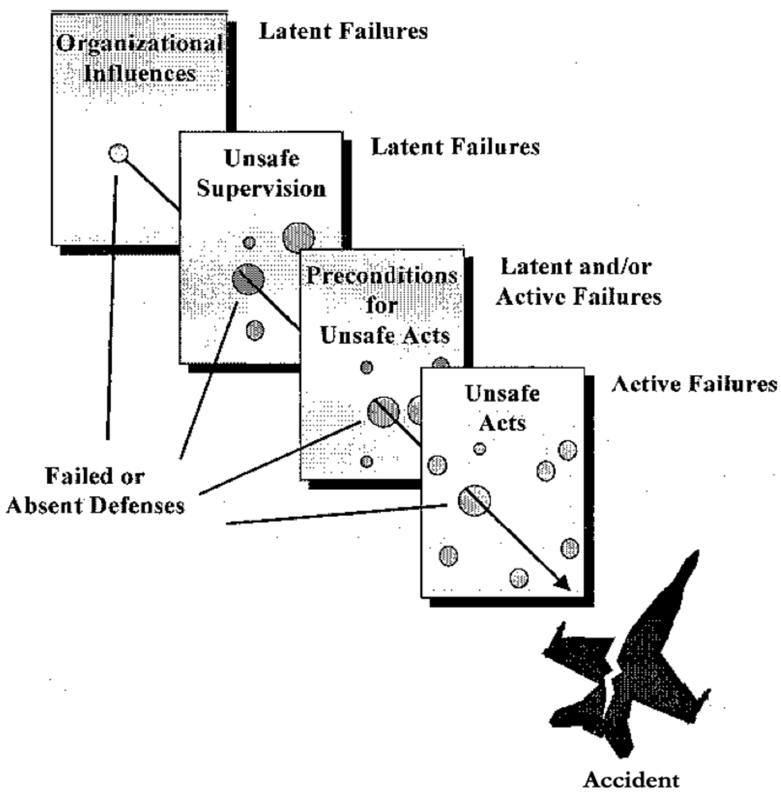


Figure 2. Reason's Swiss Cheese Model Modified for HFACS

Note. The image was copied with permission by publisher (Appendix A). From *A Human Error Approach to Aviation Accident Analysis: The Human Factors Analysis and Classification System*, by D.A. Wiegmann and S.A. Shappell, 2003, Routlage. Copyright 2003 by Taylor and Francis Group, LLC, a division of Informa plc. (pp 46–47).

Failures at level 1 within Reason's Swiss Cheese model led to nearly three-quarters of all accidents (Federal Aviation Administration Human Factors, n.d.) and unsafe acts associated with active human errors (Wiegmann & Shappell, 2003). The airline pilots' human factors errors are *active* errors (Wiegmann & Shappell, 2003). *Latent* errors penetrate the level 2 preconditions for unsafe acts, including the lack of good crew resource training or experience (Wiegmann & Shappell, 2003). Level 3 latent errors determine the presence of unsafe supervision (Wiegmann & Shappell, 2003). Scheduling airline pilots limited in experience for a particular operation within a flight represents a level 3 latent error. Level 4 latent errors are latent errors within the organization (Wiegmann & Shappell, 2003). An organization that reduces training due to budget constraints (resulting in poor CRM training) shows up in level 3, level 2, and possibly level 1 latent errors (Wiegmann & Shappell, 2003).

Regarding the conflict between training costs and profitability, Reason's Swiss Cheese model level 4 organizational errors stand out as a critical risk to safety (Wiegmann & Shappell, 2003). Kelly and Efthymiou (2019) found that organizational culture profoundly affected accidents. Organizational culture had an adverse impact 56% of the time (Kelly & Efthymiou, 2019). Additionally, an organizational culture that promoted hazardous leadership attitudes led to unit culture as a causal factor of accidents 34% of the time (Kelly & Efthymiou, 2019). Next to this layer of cultural risk lies risks associated with supervision.

Supervisory latent errors contain supervisor–influenced conditions (Wiegmann & Shappell, 2003). Latent supervisory error categories in the HFACS are inadequate supervision, planned inappropriate actions, failure to correct a problem, and supervisory violations (Wiegmann & Shappell, 2003). Financial pressures and budgetary constraints that do not provide proper CRM training can put the airplane in a hazardous situation due to any of the four supervisory errors (Wiegmann & Shappell, 2003). If the latent hazards start with getting through the organizational influences with a supervision violation, then preconditioning for unsafe acts becomes the last latent protection level.

Preconditioning for unsafe acts in the HFACS includes environmental factors, personal factors, and conditions of the operators (Wiegmann & Shappell, 2003). Environmental factors include physical and technological environments. Physical environmental examples are the flight deck lighting and vibration (Wiegmann & Shappell, 2003). Fitness to fly applies as a personal factor (Wiegmann & Shappell, 2003). The operator's condition includes the individual's mental state and physical or mental limitations (Wiegmann & Shappell, 2003). Preconditioning factors for unsafe acts exist in a latent state before a flight.

CRM Behaviors Development

CRM has evolved from managerial self-discovery in its first generation to the fifth generation, called *error troika* (Helmreich, Merritt, & Wilhelm, 1999), and the sixth generation of threat awareness (Martin, 2019). Although aviation initially developed CRM, many fields, such as medical and first responders, have developed similar CRM programs to reduce human errors (Sundar et al., 2007). Developing CRM within other areas supports the methodology as a legitimate cognitive and purposeful behavior (Tolman, 1932). Reducing errors was not CRM's original intent.

First-generation CRM, known as *cockpit* resource management, was initiated by United Airlines to improve the captain's management skills (Helmreich, Merritt, &

Wilhelm, 1999). The program focused on reducing the captain's authoritarian leadership and improving the first officer's assertiveness (Helmreich, Merritt, & Wilhelm, 1999). Early commercial aviation culture discouraged junior airline pilots from correcting the captain when discovering an error (Helmreich & Foushee, 2019). CRM became the norm in airline training, measuring leadership through psychological testing and providing techniques for improving interpersonal skills (Helmreich, Merritt, & Wilhelm, 1999). Not all airline pilots bought into first-generation CRM, and second-generation changes to CRM programs attempted to improve the lack of buy-in (Salas et al., 2006).

Second-generation CRM adds the team's involvement to communicate the plan, build SA, and deal with stress (Helmreich, Merritt, & Wilhelm, 1999). Newer CRM interventions focused on aviation-related issues, but interventions varied considerably across the industry (Helmreich, Merritt, & Wilhelm, 1999; Salas et al., 2000). Although second-generation CRM found some success, it only involved airline pilots and flight attendants.

Third-generation CRM expanded the scope beyond the airline pilots and flight attendants to include other operational staff, such as dispatchers in CRM discussions who are partially responsible per federal regulations (Helmreich, Merritt, & Wilhelm, 1999). The evolved CRM style still focused on the captain's attitudes toward the team and the interactions between team members (Salas et al., 1999).

Fourth-generation CRM began integrating with other skill and knowledge training requirements like maneuvers (Helmreich, Merritt, & Wilhelm, 1999). The FAA's Advanced Qualification Program allowed airlines to evaluate the airline pilots' retention of CRM principles (Salas et al., 2000). Training programs introduced Line Oriented

Evaluation events and simulator training events where a crew of airline pilots flies a routine flight from a departure airport to an arrival airport with challenging events along the way (Federal Aviation Administration, 2017a). The integration of simulator training and airplane information provided the needed data to determine how airline pilots apply CRM in flight (Helmreich, Merritt, & Wilhelm, 1999).

Fifth-generation CRM accepts humans as inevitable error-makers and problem-solvers (Helmreich, Merritt, & Wilhelm, 1999). Error *troika* involves avoiding and mitigating errors while working as a team (Helmreich, Merritt, & Wilhelm, 1999). Fifth-generation CRM introduced Error Management as a tool for airline pilots to identify external threats, crew actions, and outcomes (Rantz, 2002). The sixth generation added threat awareness to incorporate a model for airline pilots to follow called Threat and Error Management (TEM). Figure 3 illustrates the early threat and error management model integrated into CRM.

Airline pilots consider expected or unexpected events/risks or external errors as external threats within the environment (Helmreich, Klinect, & Wilhelm, 1999). Expected and unexpected external events or risks may become internal threats to airline pilots when the events influence the flight (Helmreich, Klinect, & Wilhelm, 1999). The airline pilots can mitigate the risk and maintain a safe flight. If the airline pilots do not mitigate the risk, it can become an error (Helmreich, Klinect, & Wilhelm, 1999). Airline pilots use CRM communication, SA, and decision-making behaviors to detect and manage errors (Helmreich, Klinect, & Wilhelm, 1999). Errors managed correctly recover to a safe flight outcome. Error not managed well will return to error detection and management using CRM behaviors.

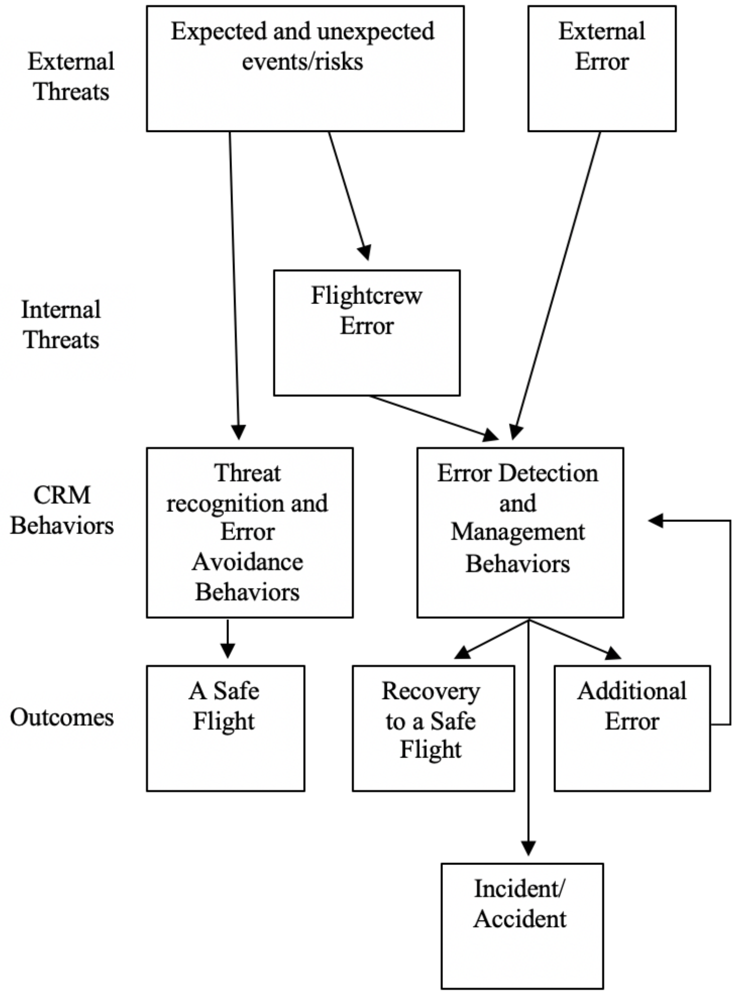


Figure 3. The Model of Flight Crew Error Management

Note. Adapted from "Models of Threat, Error, and CRM in Flight Operations," by R. L. Helmreich, J. R. Klinect, and J. A. Wilhelm, 1999, *Proceedings of the Tenth International Symposium on Aviation Psychology* (pp. 677–682). Copyright The Ohio State University.

Fifth-generation CRM harmonizes the organization's goals to operate an efficient airline, the dispatchers' aim to provide a reliable schedule, the regulatory responsibilities of the FAA, and the airline pilots' ability to provide safe service to consumers through SA (Helmreich, Merritt, & Wilhelm, 1999). Sixth-generation CRM incorporates resilient behavior through cognitive psychology (Martin, 2019) by integrating individual and group goals and organizational processes (Swanson & Holton, 2009). As CRM continues to develop, the model will focus on reducing human error by improving SA (İnan, 2018).

The captain–dominated culture shifted with CRM's evolution, although an airline pilot's ego remains a risk (Makarowski et al., 2016). In a recent study, Fabre et al. (2022) found that airline pilots paired with highly skilled, kind, trustworthy, and the authoritarian captain made more moderately risky landings. The airline pilots who were unclear about the captain's thoughts or intimidated by their status made more risky landings than when flying alone (Fabre et al., 2022).

Makarowski et al. (2016) grouped airline pilots into risk-avoiders, reasonable risk-takers, and individuals who protect their resources through aggression. Since there remains no homogenous airline pilot risk-taker type, emerging individual performance training should include instruction for coping with stress to maintain SA (Makarowski et al., 2016). Specifically, CRM program instructions could include imagery training as a possible solution for improving SA.

Situational Awareness and Surprise

Understanding the SA aspect of imagery remains essential to this study. Accurate perception of past activities, the present situation, and the near-future projected possibilities define SA (Endsley & Robertson, 2000). In more explicit terms, Endsley (2000) defines SA for pilots as perceiving a mental model for the pilot to fly the airplane safely. SA remains critical to aviation safety and has been studied extensively since the mid-1980s (Endsley, 1995).

A difference between the pilot's expectation and what occurs defines a surprise (Martin, 2019). Wessel and Aron's (2013) study determined that motor skills can slow when a surprise event occurs when reacting to a time–pressured task. The research found that motor skills can stop briefly when a surprise event occurs (Wessel & Aron, 2013). The mind can lose the cues of SA but can rebuild a mental model relatively quickly or slowly, depending on how long it takes to process and comprehend the new information (Martin, 2019). The cognitive awareness of SA loss in pilots requires, through training, the pilots to maintain control of the airplane and experience a fight-or-flight reaction until they understand the information at a cognitive level (Martin, 2019). SA remains rooted in Cognitive Theory (Endsley, 1995).

Theories to Support Situational Awareness Framework

The internal mental model that takes in information from the environment forms a picture that allows a person to decide and defines situational awareness (Jones et al., 2011). Decision-making and SA work together collaboratively with influences on workload (Adams & Pew, 1990). The mental conflict between prioritizing many complex tasks requires working memory and may diminish a pilot's SA, affecting decision-making (Adams & Pew, 1990). When performing cognitively complex tasks, a pilot assesses the situation and forms a mental model of how to perform using working memory and applying long-term knowledge. Combining long-term memories with processing the problem at hand produces a cognitive load on the human brain (Kirschner et al., 2018).

Human cognition, or how humans gain and process knowledge and understanding, defines Cognitive Load Theory (Kirschner et al., 2018). Human cognition stems from the natural information processing system, including long-term and working memory (Kirschner et al., 2018). The mind can retain a thirty-second sound bite or seven pieces of information in short-term working memory (Pike, 2015). If too much information overloads working memory, the information will not move to long-term memory stores (MindTools, n.d.).

Information has two considerations, biologically primary or secondary knowledge (Sweller & Sweller, 2006). Primary knowledge has evolved with humans and includes examples like the language one speaks, social interactions, and problem-solving (Sweller & Sweller, 2006). The information learned in school or organized procedures define secondary knowledge (Sweller & Sweller, 2006). Secondary knowledge relates to SA.

Sweller and Sweller (2006) contend that humans process secondary knowledge through five principles: the information store principle, the borrowing and reorganizing principle, the randomness as genesis principle, the narrow limits of change principle, and the environmental organizing and linking principle. The information store principle defines large quantities of data as a cognitive store of long-term memory (Sweller & Sweller, 2006).

The borrowing and reorganizing principle transfer information to long-term memory to obtain the large amounts of information long-term memory requires to build pictures for all the possible situations (Sweller & Sweller, 2006). The randomness as genesis principle creates new information during problem-solving when no information becomes available to borrow and reorganize (Sweller & Sweller, 2006). Learning occurs in borrowing and reorganizing, using randomness as the genesis principle (Sweller & Sweller, 2006). Working memory limits the vast combinations produced by borrowing and reorganizing or creating novel ideas (Sweller & Sweller, 2006). The narrow limits of the change principle contain novel information within working memory (Sweller & Sweller, 2006). They may move information to the epigenetic system, meaning the system where small permanent changes may occur over time as humans evolve (Sweller & Sweller, 2006). Novel information generates randomly, which forces working memory to be small (Sweller & Sweller, 2006).

Building Long-term memory to Assist Working-Memory

The working memory allows pilots to process information to build SA, make decisions, and safely perform the actions necessary for flight. The working memory includes potential stimuli from the perception that may generate a response (Wickens, 1974). Endsley (2000) explains that the working memory required to maintain SA describes a subset of long-term memory stores within the mental model. Even if long-term memory remains unavailable, active processing occurs in working memory (Endsley, 1995). Adams and Pew (1990) state that highly-skilled individuals bring long-term memory information into the working memory as needed for the situation.

Some components in working memory awareness include the system's current state, the predicted state, information and knowledge required for the current situation and anticipated future, the phase within the activity, and prioritized goals (Adams & Pew, 1990). Lack of time creates pressure, and one must maintain SA, even when pressured to manage tasks (Adams & Pew, 1990).

Situational Awareness Conceptual Models

Using information and knowledge about what has happened, the current state or conditions, and the predictions of a future state exists in Endsley's (1995) Model of Situational Awareness in Dynamic Decision Making. The Endsley (1995) Dynamic Decision-Making Model provides a comprehensive depiction through the three SA levels. Level 1 SA requires the pilot to perceive the dynamic elements in their environment, such as instrumentation and the terrain (Endsley, 1995). Endsley's (1995) level 2 SA requires the pilot to comprehend the present situation—similar to Gestalt Theory, which encourages a view of the whole data set to create a meaningful understanding (Swanson & Holton, 2009). During Level 3 SA, an individual projects future actions within the environment using pattern matching (Endsley, 1995). Pattern matching defines the situation and conducts an appraisal, which allows the pilot to determine the action they will take (Endsley & Robertson, 2000). To gain level 3 SA, a pilot must comprehend the environment's current status and anticipate what may happen next (Endsley, 1995). Through SA research, Endsley (2000) found that experienced pilots spent time during preflight planning anticipating what may occur on the flight to stay in a state of level 3 SA.

The Data-Frame Model of Sensemaking defines the frame as the structure linking the perceived data and giving it meaning (Klein et al., 2007). The frame assists in sensemaking by learning how to make sense of the data (Pontis & Blandford, 2016). There are varying opinions about data frames. Klein et al. (2007) determined that sensemaking revolves around the interaction of the frame with the data. Combining data with the person's knowledge, goals, and position, Klein et al. (2007) believe one can create the situation's frame. Conversely, Landman et al. (2017) state that the frame influences perception, appraisal, and action. Landman et al. (2017) contend that perception and action can occur without being framed and that multiple interconnected frames can coincide.

Dynamic Decision-Making Model Criticisms

Klein (2014) and Endsley (2015) disagree on how the Data/Frame model work. Endsley (2015) insists that Klein's (2014) Data/Frame model essentially agrees with Endsley's (1995) Dynamic Decision-Making Model in terms of data collection. Klein (2014) disagrees with Endsley (2015) in that the Data/Frame Model allows people to use the frame to determine what counts as the data processed for decision-making. Klein (2015) believes Endsley's model has evolved to explain that her SA levels were once linear and interpreted now as nonlinear. Regardless of the disagreement on the explanation of SA as a process of selecting data (Dynamic Decision-Making Model) or sensemaking constructing data (Data/Frame model), SA ultimately requires a mental model.

Endsley (2015) insists that the three levels of the Dynamic Decision-Making Model are also interconnected. While this model represents the standard researchers in SA base their research on, there have been some critics (Endsley, 2015). The criticism has sparked proper conversation to demonstrate that Endsley's (1995) Dynamic Decision-Making Model supports the questions raised. Endsley (2015) also encourages further research to add to the body of knowledge within SA.

In a separate opinion, Dekker (2015) contends that SA remains a post hoc excuse for its operationalized use, stuck in a world of circularity. Dekker (2015) states that complacency remains the reason for the loss of SA, and loss of SA spurs the reason for complacency. Endsley (2015) explains that airline pilots used SA in aviation before there was research into improving system design to enhance SA and disagrees that create SA as a post hoc reason. The paradigm of most SA research centers around how automation design affects SA, how to improve interface designs, and how to improve airline pilot training (Endsley, 2015). This study builds on Endsley's (1995) research by determining imagery training's effectiveness in enhancing SA.

Improving Both Hardware and Training

When airline pilots lose SA due to modern airplane design and complexity, organizations and regulators often attempt to solve the problem with more technology (Endsley, 2015). A complex modern flight deck utilizes computers, fly-by-wire technology, and flight management systems to monitor and alert airline pilots to changes in airplane flight modes (Congressional Research Service, 2019). In modern advanced technology flight decks, airline pilots have seen improvements and additional challenges in SA (Congressional Research Service, 2019). As airline safety records have improved, some in the industry attribute improvements to automated flight systems (Congressional Research Service, 2019). At the same time, other industry experts believe that SA and lower cognitive load positively influenced error mitigation (Congressional Research Service, 2019). The increased system complexity has caused pilot confusion, decreasing pilots' confidence (Congressional Research Service, 2019). Pilot confusion leads to incorrect responses and accidents, such as the Ethiopian Airlines flight 302 and Lion Air flight 610 737 max incidents (NTSB, 2019).

Research shows that airline pilots lose SA due to modern technology and automation on the flight deck (Federal Aviation Administration, 1996). Four areas that decrease SA include automation awareness, flight path awareness, terrain awareness, and energy awareness, including loss of control and low energy state (Federal Aviation Administration, 1996). Nearly two decades later, the Flight Safety Foundation (2014) published a guidebook for improving flight path monitoring to include altitude deviations, airspeed deviations, course deviations, and incursions on the ground. The Federal Aviation Administration (2015b) issued an Advisory Circular to all airlines to provide information for training airline pilots to recover correctly from stalls due to a loss of SA. The same problems found in the 1990s continue to plague the industry.

Surprise Events

Cognitive–emotional response to unexpected events in the airplane defines a surprise event (Foster & Keane, 2015). Surprise events lead to a loss of SA (Landman et al., 2017). A strong indication that a pilot has become surprised occurs when the pilot asks, "What is it doing now?" (Sherry et al., 2001). Other terms heard by pilots (extended from Wiener, 1989, in Woods & Sarter, 2000, p. 330) include:

- What will it do next?
- How did I get into this mode?
- Why did it do this?
- Stop interrupting me while I am busy.
- I know there is some way to get it to do what I want.
- How do I stop this machine from doing this?
- Unless you stare at it, changes creep in.

Casner and Schooler (2013) provide two explanations for the loss of SA: (a) thoughts unrelated to the task; and (b) absorption of thoughts. Task–unrelated thoughts, also known as mind wandering (Schooler et al., 2011), are thoughts that do not relate to the flight (Casner & Schooler, 2013). When airline pilots experience confusion, absorption of thoughts occurs regarding the interpretation of the automation compared to the mental model of what the pilot believes the automation should be doing (Casner & Schooler, 2013). Although automation reduces pilot workload, the freeing up of tasks reduces higher–level cognitive thoughts, allowing task–unrelated thoughts or automation confusion to diminish automation value (Casner & Schooler, 2013).

Woods and Sarter (2000) have evidence to support three factors that increase automation surprise chances. The first potential for automation surprise occurs when the automation changes on its own without pilot direction (Woods & Sarter, 2000). Another opportunity for automation surprise occurs during a gap in the mental model (Woods & Sarter, 2000). Woods and Sarter (2000) explain the gap as the difference between the pilot's expectation and the actual airplane's state. Lastly, an increase in automation surprise occurs when the pilot's knowledge of current activities or planned future behaviors do not align with the present situation (Woods & Sarter, 2000). The works of Endsley (1995), Woods and Sarter (2000), and Casner and Schooler (2013) integrate well and refine SA research.

How Situational Awareness Fits into Threat Error Management

Separating SA and the Threat Error Management (TEM) tool challenges airline pilots. Referring to the conceptual framework (Figure 1), TEM provides a tool used in CRM programs to determine error avoidance and threat awareness. Avoiding errors remains the ultimate goal for an airline pilot. Fifth-generation CRM concepts convey the acceptance that human error may be inevitable. Therefore, airline pilots need to maintain a mental model regarding flight threats, representing the sixth generation of CRM (Helmreich, Merritt, & Wilhelm, 1999).

Frederick-Recascino and Gosiewski (2004) believe the three elements of threat detection are physiological, emotional, and cognitive (Frederick-Recascino & Gosiewski, 2004). Long-term memory triggered by an event has a positive or negative perception (Frederick-Recascino & Gosiewski, 2004). The brain triggers a fight or flight response when the perceived event has a negative threat (Frederick-Recascino & Gosiewski, 2004). The individual engages, fights, or cognitively disengages flight (Frederick-Recascino & Gosiewski, 2004).

Merritt and Klinect (2006) use the industry–standard definition of "threat" as an event beyond the influence of the pilot that the pilot did not cause but increases operational complexity and requires management to maintain safety margins. Similarly, Kinney (1996) defines a threat as a severe hazard recognized by the pilot that needs to be addressed. Frederick-Recascino and Gosiewski (2004) offer a different perspective: threats and errors go hand-in-hand. Frederick-Recascino and Gosiewski (2004) agree with Merritt and Klinect (2006), who state that errors usually are reoccurring events. Frederick-Recascino and Gosiewski (2004) argue that individual errors often do not constitute a threat until enough errors create an accident trajectory in the mind that discovers the errors. Kinney (1996) asserts that threat detection has a breath of negative emotional response attached to it, forcing some action. Merritt and Klinect (2006) separate the interaction of threats and errors.

Pilot Flying and Pilot Monitoring are industry terms that can be confusing but need to be defined to understand how pilots monitor for threats. The pilot, not directly manipulating the airplane's physical controls, monitors the flight path as the *pilot monitoring* (Federal Aviation Administration, 2015a). The pilot that directly manipulates the controls, whether utilizing the autopilot controls or hand flying, describes the *pilot flying* (Federal Aviation Administration, 2015a).

Airline pilots can view external threats before and while operating the airplane, but internal threats exist within the flight team (Helmreich, Klinect, & Wilhelm, 1999). Merritt and Klinect (2006) describe threats, errors, and undesired airplane states as risks pilots manage to maintain airplane safety. As a pilot monitoring analyzes the interactions between the pilot flying and the airplane, the pilot monitoring looks for internal threats, which are pilot errors (Helmreich, Klinect, & Wilhelm, 1999).

Errors are the pilot's action or inaction in the presence of a required response that can lead to the difference between the ideal and current state (Helmreich, Klinect, & Wilhelm, 1999). Through their research, Helmreich, Klinect, & Wilhelm (1999) present five types of pilot errors: intentional noncompliance, procedural, communication, proficiency, and operational. Airline pilots can respond to the errors by trapping them before it becomes a bigger problem, exacerbating the error, or failing to detect or ignore it (Helmreich, Klinect, & Wilhelm, 1999).

Sellen (1994) developed individual error detection classifications as action–based, outcome-based, and limit function detection. An action–based error detection relies on the perception of seeing or hearing the error (Frederick-Recascino & Gosiewski, 2004). Outcome-based error detection occurs when the outcome does not match the expectation (Frederick-Recascino & Gosiewski, 2004). A limited–function error detection happens when airline pilots find no other solutions for a detected error (Frederick-Recascino & Gosiewski, 2004). The two error detection classifications of imagery in the present study are action–based and outcome–based error detection.

An undesired airplane state occurs when both the pilot flying and pilot monitoring have lost SA long enough that the airplane state leaves a safe position (Flight Safety Foundation, 2014). TEM recognizes threats that can become errors without becoming an undesired airplane state (Flight Safety Foundation, 2014). Flight Safety Foundation (2014) studied Line Operation Safety Audit data across many airlines and found that lower-performing monitoring pilots had more mismanaged errors and undesired airplane states than pilots who performed more proficiently during the observations. Airline pilot varying performance levels from the Line Operational Safety Audit supports the need to provide an avenue to training SA to support TEM.

Airline Situational Awareness Training

Federal regulators provide training guidance and recommendations to airlines. The Federal Aviation Administration (2017a) Advisory Circular 120–54A Advanced Qualification Program details CRM training and TEM recommendations and provides measurable and observable behavior examples. The Federal Aviation Administration (2004) Advisory Circular 120–51E Crew Resource Management Training expands the recommendations for CRM and training. The two advisory circulars do not provide specific situational training processes adopted by each airline (Federal Aviation Administration, 2004; Federal Aviation Administration, 2017a). Although the Federal Aviation Administration (2017a) advisory circulars provide the airlines' details for training, they are not involved with enforcing company compliance. Different airlines may not offer the same training quality to each airline pilot.

Wang et al. (2021) examined emotional intelligence regarding pilot safety. When pilots do not have the skill, ability, or knowledge for the present conditions measured by a negative situational cue, personal emotional intelligence activates, and the pilots make decisions based on their conception of the best solution for the situation (Wang et al., 2021). Pilots with inadequate safety training choose the course of action based on their attributes (Wang et al., 2021). Pilots without proper safety training demonstrated less control over the safety outcome (Wang et al., 2021).

SA training does not include airline pilot imagery training (Federal Aviation Administration, 2017a). Pilot imagery training integrates learning techniques found in fields that use imagery. In pilot imagery training, a pilot imagines a flight plan before performing the flight in a simulator or airplane. Endsley and Robertson (2000) suggest four programs to improve SA for individual pilots. The first program teaches higher-order cognitive skills in SA, including information filtering and contingency planning. (Endsley & Robertson, 2000). This study's intervention discusses contingency planning during imagery training.

The second program includes intensive preflight briefings that address this study's goals (Endsley & Robertson, 2000). Pilots visualize a flight through imagery to build a mental picture and discover cues to expect prior to the trip (Endsley & Robertson, 2000). This program supports Lipshitz's (1993) findings that mental imagery and situational assessment are significant to decision-making. Irwin and Kelly (2020) found that expert judgment provides the information that naturalistic decision-making requires.

The third suggested program encompasses situational awareness–oriented training programs (Endsley & Robertson, 2000). The programs would train SA levels one, two, and three (Endsley & Robertson, 2000). The fourth program describes structured feedback (Endsley & Robertson, 2000). Adding programs that specifically train or assist in SA should be measured. Measuring how a pilot maintains SA allows a pilot to improve (Endsley & Robertson, 2000).

Since there have been numerous studies on human factors and SA, there are many different ways to measure the data. Jane (2019) describes various SA measures and provides a guide to select one of seven currently used measures. Endsley's Situational Awareness Global Assessment Technique remains a widely used tool for measuring situational awareness (Endsley, 2019). The Situational Awareness Global Assessment Technique has a history of predictive performance in airline safety systems (Endsley, 2017).

Situational Awareness as a Part of a Safety System

Safety management remains a complex factor within a business that crosses many disciplines. (Martinetti et al., 2018). Senge's organizational learning theory complements the training and learning aspect of unsafe events and how to design a safety system. The interrelationships between different parts and the whole system within an organization define Systems theory (Swanson & Holton, 2009). Understanding systems theory provides information to the human capital practitioner to build a conceptual, holistic frame of the organization (Swanson & Holton, 2009). Systems theory applies to safety systems as safety moves across all organizational aspects (Swanson & Holton, 2009). Although this study concentrates on the safety SA may provide to airline pilots, it could also improve other areas within an airline. Safety systems within organizations include SA as a safety metric. (Martinetti et al., 2018). A safety system improves SA through long-term memory. Strengthening long-term memory may occur with imagery training—an intervention that enables appropriate responses to surprise events.

Individual Imagery Performance Improvement

Mentally rehearsing an activity's procedures without the actual physical movements defines imagery (Driskell, 1994). A meta-analysis research review from the last two decades categorized imagery as mental, kinesthetic, and mixed imagery (Toth et al., 2020). Understanding the history of imagery assists participants in using imagery to enhance performance.

Historical Significance of Imagery

Imagery as a legitimate tool for humans traces back to early psychological and cognitive theory (Roumbou, 2017). As far back as Plato and Aristotle, mental imagery theory assumes that cognition acquires and uses knowledge to bring images into memory (Roumbou, 2017). Aristotle (ca. 350 B.C.E./1961) foundationally explained a connection between our thoughts and how we imagine those thoughts. The mind can create a mental picture of an object, even without the physical qualities present (Aristotle, ca. 350 B.C.E./1961). Scruton (1974) credits Aristotle with discovering mental imagery.

Psychologists struggled to apply the scientific method to imagery (Kosslyn, 1994). Scientists and social scientists argued whether humans could create mental pictures. Instead, they believe one *remembers* physical objects (Watson, 1913). Watson's (1913) behaviorist beliefs discarded the view that mental imagery exists, which added doubt to the day's research. There was a time some researchers believed that imagination was anti-scientific, even though there was support within the scientific community (Thomas, 1999). The behaviorist's beliefs came from experimental data, which Watson (1913) claimed was not psychology's mainstay when terms like consciousness, imagery, and mental state were in the vernacular. The behaviorist views remained the mainstream viewpoint until the 1960s (Kosslyn, 1994).

Contemporary mid-twentieth century quasi-pictorial and description theories defined primary imagery and imagination perspective (Thomas, 1999). Many cognitive psychologists wanted to study a new interest called verbal learning and retention (Kosslyn, 1994). Ausubel and Fitzgerald (1961) explained verbal learning and retention as the ability to improve performance when receiving information verbally and to retain (remembering) the data for a later time. In 1971, Paivio and Csapo demonstrated that mental pictures created through imagery and verbal retention improve the capacity to store information.

Glasgow and Papadias (1992) explain that verbal memory alone demonstrated inferiority for processing information compared to verbal learning and mental imagery. Nanay (2018) described using more than one sense as multi-model mental imagery where one sense, such as hearing a specific sound, may trigger a different modality, like vision. Paivio and Csapo (1971) popularized imagery as a legitimate research area to study by conducting empirical studies. However, late twentieth-century mental imagery theories still offered differing viewpoints.

Interactive Theories, Mental Imagery, and Perception

The 1980s demonstrated that images in one's 'mind's eye' could replace physically viewing the actual object (Kosslyn, 1994). The imagery debate persisted as Kosslyn (1994) defined perception as a mental image from memory alone. Feltz and Landers (1983) reviewed 60 studies and found that mental practice was not as good as actually performing an action but provided improved performance compared to those with no mental practice. Dissenting studies support imaging and perception's negative effects on information processing (Finke, 1985). Other studies, such as Segal and Fusella (1970) explored perception and imaging and determined whether competing information processes have negative effects. Segal and Fusella (1970) reported that imagery training could interfere with perception under certain conditions. Contradictory research results motivate researchers to continue studying imagery and perception for clarity.

Kosslyn (1981) describes imagery theory at the surface as two parts, representation as mental pictures and deep representation found in long-term memory used as a reference to develop surface representation. The imagery medium remains analog and fixed where the surface representations operate (Kosslyn, 1981). The theory relies on a surface image generated and formed using long-term memory stores (Kosslyn, 1981). Pilots may experience unreliable cues not allowing the formation of situational awareness image or the ability to make a good decision which can create an error (Orasanu-Engel & Mosier, 2019).

The present study seeks to determine whether mental imagery practice can improve SA, safety performance, and reduce airlines' costs. SA level one focuses on perceiving present activities (Endsley & Robertson, 2000). Mental imagery training can improve SA by improving perception and its aftereffects (Finke, 1980).

Modern Imagery and Information Processing

Cognitive psychology's rebirth into mental imagery found support from computer programming (McLeod, 2008). Scientists designed a computer infrastructure and connected it to a human brain to monitor human mental processing (McLeod, 2008). Researchers and computer scientists created computers that imitate the actions of the human brain (Israel, 1987). McLeod (2008) suggests that human brains operate with parallel processing—allowing more than one process to co-occur—whereas computers operate in a serial system, managing one task at a time. Overlap occurs regarding information processing when comparing computer processing qualities to cognitive psychology.

Computer information processing requires data input, storage, and output (McLeod, 2008). Human cognition allows data input to occur using sensory information. Gozli (2020) explains that perception and imagination may not always be separate and that imagination enriches our perception. Imagination may be more than the physical item absent. Imagination frames the perception of what actions one may take (Gozli, 2020). Analyzed perceived data begins through the impression left by imagination and remains stored until the response (output) occurs (Gozli, 2020). Gozli (2020) describes the relationship between perception, imagination, and reason as the information process. White (1990) criticizes imagination and does not believe any connection exists between imagination and imagery. White (1990) contends that imagination prompts how the brain constructs what may be.

Creating a Machine With Human Imagery Qualities

Technology and artificial intelligence (AI) continue improving image–processing abilities (Kunda, 2018). The human-machine interface requires spatial orientation that matches how the human brain thinks, as in visual imagery–based AI systems (Petre, 2010). Some modern studies determine how an AI system can use visual mental imagery similar to human imagination (Kunda, 2018).

Visual imagery–based AI systems use multimodal pathways to determine solutions through reasoning (Kunda, 2018). Human visual mental images possess image–like representations located in areas of the brain where optically created information resides (Kunda, 2018). The images do not match the currently perceived images, but the images are essential to performing an important role (Kunda, 2018). To achieve human characteristics, AI must perform with human-like knowledge or actions. As computers begin to mimic the human brain, technology will further support experimental research into imagery's functionality.

Measuring Imagery with Computers

Using electronic brain imaging technology will help settle the imagery debate. Imagery types include mental and physical stimulation (Tokumaru et al., 2003). Neurophysiological evaluation studies involving an electroencephalogram (EEG) record electric signals during mental imagery and add to the social experimentation of research (Tokumaru et al., 2003). Chholak et al. (2019) state that technologies useful for examining imagery include functional magnetic resonance imaging, and magnetoencephalography.

Imagery Training and Practice

Performance-based activities increase imagery training every day (Filgueiras et al., 2017). Education, music, psychology, medicine, and sports are five prominent areas using motor imagery (Schuster et al., 2011). Educational examples exist across the spectrum of different fields, including math students.

Chholak et al. (2019) define v*isual imagery* as visualizing limb movement without involving the muscles. Visual imaging with added physical movement is motor or kinesthetic imagery (Chholak et al., 2019). Kinesthetic imagery feels muscle movement and may or may not include actual physical movement (Chholak et al., 2019). In a 24-year study, Toth et al. (2020) concluded that motor imagery practice has significantly improved performance. However, athletes preparing for an event, among other disciples, have used both visual imagery and kinesthetic imagery (Callow et al., 2013).

The research into human imagery characteristics investigates mental and physical mediums. In geometry problem study, Yurmalia and Herman (2021) demonstrated that the students could solve problems using kinesthetic and mental imagery through guided mental imagery (Yurmalia & Herman, 2021). Researchers studied guided mental imagery implications in psychotherapy to determine its effectiveness and benefits (Arbuthnott et al., 2001). Guided imagery uses many sensory inputs to mentally generate perpetual experiences without physical input (Arbuthnott et al., 2001). The guided imagery study results found that an encoding event improved recall to anchor important moments (Arbuthnott et al., 2001). Arbuthunott et al. (2001) contend that improved recall through rehearsing new behaviors, reinforcing a change, or planning a future goal can improve the efficacy of the change. Techniques other than guided imagery can prove helpful in preparing humans to perform at a higher level.

Some athletes use imagery to increase performance in routine imagery programs (Fazel et al., 2018). Fazel et al. (2018) state that imagery training has yet to have a specific delivery style. Routine imagery practice provides athletes with various image capture techniques for context and skills.

Progressive imagery adds contextual items from simple to complex within a training program (Fazel et al., 2018). Progressive imagery allows athletes to image at a higher fidelity (Fazel et al., 2018). Calmels et al. (2004) studied softball athletes who used audiotapes to develop a progressive imagery process. They used the Vividness of Movement and Imagery Questionnaire to measure the vividness of imagery, which led to improved performance (Calmels et al., 2004). Golfers used progressive training through relaxation, positive suggestions, goal programming, and other forms of training for two weeks before beginning the visual imagery of the training (Jenkins, 2009). After imagery training, the golfers began activation training (Jenkins, 2009).

Applying Imagery Training to Human Capital Development

Imagery training incorporates Gestalt psychology and cognitive theory elements within human capital development (Swanson & Holton, 2009). Gestalt's early work involved perception and visual perception Britannica (n.d.) Imagery training builds on perception (Finke, 1980). Imagery training supports Gestalt's psychology theory by clarifying individual goals to perform at a higher level through assembling the skills mentally and controlling the image (Di Corrado et al., 2019).

Organizations can design human capital development programs to improve processes. Van Tiem et al. (2012) describe the role of human performance technology and improvement as both an art and a science that includes improving processes, performance, and individuals that can help the organization and society. Imagery practice will demonstrate whether SA improves individual performance. If individual SA improves with imagery training, it can disseminate throughout commercial aviation, improving organizations and providing safer flying for the betterment of society.

Van Tiem et al. (2012) identify four focus points when analyzing performance improvement potential: determining desired performance, actual performance, the gap in performance, and the causes. This literature review has identified a gap in desired performance (zero accidents through goods SA) and actual performance (accidents occurring due to pilot error in SA). Imagery training and practice can potentially improve SA and solve the performance gap. Cause analysis includes environmental and individual factors (Van Tiem et al., 2012). Environmental factors include current CRM principles of acceptance that airline pilots will make mistakes. Individual factors include the absence of effective responses for airline pilots that imagery training may solve.

Imagery training supports cognitive psychology in human capital by developing an individual to perform at a higher level through improved motor tasks during competition driven by purpose, motivation, or self-efficacy (Cumming & Ramsey, 2008). Swanson and Holton (2009) explain cognitive psychology, including information processing, working memory, and long-term memory. Imagery and SA include working memory (Kirschner et al., 2018) and long-term memory (Thomas, 1999) as an essential understanding for developing cognition.

Connecting Imagery to Airline Systems Through Airline Pilots

This study focuses on airline pilot flight safety using imagery training and practice. This final section reviews the relationship airline pilot imagery training has to the airline system, previous studies involving aviation and imagery, measuring airline pilot imagery and SA, and using kinesthetic and visual imagery with airline pilots. Understanding how imagery training relates to airline pilots requires discussing

Swanson's (2001) theoretical foundations of human resource development. Comparing the components of an airline may help relate human capital's foundational theories.

Airline Pilot Imagery Training and Human Capital Development

Airlines are in business to make money and show value to shareholders (Borochin, 2020). An airplane loss due to an accident remains an economic risk to the airline (Walker et al., 2014). Passengers lost during an accident become a liability based on international and national laws (Walker et al., 2014). An airplane loss not only has costs for cleanup and disposal, but the airframe disrupts the flight schedule as revenue for that airplane no longer exists to the airline. Management and regulators understand the connection that airline pilot performance improvement has to the economic, psychological, and system theories—built on the foundation of ethics that make up human capital development (Swanson & Holton, 2009).

The airline pilot represents the last intervention in the safety system for an airline (Reason, 1990). An airline pilot flying a safe airplane represents the most critical action performed for an airline (Helmreich et al., 1999). Airline strategic business planning foundationally requires attention for economic success.

Damage to the reputation becomes a factor in the organization's financial success (Walker et al., 2014). An organization modifying a safety system after an accident requires significant monetary investment and changes to training in the system. Investments in sustainable long-term economic performance and human capital with expertise and knowledge are critical to the economic theory for human capital development (Swanson & Holton, 2009). An airline's key performance indicators work from a well–designed organizational system.

Airlines are a complex system of safety, customer service, and logistics that leverages technology while being a responsible global citizen (Alan & Lapré, 2018). Airlines develop safety management systems and processes that provide information for customers and employees, build workforce training programs, and maintain an organizational plan to remain competitive in an extremely challenging industry (Hsu et al., 2010). The ability for a flight to operate successfully requires substantial team performance.

Airlines employ large groups to fly, maintain, and service the customer. Different groups within the system work together and sometimes are independent to meet the business needs (Yeh, 2014). General systems theory requires different human capital groups to understand and connect the other subsystems within the organization (Swanson & Holton, 2009). An airline constantly evolves to meet the customer's needs, and this constant evolution represents the Futures theory (Swanson & Holton, 2009). When major global, national, and local events occur, there can be disruptions to the airline. Chaos theory requires an airline to modify human capital duties and behaviors when faced with challenges (Swanson & Holton, 2009). The safety system represents an essential system for an airline to change behaviors.

The Airline Pilot as a Safety System

As discussed throughout this study, safety risks include airline pilot performance. Even though substantial investments in safety have reduced the risk of flying, the safety system does fail. Reason's (1990) Swiss Cheese model provides layers of a safety system that can prevent errors that lead to an accident. Unfortunately, sometimes all layers fail, with the airline pilot being the final layer (Wiegmann & Shappell, 2003). Airline pilot performance remains the last layer of defense; therefore, research involving untested solutions to safety risks may provide the solution for safer airline industry practices (Wiegmann & Shappell, 2003).

Airlines have relied on CRM and TEM human factor solutions for decades, showing that pilots still make errors that can lead to accidents (Helmreich, Klinect, & Wilhelm, 1999). Performance improvement intervention for musicians, the medical field, and athletes can be imagery training (Munzert et al., 2009). Airline pilots have minimal use of imagery during training. The aviation industry calls *chair–flying* pilots practicing low-frequency, high-risk maneuvers deliberately planned out without the airplane or simulator (Brown, 2017). Some pilots chair–fly maneuvers before a simulator training event to visualize the emergency maneuvers to improve performance.

Airline pilots do not receive training to learn how to chair-fly and do not offer a standard way to practice imagery flight planning preparation. Instead, modeling established imagery training from other industries could help the airline industry determine imagery effectivity for improving SA (Williams & Cumming, 2011).

Research has found that many pilots use mental imagery while flying; however, limited data explains if pilots receive imagery training (Jentsch et al., 1997). Previous imagery training studies among pilots, although limited, provide insight into the design of this study (Tokumaru et al., 2003). A paragliding study practicing imagery and self-talk improved landing accuracy results (Hadi et al., 2019). Airline pilots utilizing imagery while connected to an electroencephalogram (EEG) showed performance progress later in their careers (Tokumaru et al., 2003). This study will draw on previous aviation imagery research to determine whether it can improve SA.

Measuring Situational Awareness and Imagery

Research has measured improving airline pilot SA (Endsley, 1995). The Situational Awareness Global Assessment Technique measured SA and was studied using pilots in previous research (Endsley, 2000). Research has measured a person's imagery ability (Williams & Cumming, 2011). Direct measures can determine areas that can improve the individual pilot (Endsley & Robertson, 2000).

A Tested Program for Imagery Training

Utilizing mental imagery and kinesthetic imagery remains essential to airline pilots because it allows them to practice essential skills (Jentsch et al., 1997). Holmes and Colton (2001) developed an imagery intervention program called PETTLEP (Physical, Environment, Task, Timing, Learning, Emotion, and Perspective). The PETTLEP imagery model uses a specific framework for developing human imagery skills. PETTLEP utilizes physical positions that replicate what one might encounter during the actual performance (Post et al., 2015). The learner imagines the environment where they may perform the task, and the instruction should match what the employee will experience during the task (Post et al., 2015). The task should match the learner's skill level, and the duration of the practice should match the time of executing the skill (Post et al., 2015). Instructors are encouraged to include emotions during the training, such as stress, distraction, and time pressures (Post et al., 2015). Finally, the airline pilot's perspective on the flight deck should match the mental or kinesthetic imaging (Post et al., 2015). Airline organizations implementing the PETTLEP model can be confident that it allows consistency with other successful visualization programs.

Summary

Imagery training for airline pilots requires thorough knowledge of aviation visualization. The literature review revealed aviation's safety history and the conflict between profitability and airline training costs. A review of human factors improvements, including CRM and TEM, identify safety improvement opportunities in the industry. A review of SA and imagery narrowed the study's focus. The review summarized how other fields use imagery training to improve performance. Additionally, the researcher summarized some economic, systems, and psychological theories that support human capital development. Lastly, the literature validates SA measures and a specific safety system intervention for aviation. The following chapter provides the plan to accomplish the study.

CHAPTER III – METHODOLOGY

This study examines the use of imagery practice to improve airline pilot situational awareness. Chapter Three describes the methodology for the imagery study among airline pilots. The chapter begins with the research objectives, research design, and population and sampling methodology. The following section describes the instrumentation and materials required to complete the study. The chapter then describes the data collection plan and procedures. Next, the chapter delineates the Institutional Review Board approval process, the data analysis plan and procedures, and the limitations. A summary will conclude chapter three information.

Research Objectives

The critical nature of completing tasks safely on the commercial airplane flight deck may improve when airline pilots utilize imagery. There is no requirement to use imagery before a flight, and airline pilots may not react to a surprise event correctly due to losing SA (Federal Aviation Administration, 2017a). An incorrect response to a surprise can lead to an accident or incident (Martin, 2019). This study aimed to examine airline pilot imagery training to improve SA. The research addressed the following research objectives:

RO1 – Describe the participants in the study, including years of flying experience, type of flying experience (civilian/military/combination), total flight hours, and age.

RO2 – Determine the relationship between imagery practice and airline pilot situational perception.

RO3 – Determine the relationship between imagery practice and airline pilot situational comprehension.

RO4 – Determine the relationship between imagery practice and airline pilot situational projection.

RO5 – Compare the difference in situational awareness for the airline pilots with imagery practice and those without imagery practice.

Research Design

The research design provides the foundational structure for the study (Trochim, n.d.). The study must provide the appropriate research design to determine the effect on safety in the flight deck through imagery training. A randomized concurrent control experimental design uses random assignment with an experimental group and a control group (Meltzoff & Cooper, 2018). This study followed an equivalent comparison group posttest design. The study used a between-subjects design to match the design components of the study. Shadish et al. (2002) contest that no optimal design exists; however, the hypothesis, threats to validity relevance, threats to inference, and elements help decide the appropriateness of the study design.

Hypothesized Causal Relationship

The experimental study involved a sample population from the actively flying U.S. Airline pilot population. Figure 4 visually depicts the randomly selected equivalent comparison group study with a posttest model for this study. The study included control and treatment groups from the sample population.

There are many designs available. Shadish et al. (2002) describe several randomized designs where practical random assignment used by a researcher provides an opportunity for causal inference. Designs can vary the use of pretests, variables, treatment location, and treatment time within the design (Shadish et al., 2002). The basic design using a concurrent control group provides a method to answer the question of what variable the researcher can control in the study (Shadish et al., 2002). In the case of the present study, figure 4 denotes the intention to control imagery practice's effects on situational awareness.

Shadish et al. (2002) express concern about the risk of attrition when utilizing a design without a pretest. There may be a question of whether those that drop out represent a different population sample from those who participate (Shadish et al., 2002). The control group in this study draws from a homogenous airline pilot population that received standardized training before operating airplanes. A no-treatment control experiment tests the molar treatment as a whole and not partial effects on components of the study (Shadish et al., 2002). For this reason, the control group received no pretest and participated in a posttest immediately.

R	*X*	*O*
R		*O*

Figure 4. Randomized Design Comparing Treatment and Control Groups

Note. Shadish et al. (2002) present a randomized design in the form of a diagram. The notation *R* represents the airline pilot sample population randomly selected for this experiment. The notation *X* represents imagery practice. One airline pilot group, the control group, will not receive practice. Both the groups receive a posttest, *O*, 3 weeks after beginning participation in the study.

The design choice considers the study's intent regarding time (Meltzoff & Cooper, 2018). Research to improve cognitive skills in music demonstrated performance improvement in a 3-week study (Lesiuk, 2010). Golf athletes who used imagery training and practice over multiple weeks had improvements through improved scores (Hammond et al., 2012). During the 3-week intervention, the airline pilots in the treatment group participated in an imagery training session, then practice the imagery skills learned during the training. Landman et al. (2017) found that theoretical and practical training outperformed theoretical training by adding context to theory in a similar aviation study.

Validity

The design selected for a study allows the researcher to control validity issues (Shadish et al., 2002). This experimental study contains a randomly assigned control group and a treatment group. Equivalent groups strengthen internal validity by reducing selection threats (Shadish et al., 2002). Trochim (n.d.) suggests using a random sample to improve external validity by choosing the correct people for the study and reducing attrition (Shadish et al., 2002). The researcher disseminated the intervention, posttest, and data collection electronically. The researcher used software to manage and record the data digitally to reduce administrative errors and strengthen statistical conclusion validity. Homogeneity exists among the sample since all participants are airline pilots actively flying, and the practice will occur in their current setting, strengthening statistical conclusion validity. Construct validity strength requires matching the sample, setting, treatment, and outcome constructs to the study (Shadish et al., 2002). The instrument eliminates reactivity to the experimental situation, which aids in construct validity. The benefits from improved validity, based on design, conclude an appropriate experimental design.

This study examined the effects of imagery practice on airline pilots. The posttest used a validated measurement tool for measuring SA (Endsley, 1995). The remainder of this chapter will address the population and sample population, the instrument and materials, *the Institutional Review Board approval process*, the data collection and analysis, and the limitations.

Population and Sample

The population for this study covers U.S. airline pilots. The government estimates the certified airline transport pilot population in the United States at 163,934 (Federal Aviation Administration, 2022b). In 2021, the U.S. Bureau of Labor Statistics estimated that United States Airlines employed 81,310 airline pilots were employed in the United States. Challenges exist to conducting a study available to all employed airline pilots due to accessibility to the whole population.

Methodology for Choosing the Population

The accessible population represents the population that a researcher has access to collect data (Trochim, n.d.). Pilots are located all over the world operating in different time zones. A common communication thread does not exist for all airline pilots, making it difficult to conduct a study that encompasses the entire population. For these reasons, this study limited participation of the accessible population to one group within an airline pilot's association.

Description of the Sample

The airline pilots chosen for the study are employed by a large cargo airline with domestic and international operations, reflecting the larger population of airline pilots worldwide. The accessible airline pilot population includes the members of the Airline Pilots Association, who receive communications via email. The association Master Executive Council approved (Appendix B) disseminating solicitation information to its members on behalf of the researcher. To be eligible for the study, the airline pilot must be actively flying and not on vacation, out sick, or in a non-flying status during the study. A closed Facebook group, approved by the page administrator (Appendix C), will also host an advertisement for the study.

The airline pilot population in this study completed an identical selection process to obtain employment at the airline. The critical eligibility factors are the minimum flight hours each pilot has to attain before interviewing for a flight position and possessing an Airline Transport Pilot certificate from the FAA or the ability to hold the certificate once they meet the minimum hours. The airline used in the sample requires all airline pilots to have a minimum of 1,500 hours of multiengine total fixed-wing flight hours and 500 required (1,000 preferred) pilot-in-command hours in a turbine power jet or turboprop 12,500 pounds (FedEx, 2021). Typically airline pilots hired at an airline exceed the minimum requirements since the industry remains highly competitive to attain employment at a major airline (Delta, 2021). The accessible population represents the airline pilots at an international cargo airline.

Along with distinguishing characteristics, the design needs a method to draw the sample (Trochim, n.d.). The study utilized probability sampling by using the airline pilots on the seniority list with a random assignment methodology to place a pilot in the group receiving the imagery training or the group without additional training. Meltzoff and Cooper (2018) state that probability sampling should reduce sampling bias when using a diverse population. The accessible population of airline pilots represents various backgrounds of experience, such as civilian and military, various experience levels measured in flight hours, years of experience, and various ages.

The population of airline pilots fits the study, as it represents a concept of two pilots minimum required to operate the airplane. Some less sophisticated airplanes require one pilot. Single pilot operations are excluded from the study as the study investigates the pilot monitoring and not physically flying at the controls. In order to determine the existence of causal inference to SA improvement from imagery training, there needs to be pilot flying and pilot monitoring, thus the need for at least two pilots.

Sample Size

A power analysis requires determining the appropriate sample size (Field, 2018). *Statistical power* relies on the probability that the experiment will find a significant effect if an effect is present (Field, 2018). Power analysis uses sample size, effect size, data variation, and the statistical significance criterion information established before a study (Meltzhoff & Cooper, 2018). A meta-analysis of 243 studies revealed that the SAGAT instrument predicted performance in 90% of the studies, along with sensitivity in 94% of the studies (Endsley, 2019). The consistency of the meta-analysis drives the effect size. The confidence level measures the certainty that the sample matches the population (Field, 2018).

The power analysis determined that a population size with a confidence level of 95%, a margin of error of 5%, and a population proportion of 50% recommends a sample size of 351 people using the eligible population of 4,040 individuals (Calculator, n.d.). In a study involving airline pilots utilizing a survey, Bourgeois-Bougrine et al. (2003) had a respondent rate of 21.5%. A rate of 21.5% for 4,040 airline pilots will deliver 868 volunteers for this study—over two times the needed volunteers. In another study, Nicholas et al. (2001) had a 61.8% response rate for a survey among airline pilots.

Understanding that the sample size may have some attrition due to airline pilot personal emergencies, illness, or other reasons, the target sample size for the study increased to 360 people. Although 214 airline pilots volunteered to participate, only 179 completed all the survey responses.

Sampling Procedures

Airline pilots participated in the study. Airline pilots who volunteered for the study were randomly assigned to the control or treatment group—the methodology for an assignment rooted in the volunteer master list. A master volunteer list with 360 subject lines used a GraphPad (2022) random number generator to assign an airline pilot to either the group receiving the imagery training or the group receiving no training.

A Facebook invitation (Appendix D) and an email invitation through the Airline Pilots Association (Appendix E) invited eligible airline pilots to participate in the study. A reminder Facebook message (Appendix F) and reminder email (Appendix G) was sent out after a week to remind the airline pilots of the study and to sign up. The airline pilots interested in participating in the study responded by selecting the link for the electronic consent form (Appendix H) to fill out and return. The electronic consent form (Appendix H) established the project information, description, purpose, benefits, risks, confidentiality, alternative procedures, and informed consent of the study. Once the eligible volunteers had electronically signed a consent form (Appendix H), their names were placed in the pool of the Master Volunteer List.

After all the participants were in the pool, the sample was divided into the treatment group (receiving the imagery training and practice) and the control group (not receiving any training and practice). A random list generator was used to ensure that the groups were selected without bias (GraphPad, 2022). Names of the participants were independently stored to be used to draw for a gift card once the study was complete.

Unit of Analysis

Trochim (n.d.) describes the unit of analysis as the procedure to determine what unit to use for a study. Although airline pilots work as a team of two or more, this study focuses on the individual airline pilot's monitoring ability to improve SA through imaging. The individual airline pilot represents the unit for determining the relationship between imagery practice and improved SA.

Criteria Used to Determine Sample

The accessible eligible population size for the airline includes 4,040 airline pilots. The accessible eligible population excludes ineligible airline pilots in a non-flying status at the time of the experiment. A bid package lists all eligible airline pilots as captains and first officers. The company bidding packages were analyzed for the airline pilot's eligibility based on active flying status. The airline pilots currently in a training status or other non-flying duties are not eligible since they cannot perform the required flights by the study. An eligibility question was asked of each individual on the consent form. Eligibility requires that the airline pilot will be actively flying during the three-week study, meaning they are not in a status other than flying.

Instrumentation

The format for the treatment group included completing a training program, practicing imagery during the three weeks after the training, then completing the posttest survey. The control group completed the posttest survey only. The instrumentation section will explain the choice to use SAGAT, including reliability and validity, a description of the instrument, scale scoring, the posttest format, a description of the training session, and the practice format.

Many different instruments are available to measure SA. As a non-technical competency, SA may not be as straightforward or easy to measure as specific technical knowledge and flying skills (Nguyen et al., 2019). Freeze-probe, real-time, post-trial self-rating, observer-rating, performance measures, and process indices techniques are the categories of SA measurement (Nguyen et al., 2019). Each SA measurement technique has advantages and disadvantages. A review of the many instruments available helps understand the appropriateness of the chosen instrument.

Types of SA Measurement Techniques

The freeze probe technique includes the Situational Awareness Global Assessment Technique (SAGAT), Situational Awareness of Enroute Air Traffic Controllers in the Context of Automation, and Situational Awareness Control Room Inventory methods (Nguyen et al., 2019). The advantages of freeze probe techniques are direct and objective measures that collect data during the event (Nguyen et al., 2019). The disadvantages of freeze probe techniques are the intrusiveness of the method, which requires a simulation. It may be hard to create real-world activities, along with validity issues, if the participant memorizes the information (Nguyen et al., 2019).

The real-time probe technique methods are Situation Present Assessment Method and Solutions for Human–Automation Partnerships in European Air Traffic Management (Nguyen et al., 2019). The real-time probe technique advantage includes not freezing the task employed in the field (Nguyen et al., 2019). The disadvantages of real-time probe techniques include the risk of intrusive, biased results and a burden on SMEs collecting data (Nguyen et al., 2019).

Post-trial self-rating techniques include the Situation Awareness Rating Technique, Situation Awareness Rating Scales, Crew Awareness Rating Scale, Mission Awareness Rating Scale, and Quantitative Analysis of Situational Awareness (Nguyen et al., 2019). Post-trial self-rating techniques are non-intrusive, easy to implement, and inexpensive to conduct (Nguyen et al., 2019). The disadvantages of post-trial self-rating techniques are subjectivity, data collection issues, and sensitivity issues (Nguyen et al., 2019).

Situation Awareness Behavioral Rating Scale uses the observer rating technique. This measurement works in the field, just like the real-time probe technique (Nguyen et al., 2019). The disadvantage of this measurement includes validity issues, behavioral bias, and the requirement for multiple SMEs (Nguyen et al., 2019).

The Operation Score represents the performance measures technique (Nguyen et al., 2019). The advantage of the Operation Score technique includes the simplicity of achieving measurement, which acts as a backup for other SA measures (Nguyen et al., 2019). The disadvantage requires that an expert in the subject may score well even with poor SA (Nguyen et al., 2019).

Process Indices use eye-tracker technology (Nguyen et al., 2019). *Eye tracker technology* remains a non-intrusive method that can determine what element someone focuses on (Nguyen et al., 2019). The disadvantage of eye-tracking technology includes the indirect nature that may be difficult to implement outside a lab setting (Nguyen et al., 2019). There are also some issues with the eye tracker misreporting something that the person looks at but does not see the SA marker, producing incorrect data (Nguyen et al., 2019).

Appropriateness of SAGAT

With permission (Appendix I), the researcher selected the SAGAT to measure SA in this study. SAGAT's attributions provide an objective instrument with high reliability, sound sensitivity, and strong construct and predictive validity (Endsley, 2021). SA represents a non-technical skill requiring an instrument to collect accurate, objective data from the participant.

SAGAT allows the researcher to present a simulation of an actual event that inserts short freezes into an exercise (Endsley, 2021). In-depth task analysis for each domain provides accurate queries asked to the participants during the freezes. During the freezes, the participant's instruments blank out, a set of SA queries appear, and the participant responds through the recorded survey (Endsley, 2021). Once the participant completes the queries, the simulation will continue from where it was frozen (Endsley, 2021). The simulation response data accumulates and compares to the actual answers (Endsley, 2021).

Instrument Validity and Reliability

The SAGAT instrument has a high level of validity and reliability (Endsley, 2000). Endsley (2000) focused on two measurements to reinforce validity: criterion validity and construct validity. The American Psychology Association (n.d.) defines *criterion validity* as measuring the outcomes that the assessments were designed to measure. Criterion validity can be predictive and provides a researcher with a way to piece together data to support the predictive conclusion (American Psychology

Association, n.d.). Research demonstrated that fighter pilots were more successful in carrying out duties to extinguish a target if they had the SA regarding the target (Endsley, 1990). Follow-on studies by Endsley and Smith (1996) supported the criterion validity strength further in a similar fighter pilot study.

Construct validity represents how well the test represents the measurement (Shadish et al., 2002). One criticism challenging the construct validity of SAGAT includes intrusiveness (Nguyen et al., 2019). Intrusiveness represents the interruptions within a study on task performance (Nguyen et al., 2019). Endsley (2000) used SAGAT's freeze technique to study fighter pilot performance. The fighter pilots would perform a portion of a simulated mission, and then the simulations would freeze to gather data (Endsley, 2000). The fighter pilots would then continue on the simulated mission (Endsley, 2000). The resulting data during a simulated mission with freezes demonstrated no significant intrusive impact on pilot performance (Endsley, 2000).

A second challenge to SAGAT's construct validity is how it reflects the participant's memory ability (Endsley, 2000). Endsley (2000) defends SAGAT, explaining that data execution involves collecting data using concurrent memory queried immediately upon a freeze. Endsley (2000) continues to defend the construct validity of SAGAT, stating that both working memory and long-term memory are where SA information storage occurs. Endsley (2000) tested pilot performance after a freeze between 20 seconds to 6 minutes without affecting the results.

A measure of test validity defines sensitivity. Trevethan (2017) describes sensitivity as how a test identifies the condition that exist or are not present. Endsley

(2000) documented the sensitivity and predictive validity within a review of SAGAT and determined with high confidence that the testing methodology provides accurate data.

Another researcher's ability to repeat a study that produces similar results defines reliability (Trochim, n.d.). SAGAT demonstrates instrument reliability through many studies and a meta-analysis. (Endsley, 2021). Test-retest scores across multiple tests separated by over a month demonstrated consistent results in multiple subjects, including fighter pilots and car driving (Endsley, 2021).

Instrument Description

The SAGAT instrument collects *query* data at the freezes of a flight in a non-specific airplane type. This study used Endsley's (2021) validated questions developed in a previous SAGAT study. Endsley (2021) advises conducting a goal-directed task analysis to assess the goals of a new study for all three levels of SA. The study used the existing questions with the same goals, eliminating the need to conduct a goal-directed task analysis. The questions asked are called queries (Endsley, 2021).

With permission (Appendix I), this study used Endsley's (2021) commercial aviation and general aviation SAGAT instrument. Endsley's (1995) original instrument contained 34 queries. Endsley (2021) suggested that queries can be modified or eliminated for the study if a query remains not relevant to the conditions. Four queries did not fit the video presentation format, and the researcher omitted them from this instrument. The instrument for this study contains 30 queries. There are 12 level 1 SA perception queries, 9 level 2 SA comprehension queries, and 9 level 3 SA projection queries (Endsley, 2021). The SAGAT queries include multiple-choice responses. Endsley (2021) recommends that subject matter experts review draft queries; however, since this data set has been tested and used by the original researcher who created SAGAT and other studies, previous studies define the intent of the queries.

Previous users of the SAGAT instrument recommend random sampling across many points in time (Endsley, 2021). The sampling in this study occurs randomly, with the video's freeze-point occurring at different times in a flight. Endsley (2021) recommends 30 to 60 samples minimum for each query to have sufficient power. Endsley (2021) used 10 participants through 4 trials and 3 freezes to administer each query 1/2 of the time for a total of 60 samples for each query (10 participants x 4 trials x 3 freezes x .5 administrations = 60 samples). The format in aviation studies that use SAGAT typically includes a small number of participants sampled many times on each query (Endsley, 2021). This study used a larger group of participants, with each participant sampling a query once.

Endsley (2021) recommends a larger group of participants when conducting a between-subjects experimental design vice a within-subject; however, using either design may be acceptable. This study used 179 participants who completed the study, including 85 treatment group participants and 94 control group participants. There are 30 total SA queries. The total samples from all 30 SA queries were 5,370 (360 samples x 30 SA queries = 5,370). The sample should reduce history-type internal validity threats, defined as previous events within the study that can affect the participants (Meltzhoff & Cooper, 2018).

Scoring of Scales

Endsley (2021) recommends scoring multiple-choice data as a correct or incorrect answer based on an *operational tolerance band*. Endsley (2021) recommends some queries score using the associated answer category. An answer that the participant leaves blank scores as an incorrect answer (Endsley, 2021). Appendix J represents the scoring tolerances for this study using Endsley's (2021) commercial aviation and general aviation SAGAT instrument.

For this study, the performance band values (Appendix J) are determined using data from the Airline Transport Pilot and Type Rating for Airplane Airman Certification Standards (Federal Aviation Administration, 2019) and operational information from the SAGAT (Endsley, 2021). The standards represent the parameters an airline pilot should maintain an airplane within, or in this case, the pilot monitor's knowledge of the airplane's parameters based on their own SA at the time of the freeze. Answers available to the participant were multiple choice, and each answer's defined value represented one point if answered correctly. The correct multiple-choice answer represents the parameters of the tolerance band found in Appendix J. All other answers are outside the performance band and will score 0 points.

The instrument queries represent one point per response. The score represented when the airline pilot answered the SA query correctly. SA1 value represents 12 points. SA2 value represents nine points. SA3 value represents nine points. Table 2 displays a map of the posttest survey questions. Questions 1–4 collect demographic data. Questions 5–34 were used to generate an overall score for comparison between the control and treatment groups. The sum of correct answers to questions 5–34 will be compared between groups. Questions 35 and 36 ask the treatment group how many flights the participants went on and how many times the participants practiced imaging the flight plan during the 3-week Questions 35 and 36 were used to determine if practice correlates to SA.

Table 2 *Posttest Survey Map*

RO	Questions	Code book reference	Associated construct of situational awareness
RO1	1–4	1–4	Demographic information
RO2	5–8, 15–18, 25–28	5–8, 15–18, 25–28	SA Level 1 Perception
	35	39	Number of flights
	36	40	Number of times practicing
		35	SA Level 1 total posttest score
RO3	9–11, 19–21, 29–31	9–11, 19–21, 29–31	SA Level 2 Comprehension
	35	39	Number of flights
	36	40	Number of times practicing
		36	SA Level 2 total posttest score
RO4	12–14, 22–24, 32–34	12–14, 22–24, 32–34	SA Level 3 Projection
	35	39	Number of flights
	36	40	Number of times practicing
		37	SA Level 3 total posttest score
RO5		38	SA total cumulative score with imagery practice
		44	SA total cumulative score without imagery practice

Format of the Posttest

The posttest for this study uses the SAGAT methodology of freeze-probe. The posttest begins with a welcome page using the survey software. The survey instructions explain that the participants answer four demographic questions and then watch a video of a flight from Newark Liberty International Airport to Philadelphia International Airport. The video freezes then participants answer ten questions. The exact process occurs two more times. At the end of the third set of questions, the control group completed participation in the study. The treatment group was asked two additional questions at the end of the third video to provide data for *RO5.* The treatment group has completed participation in the study.

Training Session Description

The treatment group's training session (Appendix K) was designed utilizing the ADDIE process predicated on information sourced from current imagery training and practice using PETTLEP performance-based training (Ford, 2010). The training session begins with an introduction. Lesson 1, the introduction, defines the training objectives and displays a video, used with permission (Appendix L), to introduce imagery. Lesson 2 describes the Blue Angels' techniques to practice their performance before flying a show. The Blue Angels video, used with permission (Appendix M), demonstrates the use of mental and kinesthetic imagery. The highlights of the video are displayed for the learner. Lesson 3 introduces PETTLEP, the imagery intervention program developed by Holmes and Collins (2001). PETTLEP uses the imagery of the Physical, Environment, Task, Timing, Learning, Emotion, and Perspective for performance improvement (Holmes & Collins, 2001). Each of the seven tasks of PETTLEP is described, and aviation knowledge check examples are provided using flash cards. Lesson 4 explains specifically how the treatment group participants use imagery over the following three weeks to practice what has been learned during the training.

The training session utilized an analysis of the information regarding PETTLEP training used in sports (Norouzi et al., 2019), nursing (Wright et al., 2008), weightlifting (Wright & Smith, 2009), and other motor skill areas (Post et al., 2015). The design phase of this training exemplifies performance-driven tasks, which Ford (2010) states revolve around creating specific training tasks for participants to perform their jobs.

The development stage requires the information to provide tasks within the lesson and then practice to consolidate the information for the learner, which Ford (2010) says has to have a clear set of set goals or blueprints. The researcher develops the information from PETTLEP training programs (Holmes & Collins, 2001; Norouzi et al., 2019; Post et al., 2015; Wright & Smith, 2009) and SME knowledge regarding SA, a significant training session. The training program utilized Articulate 360 for developing the presentation. The design was implemented in an SME small group trial for feedback. Adjustments were made to the presentation based on the feedback to improve the product, which established some evaluative qualities.

Practice Session Format

Once the treatment group completed the training course, the treatment participants were directed to practice imagining the flight plan. The treatment participants could use flight plans from past flights using the techniques learned during the training session to practice imaging. Any flight plan available could be used to practice imaging techniques.

Treatment participants were asked to record the number of times a flight plan has been practiced. The data was asked for during the posttest. The participant was given a simple flight plan before the posttest using the learned techniques to image the flight plan.

Data Collection

The researcher began the data collection process once the Institutional Review Board (IRB) approved this study for research. IRB approval considers human subject protection, proper researcher certification, and an informed consent process (Roberts & Hyatt, (2019). This study used human participants. The University of Southern Mississippi Institutional Review Board application includes integrity awareness and validation training, the research procedure description with supporting research instruments, the study's risks and benefits, and the study's classification. The remaining data collection section provides information regarding the procedures required to collect the data for this study.

Procedures

Table 3 displays the data collection plan for this study. With IRB approval attained, the data collection plan commenced with email information and Facebook messages soliciting volunteers, a reminder volunteer advertisement, and volunteer acceptance information. The volunteer posting was available through the Airline Pilot Association communications (Appendix E) and an advertisement post on a Facebook page (Appendix D) whose membership remains open to airline pilots from the population sample. A dedicated email address and a phone number were posted on advertisements to answer questions for potential participants.

Volunteer participants provided their name, email address, telephone number, and consent (Appendix H) for permission to participate, communications, and information regarding the study. The volunteers provided their full name and signature electronically as a record of informed consent. The personal information was stored separately from the

Table 3 *Data Collection Plan*

Week	Task
Week 0	Receive IRB approval.
Week 1 Day 1	Send the invitation to participate in the study via pilot email 1 and load message 1 to Facebook page.
Week 1 Day 2–7	Receive and compile volunteer list through consent forms.
Week 2 Day 1	Load Facebook participation message 2.
Week 2 Day 1–7	Receive and compile volunteer list through consent forms.
Week 2 Day 3	Send email participation reminder message 2.
Week 3	Treatment Begins.
Week 3 Day 1	Send instruction email to treatment participants and control group.
Week 3 Day 5	Send a reminder email 1 to treatment group to practice imaging a flight.
Week 4 Day 1	Send reminder email to control participants who have not completed the posttest.
Week 4 Day 3	Send a reminder email 2 to treatment group to practice imaging a flight.
Week 5 Day 1	Send a reminder email 3 to treatment group to practice imaging a flight.
Week 5 Day 7	Email treatment participants to conclude the study. Include a link to the posttest.
Week 6 Day 4	Send reminder email to treatment participants who have not completed the posttest.
Week 7 Day 1	Final deadline for posttest completion

study's data to ensure confidentiality. The research data is available to the research team. Participants' names were only used in a random drawing to award one participant a $500 Visa gift card. A participant who did not complete the treatment (for the treatment group) and complete the posttest for either the treatment or control groups became ineligible for the incentive drawing program.

The researcher sent a reminder email message (Appendix G) and a reminder Facebook message (Appendix F) during week 2 to encourage participation in the study. The study began on week 3. On day 1 of week 3, an email with a link was sent to all participants. The control group received an email (Appendix N) with a link for participants to take a posttest (Appendix O). A reminder email (Appendix P) was sent to the control group on week 4 day 1.

The treatment group email (Appendix Q) provided a link to the online imagery training. Once the imagery training is completed, the treatment participants were encouraged to practice their new skills over the remaining three weeks. Three emails (Appendices R, S, T) were sent to the treatment group three weeks after training to remind the participants to practice imaging flights. On week 5, day 7, an email was sent to the treatment group participants with a link (Appendix U) to take the posttest (Appendix V). The posttest survey queries were identical for both groups, except that the treatment group posttest (Appendix V) asked for the number of times they practiced imaging a flight and the number of flights flown during the three weeks. A reminder email to complete the posttest was sent on week 6, day 4 (Appendix W). The final deadline to complete the posttest was week 7, day 1.

Posttest Video Explanation

The survey questions reflect the SA information the participants gleam from a video of a simulated flight from Newark Liberty International Airport to Philadelphia International Airport in a Boeing 757. The video displays three views of the flight deck, including the view out of the main windows and mode control panel, the primary flight and navigation displays, and the flight management system computer. The 757 is a representative sample airplane. The participants in the study were not required to have flight experience in the 757. The airplane contains standard advanced flight deck instruments that airline pilots without 757 experience can read to gather the SA required for the study. The video has three unequal segment lengths with associated queries to follow the video. Since the study utilizes a random assignment methodology, there should not be a risk to validity based on some airline pilots having 757 experience.

Data Protocols

All data collection for the control posttest (Appendix O) and treatment posttest (Appendix V) were accomplished online. All participants had access to a tablet computer. The consent form (Appendix H), training program (Appendix K), and survey (Appendix O and Appendix V) were accomplished on a computer, laptop, or tablet device. The researcher recommended not using a mobile device to watch the survey video as the screen may be too small. The posttest was administered on a web-based data collection tool. The data was transferred to Microsoft Excel. Once the treatment group had completed the imagery training, they could return to reference the online imagery training information at any time during the imagery practice.

The data is being stored electronically on a computer hard drive for three years. 45CFR46.115b requires a researcher to retain records for at least three years (National Archives, 2022d). The data will be available for inspection for this period upon completion of the research study for three years after publication.

Data Analysis

The data analysis section provides information that describes the research objective and the type of statistical test appropriate to determine the statistical significance of the data. Fink (2003) states that statistics uses math to organize information and interpret its meaning. Meltzhoff and Cooper (2018) stress that using the appropriate statistical tests to answer the research question, meet the assumptions, and handle the data correctly while controlling for type I errors remains key to a good analysis. Appendix Z includes a codebook for reference to data points.

The research objectives for this study represent three types of statistics. RO1 uses descriptive statistics to show the frequency of values. Descriptive statistics measure central tendency (Fink, 2003). The descriptive statistics for *RO1* include years of flying experience, age, type of flying experience (civilian/military/combination), and total flight hours.

RO2 through *RO4* determine if a relationship exists between imagery practice and situational awareness. A relationship statistic determines the relationship among or between two variables (Fink, 2003). The SAGAT test will provide data for the three levels of SA, and each level will be tested separately based on the recommendations of the original instrument design (Endsley, 2021).

RO5 compares the treatment and control group participants' posttest change in situational awareness imagery scores. Fink (2003) describes a comparison as comparing results between a control group and a treatment group, representing this study's design. If a difference exists between the two groups, the statistical analysis will determine the magnitude of the difference (Fink, 2003).

Table 4 *Data Analysis Plan*

RO	Variable item(s)	Scale	Statistical test
RO1	Total Years Flying	Ordinal	Frequency Distribution
	Age	Ordinal	Frequency Distribution
	Flying Experience	Nominal	Frequency Distribution
	Total Flight Hours	Ordinal	Frequency Distribution
RO2	Imagery Practice SA Level 1 Perception	Ratio Ratio	Pearson's *r*
RO3	Imagery Practice SA Level 2 Comprehension	Ratio Ratio	Pearson's *r*
RO4	Imagery Practice SA Level 3 Projection	Ratio Ratio	Pearson's *r*
RO5	Pilot Groups Posttest Scores	Nominal Interval	*t*-test

The data analysis plan (Table 4) represents the research objective, its variables, and the statistical tests performed in this study. The following section explains the rationale for the analysis choices and the process described to accomplish the testing. The statistical tests data set used Microsoft Excel to store the data and IBM SPSS© to perform the statistical tests. The information provided in the data analysis plan (Table 4) explains the variable, items, scale, and statistical test. Table 4 is divided into each research objective.

Summary

This experimental study uses random selection of an airline pilot population to determine if imagery practice can improve SA. This chapter discussed the research design, population, sample, instruments, data collection plan, IRB information, and data analysis plan to conduct the study. The population of accessible airline pilots reflects the larger population of airline pilots. The SAGAT instrument has effectively measured situational awareness in the past, and the researcher selected SAGAT for the present study, given its validity and reliability (Endsley, 2021). The study format represents a posttest design with the treatment group receiving imagery training (including videos) and practicing over three weeks. All data was collected and is being stored electronically. The researcher analyzed the data after running tests with statistical software in the following chapter.

CHAPTER IV – RESULTS OF THE STUDY

This study aimed to examine the relationship between imagery and airline pilot situational awareness. The results focus on answering two research questions. Does the practice of imagery improve airline pilot situational awareness? Do airline pilots who receive imagery training and practice improve situational awareness perception, comprehension, or projection? Chapter Four reports the results of the study. This chapter explains the research objectives and results for each objective. A statistical analysis of the data associated with each objective, including assumptions testing, explains the results. Tables and written explanations provide the results. Chapter Four begins with a population description and the participant demographic information.

Research Objective 1

Describe the participants in the study, including years of flying experience, type of flying experience (civilian/military/combination), total flight hours, and age.

The study invited participation from 4,040 airline pilots employed at a large cargo airline that flies domestically and internationally. The study had 757 people view the consent form, with 301 responding to the consent form. During the consent form process 87 people opted out at some point, leaving 214 completed consent forms. The average time to complete the consent form was 3 minutes. The participants were randomly assigned to the treatment and control groups, with 107 participants in each group. The group without imagery practice had 94 participants complete the survey for an 87.9% completion rate. The group with imagery practice had 85 participants complete the survey for a 79.4% completion rate. Data were discarded for partially completed surveys.

Years of Experience

Airline pilot years of experience were collected into one of five groups. Most airline pilots in both the group with imagery practice and without imagery practice possessed 25 or more years of experience flying airplanes. The imagery practice group participants had 74.1% of airline pilots with 25 or more years of experience. Of the participants who did not practice imagery, 78.7% of participants reported more than 25 years of experience. Only one participant in the imagery practice group had 10 years of experience or less. Airline pilots with 11 to 15 years of experience account for 2.8% of the cumulative participants. Airline pilots with 16 to 20 years of experience account for 6.7% of cumulative participants. Airline pilots with 21 to 25 years of experience account for 13.4% of the cumulative participants. Table 5 contains the frequency distribution for airline pilots' years of experience. The demographic data includes individual groups, combined groups, and cumulative percentages.

Table 5 *Participants by Years of Experience*

Demographic	Imagery practice		No imagery practice		Combination		Cumulative percent
	n	%	*n*	%	*n*	%	%
Less than 5 years	0	0	0	0	0	0	0
5 to 10 years	1	1.2	0	0	1	0.6	0.6
11 to 15 years	2	2.4	3	3.2	5	2.8	3.4
16 to 20 years	6	7.0	6	6.4	12	6.7	10.1
21 to 25 years	13	15.3	11	11.7	24	13.4	23.5
More than 25 years	63	74.1	74	78.7	137	76.6	100.0

Age

Airline pilot age was reported into one of five groups. The range of age included less than 29 and up to age 64 due to the mandatory retirement age of 65. The largest group included eighty participants age 50 to 59 years old, which made up 41.5% of the total participants. The 40 to 49-year-old and 59 to 64-year-old groups each included 24% of the total participants. The 30 to 39-year-old group represents 6.2% of cumulative participants. Participants 29 years old and younger included 1.1% of the cumulative participants. Table 6 displays the frequency distribution data related to age.

Table 6 *Participants by Age*

Demographic	Imagery practice		No imagery practice		Combination		Cumulative percent
	n	%	*n*	%	*n*	%	%
29 or less years	0	0	2	2.1	2	1.1	1.1
30–39 years	6	7.1	5	5.3	11	6.2	7.3
40–49 years	19	22.4	24	25.6	43	24.0	31.3
50–59 years	41	48.2	39	41.5	80	44. 7	76.0
60–64 years	19	22.3	24	25.5	43	24.0	100.0

Type of Flying Experience

Airline pilot type of flying experience was reported as civilian only, military only, and combined military and civilian experience. The data represents the previous experience the airline pilot gained prior to employment at the airline. The cumulative participant demographic identified 53.6% as having a combination of military and civilian experience. Another large group, 44.7%, reported having civilian experience only. Lastly, the military only experience represented 1.7% of the participants. Table 7 contains frequency distribution data related to the type of previous experience.

Table 7 *Participants by Previous Experience*

Demographic	Imagery practice		No imagery practice		Combination		Cumulative percent
	n	%	*n*	%	*n*	%	%
Military	2	2.4	1	1.1	3	1.7	1.7
Civilian	40	47.0	40	42.6	80	44.7	46.4
Combination	43	50.6	53	36.4	96	53.6	100.0

Total Flight Hours

The total flight hours represent another measure of experience level for an airline pilot. The flight hours of airline pilot participants ranged from less than 4,000 to more than 20,000, rounded to the nearest 1,000 hours. In describing total flight hours, 40.8% reported 4,000 to 9,000 flight hours. The next largest group of airline pilots, 39.1%

Table 8 *Participants by Total Flight Hours*

Demographic	Imagery practice		No imagery practice		Combination		Cumulative percent
	n	%	*n*	%	*n*	%	%
Less than 4,000	0	0	1	1.1	1	.6	0.6
4,000–9,000	32	37.6	41	43.6	73	40.8	41.4
10,000–15,000	35	41.2	35	37.2	70	39.1	80.5
16,000–20,000	13	15.3	11	11.7	24	13.4	93.9
More than 20,000	5	5.9	6	6.4	11	6.1	100.0

reported 10,000 to 15,000 flight hours. The group that reported 16,000 to 20,000 flight hours was 13.4% of the participants. A smaller group of 6.1% of participants reported more than 20,000 flight hours. Lastly, 0.6% reported less than 4,000 flight hours. Table 8 displays the frequency distribution data related to total flight hours.

Research Objective 2

Determine the relationship between imagery practice and airline pilot situational perception.

Research Objective 2 determined if the two variables, imagery practice and situational awareness perception, have a relationship. The imagery practice survey collected the frequency each participant practiced imagery during the study. The number of practice sessions ranged from 0 to 22 times. Twelve questions throughout the survey queries measured situational awareness perception. The perception query range included a possible score of 0 to 12.

The analysis utilized Pearson's *product-moment correlation* statistical test. Statistical correlation analysis aims to determine the relationship between two variables to each other (Trochim, n.d.). Pearson correlation coefficient, labeled as r, determines the strength of two interval variables and the direction of the linear relationship (Field, 2018). The correlation coefficient value ranges between -1, a negative relationship, and +1, a positive relationship, with a value of 0 representing no relationship (Laerd, n.d.).

RO 2 Pearson's Product-moment Correlation Assumptions

Assumptions are steps before the statistical test that identify conditions to produce accurate test statistics and p-value (Field, 2018). Pearson's product-moment correlation requires such assumptions to be met. Laerd (n.d.) discusses five assumptions that must be considered to analyze using Pearson's product-moment correlation. The first assumption for Pearson's product-moment correlation requires two variables measured on a continuous scale (Laerd, n.d.). Both the dependent variable of the survey score of situational awareness perception and the independent variable of the number of times the participant practiced imagery during the study are ratio variables. Both variables meet the conditions of a ratio variable, including the measurement of zero.

The second assumption for Pearson's product-moment correlation requires variables that are paired (Laerd, n.d.). The data for all eighty-five participants who completed the survey provided a situational awareness perception score and the number of times that imagery was practiced. The third assumption investigates that the variables have a linear relationship with no significant outliers (Laerd, n.d.). A scatterplot depicts if a linear relationship exists (Trochim, n.d.). Figure 5 displays the linear relationship between the two variables of SA perception score and imagery practice sessions.

The fourth assumption investigates the existence of outliers (Laerd, n.d.). A review of Figure 5 identified one outlier that scored two out of twelve and studied four times during the study. Laerd (n.d.) suggests procedures for testing with and without outliers. After running the Pearson's product-moment correlation with and without the outlier, the result suggested minimal difference. The outlier was not modified or removed from the results and remained part of the data. The last assumption determines if the data has been normally distributed (Laerd, n.d.). The sample size for this study represents a large group and will require using the Kolmogorov-Smirnov test for normality. Data

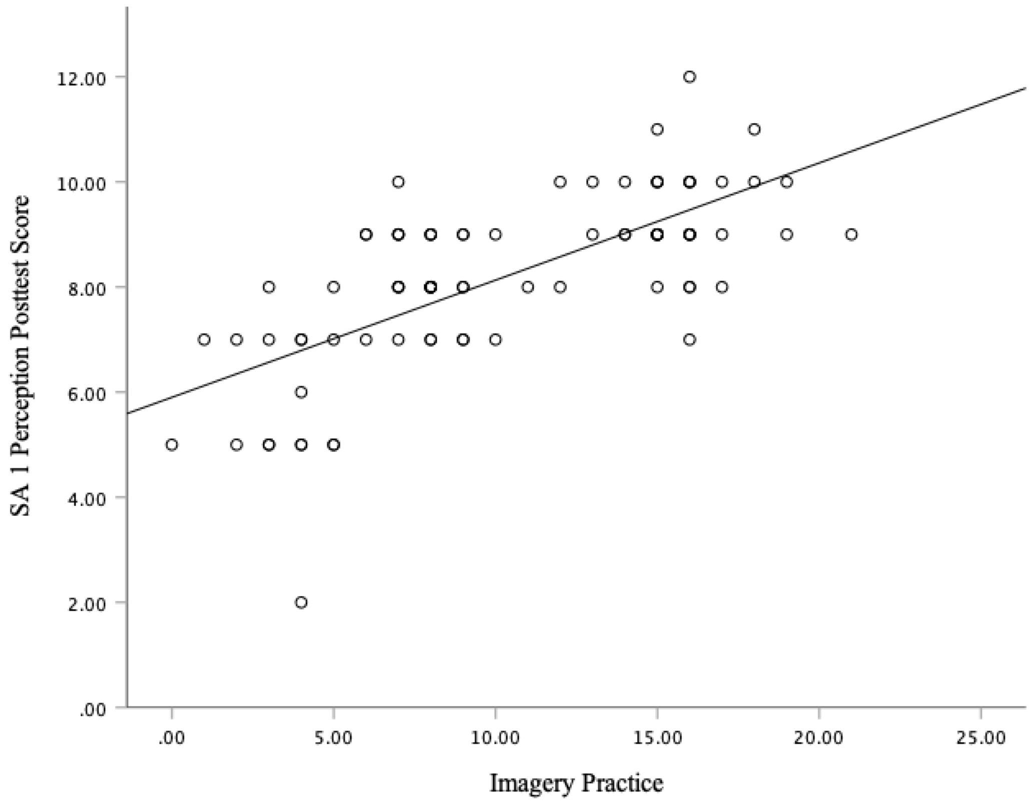


Figure 5. Linear Relationship Between SA Perception Score and Imagery Practice

depicted in table 9 provides information regarding normality. Not all variables from the dataset were normally distributed when assessed using the Kolmogorov-Smirnov

Table 9 *Test for Normality SA Perception*

Variable	Kolmogorov-Smirnov test		
	Statistic	*df*	*p*
SA Perception Survey Score	.180	85	< .05
Imagery Practice Sessions	.161	85	<.05

test ($p < .05$). This result, however, may not reflect the actual distribution of the data. Laerd (n.d.) states that large sample sizes of above 50 cases may be normally distributed even though the results of the Kolmogorov-Smirnov Test reveal non-normal distribution results. Field (2018) explains that the central limit theorem assumes a normal distribution with a sample size of at least 30. As the sampling size increases, the sample distribution continues to move toward a normal distribution and eventually becomes normally distributed (Field, 2018). The participant sample size meets the definition of a large sample, as 85 imagery practice participants completed the survey.

RO2 Results of Correlation Test

With all assumptions addressed, running a Pearson's product-moment correlation was appropriate. The descriptive statistics and Pearson's product-moment correlation define the results. The sample of 85 imagery practice participants had a mean posttest survey score for SA perception of 8.19 and a standard deviation of 1.67. The imagery practice participants had a mean of 10.26 practice sessions with a standard deviation of 5.19. Guilford's interpretation guidelines determine the magnitude of the correlation between variables (Field, 2018). Table 10 represents Guildford's Rule of Thumb interpretation guidelines.

Table 10 *Guildford's Rule of Thumb*

$\lvert r \rvert$ Value	Strength of the relationship
< 0.20	A very weak correlation
0.20–0.40	A weak correlation
0.40–0.70	A moderate correlation
0.70–0.90	High correlation
0.90–1.00	A very high correlation

Note. Adapted from "Guildford's Rule of Thumb," by J. P. Guildford, 1973. *Fundamental Statistics in Psychology and Education* (5th ed.). Copyright McGraw-Hill.

The correlation coefficient indicates a moderate positive correlation between situational awareness perception and the number of imagery practices sessions completed by airline pilots, $r = .69$, $n = 85$, $p < .05$. The results of the Pearson's product-moment correlation test in table 11 represent the relationship between situational awareness perception and imagery practice sessions.

Table 11 *Correlation Table for SA Perception*

Variable	Statistic	Perception posttest score
Practice Sessions	Pearson's Correlation	.692**
	p	< .001
	N	85

** Correlation is significant at the 0.01 level (2-tailed).

Research Objective 3

Determine the relationship between imagery practice and airline pilot situational comprehension.

Research Objective 3 determined if imagery practice and situational awareness comprehension have a relationship. Situational awareness comprehension measured nine questions throughout the survey queries. The comprehension query scores range from a possible score of zero to nine.

RO3 Pearson's Product-moment Correlation Assumptions

Research Objective 3 addressed all five assumptions. Situational awareness comprehension and imagery practice sessions are ratio data. Both variables are paired

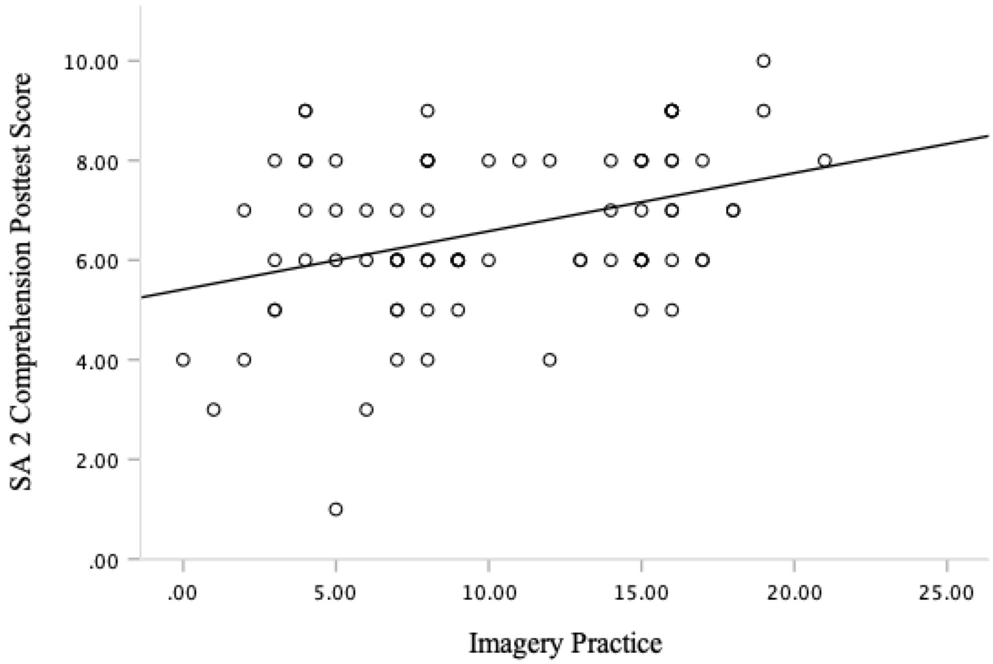


Figure 6. Linear Relationship Between SA Comprehension Score and Imagery Practice

with 85 participants. The scatterplot in figure 6 denotes a linear relationship. Looking at the data in figure 6 exposes one outlier. After running the Pearson's product-moment correlation with and without the outlier, there was a minor difference. The outlier was included in the correlation results. Table 12 represents the Kolmogorov-Smirnov test for normality.

Table 12 *Test for Normality SA Comprehension*

Variable	Kolmogorov-Smirnov test		
	Statistic	*df*	*p*
SA Comprehension Survey Score	.166	85	< .05
Imagery Practice Sessions	.161	85	<.05

Not all variables from the dataset for Research Objective Three were normally distributed when assessed using the Kolmogorov-Smirnov Test ($p < .05$). Similar to Research Objective 2, the decision remains to continue with a Pearson's product-moment correlation statistical test rests on a large population group that supports the central limit theorem.

RO3 Results of Correlation Test

The data results of Pearson's product-moment correlation test in table 13 represent the relationship between situational awareness comprehension and imagery practice sessions. With a sample size of 85, the mean posttest survey score for situational awareness comprehension was 6.61, with a standard deviation of 1.634. The mean for imagery practice sessions was 10.26, with a standard deviation of 5.19. Guildford's rule of thumb was used to determine the relative strength of the relationship. The correlation coefficient indicates a weak positive correlation between situational awareness comprehension and the number of imagery practice sessions completed by airline pilots, $r = .37$, $n = 85$, $p < .05$. Table 13 depicts the results from Pearson's product-moment correlation test.

Table 13 *Correlation Table for SA Comprehension*

Variable	Statistic	Comprehension posttest score
Practice Sessions	Pearson's Correlation	.371**
	p	< .001
	N	85

** Correlation is significant at the 0.01 level (2-tailed).

Research Objective 4

Determine the relationship between imagery practice and airline pilot situational projection.

Research Objective 4 determined if imagery practice and situational awareness projection have a relationship. Situational awareness comprehension measured nine questions throughout the survey queries. The projection query scores range from a possible score of zero to nine.

RO4 Pearson's Product-moment Correlation Assumptions

Research Objective 4 addressed all five assumptions. Situational awareness projection and imagery practice sessions are ratio data. Both variables are paired with 85 participants. The scatterplot in figure 7 denotes a linear relationship. The scatter plot

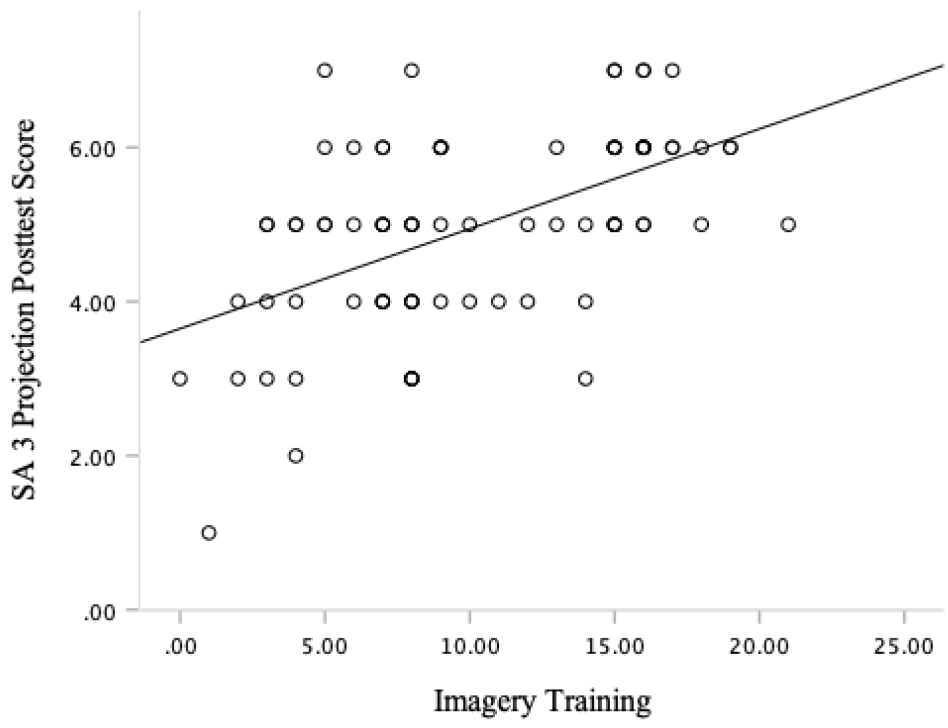


Figure 7. Linear Relationship Between SA Projection Score and Imagery Practice

denoted a broader data pattern compared to Research Objective 2. No identifiable outliers exist after reviewing figure 7.

The imagery practice participants represent a large group. Table 14 represents the Kolmogorov-Smirnov test for normality. Not all variables from the dataset for Research

Table 14 *Test for Normality SA Projection*

Variable	Kolmogorov-Smirnov test		
	Statistic	*df*	*p*
SA Projection Survey Score	.198	85	< .05
Imagery Practice Sessions	.161	85	<.05

Objective 4 were normally distributed when assessed using the Kolmogorov-Smirnov test ($p < .05$). Considering the central limit theorem for a large sample, Pearson's product-moment correlation test assumptions are met.

RO4 Results of Correlation Test

The data results of Pearson's product-moment correlation test in table 15 represent the relationship between situational awareness projection and imagery practice sessions. With a sample size of 85, the mean posttest survey score for situational awareness projection was 4.99, with a standard deviation of 1.24. The mean for imagery practice

Table 15 *Correlation Table for SA Projection*

Variable	Statistic	Projection posttest score
Practice Sessions	Pearson's Correlation	.533**
	p	< .001
	N	85

** Correlation is significant at the 0.01 level (2-tailed).

sessions was 10.26, with a standard deviation of 5.19. Guildford's rule of thumb was used to determine the relative strength of the relationship. The correlation coefficient indicates Correlation Table for SA Projection and Imagery Practice a moderate positive correlation between situational awareness comprehension and the number of imagery practice sessions completed by airline pilots, $r = .53$, $n = 85$, $p < .05$. Table 15 displays the results from Pearson's *product-moment correlation* test.

Research Objective 5

Compare the difference in situational awareness for the airline pilots with imagery practice and those without imagery practice

Research objective 5 compares the means of SA in airline pilots with imagery practice and those without imagery practice. In an experimental design with random selection, Fink (2003) describes a *t*-test as a data analysis that tests the hypothesis of the means. In order to run a valid t-test, assumptions must be met.

RO5 Assumptions for t-test

Independent-sample *t*-test requires six assumptions (Laerd, n.d.). The first assumption for *the t*-test requires one continuous dependent variable (Laerd, n.d.). The continuous dependent variable includes the total posttest score, which has a cumulative result of situational awareness perception, comprehension, and projection scores.

The second assumption for an independent-sample *t*-test requires one independent variable of two categorical groups (Laerd, n.d.). The independent variable includes participation groups. The two participation groups are the airline pilot group with imagery practice and without imagery practice.

The third assumption for an independent-sample *t*-test requires independent observations (Laerd, n.d.). The two groups of airline pilots were randomly assigned to the two groups, with no overlap. The random assignment assures no relationship between the two groups.

The fourth assumption, the independent-sample *t*-test, investigates for outliers within the data (Laerd, n.d.). Figure 8 displays boxplots for the two study groups' survey scores. Although the group without imagery practice has one outlier and the group with imagery practice has two outliers, the data was included in the test due to the large sample size that did not affect the test significantly. The large sample size did not bias the sum of the squares, leaving the outliers in place.

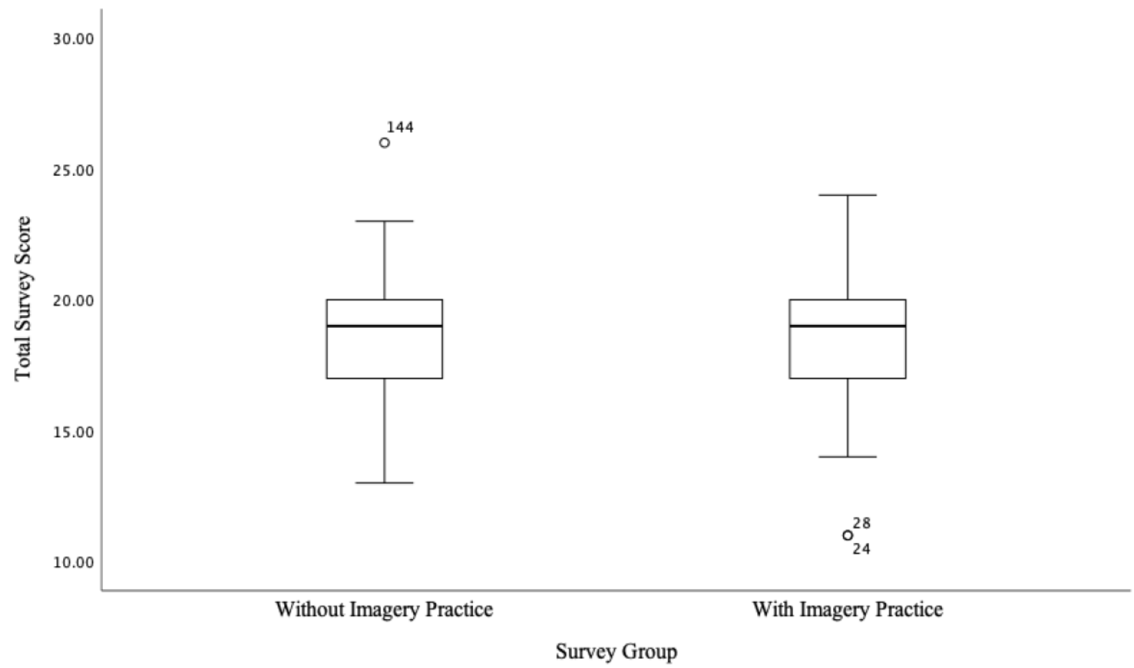


Figure 8. Boxplot Display for Total Survey Scores and Survey Groups

The fifth assumption for the independent-sample t-test determines if the data violates normality. Laerd (n.d.) recommends using normal Q-Q plots to determine normality. Figure 9 displays the normal Q-Q plot for the participant scores without imagery practice. Survey total scores for participants without imagery practice were normally distributed.

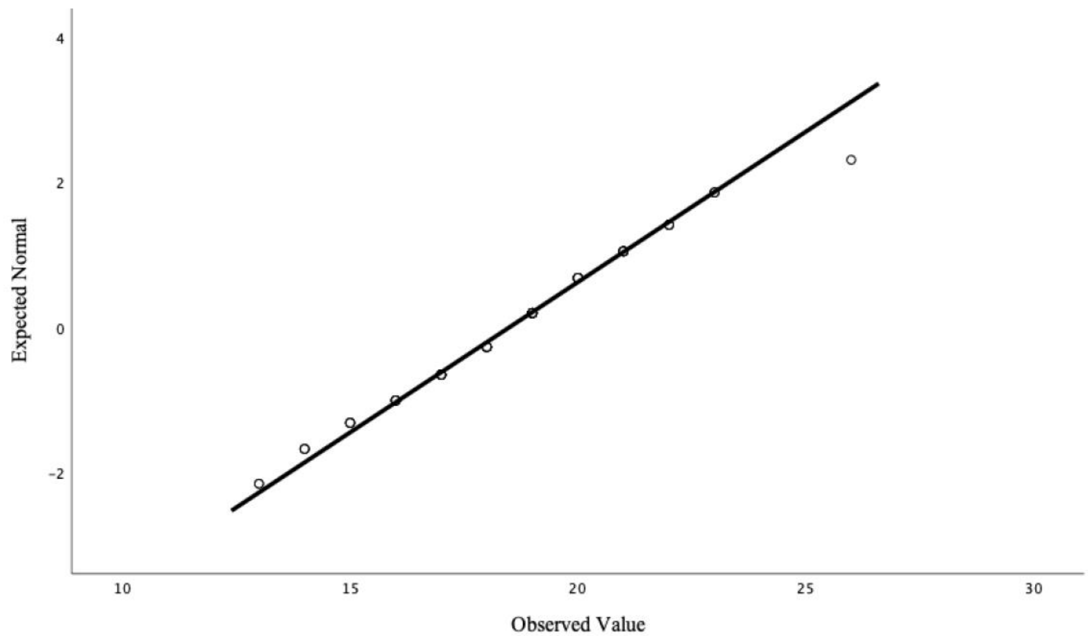


Figure 9. Normal Q-Q Plot for Participant Scores Without Imagery Practice

Figure 10 displays normal Q-Q plot for participant scores with imagery practice. Survey total scores for participants without imagery practice were normally distributed.

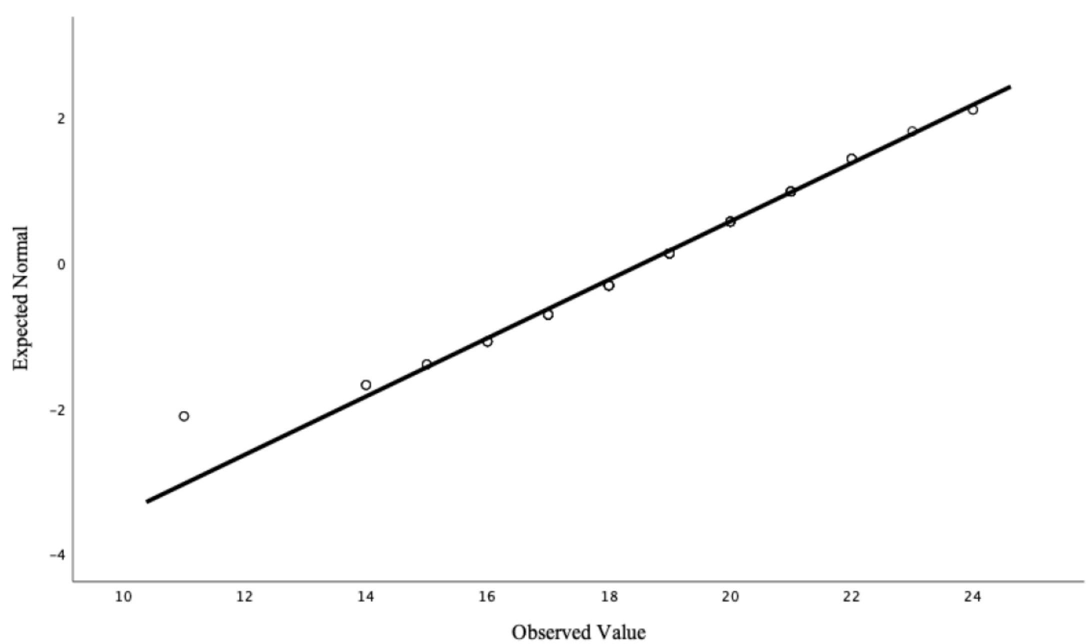


Figure 10. Normal Q-Q Plot for Participant Scores With Imagery Practice

The final Assumption determines the homogeneity of variances. The two groups have unequal participants due to dropouts. There were 85 imagery practice participants and 94 non-imagery practice participants. The imagery practice participants score (*M* = 18.58, *SD* = 2.49) was higher than non-imagery practice participants (*M* = 18.49, *SD* = 2.42). Levene's test of equality of variances determines if the variances are different in the population (Laerd, n.d.). Table 16 provides the results of Levene's test. There was a homogeneity of variances for survey scores for participants with imagery practice and without imagery practice (p = .884).

Table 16 *Levene's Test of Equal Variances*

Test	F	*p*	*t*	df	Significance (2-tail)
Assumption of Equal Variances	.021	.884	.237	177	.813

There were 85 imagery training and 94 non-imagery training participants. An independent-samples *t*-test was run to determine if there was a difference in situational awareness between imagery training and non-imagery training participants. There were few outliers in the data as assessed by inspection of a boxplot. Survey scores for both groups were normally distributed, as assessed by the Q-Q plots, and there was homogeneity of variances, as assessed by Levene's test for equality variances (p = .884). The imagery training participants had a higher situational awareness score (*M* = 18.58, *SD* = 2.49) than non-imagery training participants (*M* = 18.49, *SD* = 2.42), a non-statistically difference, *M* = 0.09, 95% CI [-0.64 to 0.81], $t(177)$ = .237, p = .813, d = .36. Cohen's *d* measures effect size (Field, 2018). *The* Cohen's *d* effect size of .36 indicates a small to medium effect size.

Summary

The results of this study provide information to answer the research questions. Does the practice of imagery improve airline pilot situational awareness? Do airline pilots who receive imagery training and practice improve situational awareness perception, comprehension, or projection? The study reached out to 4,040 airline pilots, with 214 who agreed to participate and 179 that completed the study.

The results followed descriptive statistics using frequency distribution, Pearson's product-moment correlation, and an independent-samples t-Test to analyze participants' responses. Frequency distribution investigated years of experience, age, type of flying experience, and hours of flight experience for Research Objective 1. For Research objectives 2, 3, and 4, Pearson's product-moment correlation determined the relationship between imagery practice and levels of situational awareness perception, comprehension, and projection. The result displayed a moderate positive relationship for situational awareness perception and projection and a weak positive relationship for situational awareness comprehension. For Research Objective 5, an independent-samples t-Test determined a small but insignificant difference in performance between the imagery training group and the non-imagery training group. Chapter 5 will discuss this study's findings, conclusions, recommendations, and implications.

CHAPTER V – CONCLUSION

This study focused on airline pilot situational awareness improvement utilizing imagery practice. Researchers found pilot error attributable to over 70 percent of airline accidents (Federal Aviation Administration Human Factors, n.d.). Airline pilots rely on CRM behaviors to look for threats to mitigate and identify errors (Helmreich, Klinect, & Wilhelm, 1999). Current airline training programs do not incorporate imagery practice into training programs (Federal Aviation Administration, 2017a). Chapter I of this study provides the background information for the study. Chapter II investigates the literature on aviation and imagery that support this study. Chapter III explaines the methodology for conducting an experimental study for situational awareness using imagery practice. Chapter IV provides the results of the study. Chapter V presents the findings, conclusion, recommendations with implications, limitations, and recommendations for further research.

Research Findings, Conclusions, and Recommendations

Research findings provided an interpretation of the information discovered from the study. Conclusions surmise the connections between the research to the findings. Recommendations provide valuable information for the aviation industry and further aviation research using the results.

Finding 1 –Imagery improved situational awareness for airline pilots who practiced more frequently

The airline pilot participating in the imagery practice performed better on specific situational awareness indicators during a simulated flight. Each query for the three levels of situational awareness signaled performance improvement. The more an airline pilot practiced imagery, the better they scored on the survey. There was a positive relationship between the number of times an airline pilot practiced imagery and how well they performed on the situational awareness survey.

Airline pilot situational perception was identified at a moderate rate for airline pilots who practiced imagery. Airline pilots identified the airplane's current airspeed, altitude, heading, and configuration at a very high level. Airspeed, altitude, and heading are the three essential components of flight that a pilot uses for basic perception. Airplane attitude and air traffic control facility were moderately identified correctly. The majority of participants responded to the current wind direction, fuel load, and glide path inaccurately the majority of the time.

Airline pilot situational comprehension was identified at a low rate for airline pilots who practiced imagery training. Airline pilots specifically struggled to identify the current wind direction and speed, the current course compared to the plan, and whether the flight was within conformance of the clearance. Comprehending the areas the airline pilots demonstrated weakness requires confirmation of internal and external information to the airplane.

Airline pilot situational projection was identified as a moderate rate for airline pilots who practiced imagery. Airline pilots effectively identified obstacle clearance issues, traffic conflict, and runway projected touchdown location and runway turnoff. Areas that airline pilots struggled to project included forecasting the next waypoint, destination distance, and the direction of the conflicting traffic.

Conclusion

The performance improvement for airline pilots who practiced imagery is aligned with other performance-level individuals who practice imagery. Schuster (2011) demonstrated the benefits of imagery to performance-based activities such as music, medicine, and sports that have provided some of their participant's imagery training and practice. Both visual and kinesthetic imagery practice have prepared athletes to improve their performance (Callow et al., 2013). With imagery practice among airline pilots now studied for situational awareness performance improvement, aviation safety-related organizations should organize and lobby for imagery practice permanency.

Recommendations

Airline regulators should mandate imagery training with the tasks required for initial and recurrent airline training. Formal training supported by individual airlines can add to the airline pilot's ability to be situationally aware of the threats and errors made within the flight deck. Although this study utilized imagery with individual pilots, a sanctioned study with multiple airlines may find stronger methods for delivering the training and measuring the queries in the simulator. The military, universities, and flight schools can teach the skills required to imagine a flight so that pilots have the skillset before employment with the airlines.

Finding 2 –Airline pilots who practiced imagery improved overall situational awareness, but only slightly over those who did not receive training

The participants demonstrated a negligible amount of situational awareness improvement for those airline pilots who practiced imagery from those who did not practice. The participants who did not receive imagery training still performed well in similar areas to those who received the training. The slight difference in the overall performance for imagery practiced pilots occurred over a short 3-week period. Changing a habit from a 3-week study remains difficult since the influence of e-learning and imagery practice competes against years of previous experiences.

Airline pilot training using e-learning and practice occurred with most imagery practice participants practicing imagery multiple times. The commitment to practicing multiple times a week for three weeks allowed the researcher to determine if there was a relationship between imagery practice and improved SA. Three weeks may not have been enough time to develop those imagery skills to substantially change in individual skills.

This study did not ask participants whether they used visual or kinesthetic imagery during their imagery practice sessions. The findings do not provide the quality of imagery practice by not specifically asking what type of imagery practice was used. The findings only provide the number of times pilots practiced imagery.

Conclusion

Images created through one's 'mind's eye,' as described by Kosslyn (1994), can replace physically viewing an object. Airline pilots were asked to use their 'mind's eye' to visualize flights. Although performance using mental practice was found by Feltz and Landers (1983) not to be as good as actually performing using the actual situation, it was found to improve performance. Toth et al. (2020) stated that motor imagery does provide significant improvement. Neuper et al. (2005) found that EEG recordings demonstrated that training utilizing kinesthetic experiences were more effective than visual presentations. The imagery training and practice in this study did not provide enough performance improvement to demonstrate a substantial difference.

Recommendations

Since this study did not show significant improvement, the actual training that the industry can implement may need to be more robust regarding training and practice length. The imagery training and practice needs to provide airline pilots with specific scenario-based examples of well-performed visual and motor imagery practice. Before proposing imagery training and practice to the airlines, a follow-on study can assist in building an airline curriculum. A secondary study that measures the specific type of imagery training applied by including a group with visual imagery training only, a group with a combination of visual and motor imagery training, and a group with no imagery training can provide a higher level of detail to the data.

Finding 3 –More experienced airline pilots participated in this study in higher numbers compared to less experienced airline pilots

Airline pilot participants had high experience levels measured in years and age. The airline pilots who participated in the study had many years of experience, with most having decades of experience. The participants' flight hour experience level demonstrated that the airline pilots required a survey that interested all demographics.

There was a large number of airline pilots who reviewed the link for the study but ultimately did not sign up to participate. Since the years of experience and age demographic were grouped into a more experienced group, something may have influenced less experienced in years and younger pilots from signing up and participating. This particular airline has hired many airline pilots over the last five years. However, the participant demographics do not reflect significant participation in the younger group with less years of experience. In this study, only one pilot had 10 years of experience or less, and only 13 pilots were 39 years old or younger out of a total of 214 participants.

Conclusion

Participation in improving SA through imagery requires motivation. Cumming and Ramsey (2008) state that improved task performance requires purpose, motivation, and self-advocacy. A study regarding SA utilizing imagery may not appeal to all pilots. Some pilots may feel they already possess good SA skills and may not buy into the techniques of imagery practice. Van Tiem et al. (2012) identify determining the gap between desired performance and actual performance to change behavior. If airline pilots do not feel they possess this gap, they may not add imagery to their preparation. Endsley (2000) found that experienced pilots do preflight plan to anticipate what might happen during a flight which may reflect informal imagery for situational projection of what may happen. Tokumaru et al. (2003) found that pilots with higher levels of experience performed better with imagery practice compared to pilots with less experience.

Recommendations

Industry leaders may build lines of communication with airline advocacy groups, such as the Flight Safety Foundation, and regulators, such as the Federal Aviation Administration and National Transportation Safety Board, that include resources for imagery training techniques. Pilots with a positive experience with imagery practice can build a personal belief regarding training and imagery practice. Industry leaders should explain the benefits of imagery to pilots with less experience and younger pilots in order to build their confidence using imagery training and practice. The new imagery practice behavior should provide results to reduce pilot monitoring errors.

Implications

The research has opened the door to reevaluating the current generation of Crew Resource Management. The aviation industry has relied upon Threat and Error Management, the fifth generation of CRM, for decades (Helmreich, Klinect, & Wilhelm, 1999). There has been little change to the methodology to improve human factors to reduce human error, as the most current generation of CRM focuses on resilient behavior through cognitive psychology (Martin, 2019). This research may suggest that the avenue to investigate human performance improvement in the flight deck begins with reassessing how to improve situational awareness through imagery practice. The development of the seventh generation of CRM that modifies the TEM model whereby threats are identified as SA markers with the positive behaviors visualized prior to flight may provide a change model. This next generation of CRM can add to the sixth-generation CRM that focuses on cognitive psychology.

Research confirms that airline pilots' incorrect actions or inactions cause most accidents. Airline pilots must understand that the current airline training does not include imagery practice (Federal Aviation Administration, 2017a). Individual pilot errors continue to cause accidents and incidents (NTSB, 2010). Airline pilots are susceptible to errors that they may not have the tools to mitigate from their previous experiences or training.

Individual airline pilots handle the current state of pilot confusion from perception and comprehension through personal monitoring techniques (Flight Safety Foundation, 2014). A universal monitoring system recognizable by all airline pilots may reduce pilot errors that cause airplane accidents and incidents. The FAA uses advisory circulars to implement suggested training programs to improve aviation safety (Federal Aviation Administration, 2015c). A universal monitoring system implemented in an updated CRM advisory circular may provide a conduit for airline compliance.

Limitations

Challenges and limitations exist beyond the researcher's control (Roberts & Hyatt, 2019). Specifically, there are limitations in applying imagery to airline pilots. The focus of this study is the SA of the individual airline pilot. This study does not account for an individual's situational awareness gained from the input of others on the flight deck. Instead, it is limited to visible individual cognitive improvement from training. The narrow focus of the individual eliminates the interaction between airline pilots that can attribute to individual SA.

This study did not collect EEG measurement data. The connection of neuroscience data to social science data collection did not occur. Studies that include neuroscience data provide definitive brain patterns that can establish specific reactions individual SA queries may not measure. Establishing specific brain patterns for effective and ineffective SA markers during imagery may establish baseline data for building an airline pilot SA database for designing training programs.

Since this study used only airplane transport-rated pilots, the results may not apply to other categories of pilots. Pilots who fly general aviation, fighter pilots, or commercial license functions like agricultural, banner towing, and skydiver flights may not experience the same functions of SA due to training differences and airplane pilot requirements, such as single pilot operations.

Recommendations for Future Research

The researcher suggests recommendations for future research to continue growing the knowledge of situational awareness. This research can benefit from a study that utilizes a higher fidelity information delivery system. Since each participant utilized a laptop or notebook computer, there is a loss of fidelity control for the information. Controlling the delivery may produce better results. An example may be to conduct the same study utilizing airplane simulation.

The second recommendation suggests using a smaller group of airline pilots with repeated measures when researching imagery training effects on situational awareness. The original developer of the SAGAT methodology used a small group of ten pilots for a study that sampled each query approximately ten to twenty times (Endsley, 2021). By using a smaller group of pilots, but sampling the queries more often, there would be less risk of dropouts.

The third recommendation relates to the first two recommendations by suggesting a mixed-methods research study that samples information regarding how the airline pilot feels about the use of imagery practice. Many airline pilots commented after the study regarding qualitative information related to the study. The qualitative information may have assisted in understanding the qualitative data collected regarding situational awareness.

The last recommendation is to investigate a similar study involving less experienced airline pilots using imagery to improve situational awareness. Since this study found a lack of participation by less experienced pilots, a study regarding the less experienced demographic may produce interesting results. The results may provide insight into why there was a lack of participation by less experienced pilots in this study.

Discussion

Human capital development supports individual development and performance improvement (Swanson & Holton, 2009). This study investigated improving airline pilot situational awareness performance. Specifically, this study conducted an experimental study designed to examine how imagery practice influences perception, comprehension, and projection, Endsley's (1995) three levels of situational awareness. The theoretical definition of how the implementation of imagery to situational awareness affects airplane safety requires a discussion of those theories with the study's findings.

The study gathered quantitative data to determine if the Cognitive Load theory of airline pilots making situational awareness errors causal to aircraft accidents can be improved. Kirschner et al. (2018) explain cognitive load as how humans process and gain knowledge and understanding. Aviation industry experts found that lower cognitive loads positively influence SA (Congressional Research Service, 2019).

The cognitive load on an airline pilot's mind determines how well they can maintain SA. Pike (2015) studied how the mind can recall thirty-second sound bites or seven pieces of information. Endsley (2021) designed the SAGAT methodology as an instrument that collects data with a freezing technique to gather data within the working memory.

This study used the SAGAT methodology with three specific freezes that occurred on departure, cruise, and arrival for a simulated flight. SA perception, comprehension, and projection queries were sampled in the three phases of flight. The study's findings answered the research question *Do airline pilots who receive imagery training and practice improve situational awareness perception, comprehension, or projection?* The key findings from the study align with the literature that those who utilize imagery practice see a performance improvement. The research used the queries of SA perception, comprehension, and projection to determine the relationship between SA from information that existed (perception), information that exists (comprehension), and information forecasted in the future (projection). In all three cases, there was a positive relationship, according to the data. The relationship was stronger for perception and projection. The relationship was weaker for comprehension.

This study did not conclusively answer the question: *Does the practice of imagery improve airline pilot situational awareness?* There was no significant result to report that the practice of imagery training provided substantial results. Although the data did not provide a definitive result, it did provide a positive indication of imagery practice. See Table 17 for a summary of the results. Improvement to SA can impact pilot monitoring errors. Utilizing imagery to improve SA requires practice. The data from this study does provide information for regulators and airlines to consider building training programs that include imagery practice. Endsley (2021) mentioned that cumulative scores of SA queries might not provide positive results as the sensitivity of the measurement is reduced significantly. The combined information may not be as diagnostic (Endsley, 2021).

Table 17 *Summary of Findings*

Research Objective Goal	Finding
Demographic of pilot experience:	
Years of experience	Majority over 25 years
Age	Only 7.3% 39 or younger
Previous flight experience	Majority combination civilian and military
Flight hours	Spread mostly from 4,000 to 20,000 flight hours
Correlation between:	
Imagery practice and situational perception	Moderate positive correlation
Imagery practice and situational comprehension	Weak positive correlation
Imagery practice and situational projection	Moderate positive correlation
Relationship between:	
Imagery practice and situational awareness improvement	No statistical significance but some improvement

Summary of the Study

With airline accident investigations consistently finding pilot error as the primary cause, it is imperative to determine where the error occurs and how to reduce errors. The NTSB (2010) report, and other previous accidents (NTSB, 1979, 1994), demonstrate a relationship between loss of situational awareness in monitoring and human error continues to be the primary causal factors.

Other industries utilize individual performance improvement utilizing imagery practice (Fazel et al., 2018). Previous studies utilizing imagery training improved individual performance in music, education, and athletes (Schuster et al., 2011). A specific study with paraglider participants determined that self-talk, a form of imagery practice, improved landing accuracy results (Hadi, 2019). Another study utilizing EEG found that pilots with higher experience levels had more vivid imagery levels than those with less experience (Tokumaru et al., 2003).

Performance improvement, which includes organizational, team, process, and individual performance improvement, is a cornerstone of human capital development (Swanson & Holton, 2009). Imagery practice provides individual performance improvement of situational awareness. The personal improvement of an individual that organizational leadership support with a researched training and practice process supports the three legs of economic, system, and psychological theories of human capital development (Swanson & Holton, 2009). This study demonstrated the connection to individual situational awareness performance improvement through imagery practice using an imagery training process, which may improve team decision-making performance.

With the basis of current literature, this study investigated if imagery practice improves airline pilot SA. The study utilized Holmes and Colton's (2001) PETTLEP imagery intervention program to develop e-learning for the participants who would receive imagery training and then practice imagining a flight plan for three weeks. Endsley's (1995) SAGAT methodology queries airline pilots' perception, comprehension, and projection of situational awareness.

The research question asked, *Do airline pilots who receive imagery training and practice improve situational awareness perception, comprehension, or projection?* The study randomly selected participants into two groups and measured the progress of those airline pilots who practiced imagery. The findings demonstrated a positive relationship for pilots who practiced imagery to improve perception and projection moderately and comprehension at a lower level. The results of this study align with previous research in imagery practice, such as performance athletes (Fazel et al., 2018). The results demonstrated a minor improvement to, but not a significant change to positively answer the research question, *Does the practice of imagery improve airline pilot situational awareness?* Further research can improve the methodology and control of a similar study directly impacting imagery practice on airline pilots in SA.

APPENDIX A – Permission to Use Figure 2

CCC | Marketplace™

This is a License Agreement between Brian Sajdak ("User") and Copyright Clearance Center, Inc. ("CCC") on behalf of the Rightsholder identified in the order details below. The license consists of the order details, the CCC Terms and Conditions below, and any Rightsholder Terms and Conditions which are included below.

All payments must be made in full to CCC in accordance with the CCC Terms and Conditions below.

Order Date	11-Mar-2022
Order License ID	1198711-1
ISBN-13	9780754618751
Type of Use	Republish in a thesis/dissertation
Publisher	ASHGATE PUBLISHING LTD
Portion	Chart/graph/table/figure

LICENSED CONTENT

Publication Title	A human error approach to aviation accident analysis : the human factors analysis and classification system
Author/Editor	Wiegmann, Douglas A., Shappell, Scott A.
Date	01/01/2003
Language	English
Country	United Kingdom of Great Britain and Northern Ireland
Rightsholder	Taylor & Francis Informa UK Ltd - Books
Publication Type	Book

APPENDIX B – Permission to Use Population Sample

N[redacted] MEC Chair <[redacted] Mon, Mar 14 at 11:15 AM

T[redacted]

C[redacted]Vice Chair,

L[redacted]Sec-Treas,

M[redacted]ion

Brian,

You are good to go. Let us know haw you want to proceed.

Captain[redacted]

MEC Chair

FDX Master Executive Council

Air Line Pilots Association, Int'l

Cel[redacted]

Brian Sajdak <u2wowy@ymail.com> Thu, Mar 10 at 3:27 PM

To: N[redacted]r, FDX MEC Chair

Hi Chris,

I appreciate you getting back to me. I am researching the effects of imagery on situational awareness in airline pilots. I would like to be able to ask for volunteers from our pilot group to participate in a study that would teach them some visualization (imagery) techniques and a control group that would not get the training. All of the training is online and there would be a pretest and posttest. All information is anonymous and does not have anything to do with the company. I am merely looking for a sample of airline pilots and would like to use our group as the sample population.

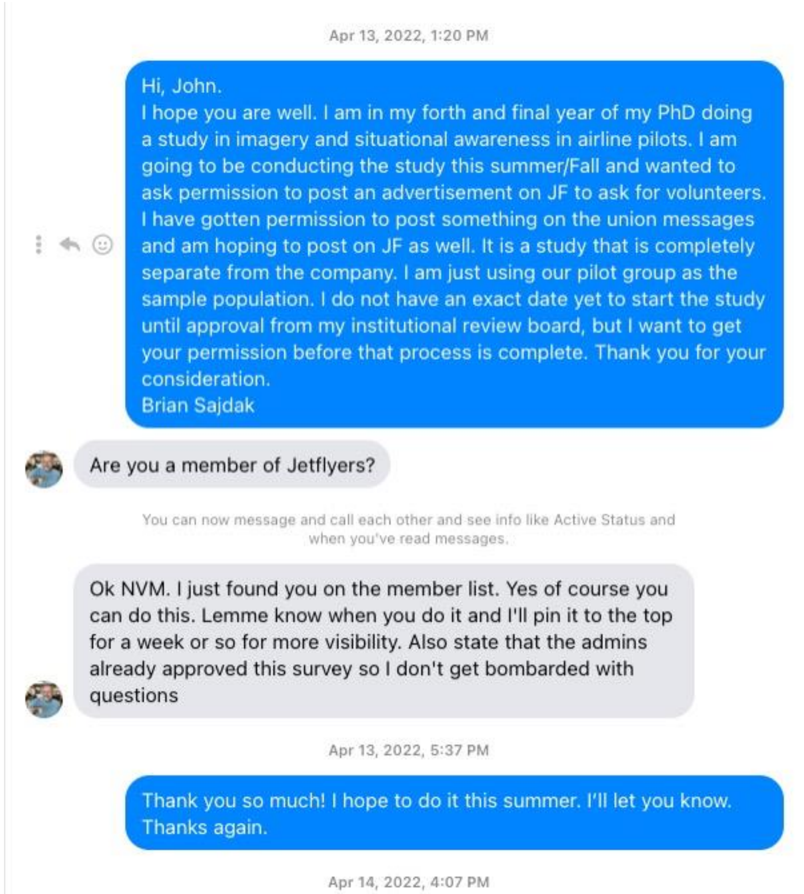
I have to follow all laws and regulations for proper use of data for confidentiality and anonymity through my university's Institutional Review Board. I know that we have used our pilot group in the past to disseminate information about a study to ask for volunteers for others who have completed a Ph.D. I am happy to answer any questions you may have and can definitely reach out to Nick as well.

Thanks again for contacting me.

Brian Sajdak

[redacted]

APPENDIX C – Permission to Advertise Participation on Facebook



Apr 13, 2022, 1:20 PM

Hi, John.
I hope you are well. I am in my forth and final year of my PhD doing a study in imagery and situational awareness in airline pilots. I am going to be conducting the study this summer/Fall and wanted to ask permission to post an advertisement on JF to ask for volunteers. I have gotten permission to post something on the union messages and am hoping to post on JF as well. It is a study that is completely separate from the company. I am just using our pilot group as the sample population. I do not have an exact date yet to start the study until approval from my institutional review board, but I want to get your permission before that process is complete. Thank you for your consideration.
Brian Sajdak

Are you a member of Jetflyers?

You can now message and call each other and see info like Active Status and when you've read messages.

Ok NVM. I just found you on the member list. Yes of course you can do this. Lemme know when you do it and I'll pin it to the top for a week or so for more visibility. Also state that the admins already approved this survey so I don't get bombarded with questions

Apr 13, 2022, 5:37 PM

Thank you so much! I hope to do it this summer. I'll let you know. Thanks again.

Apr 14, 2022, 4:07 PM

APPENDIX D – Facebook Invitation to participate Message 1

APPENDIX E – Email to Participate Message 1

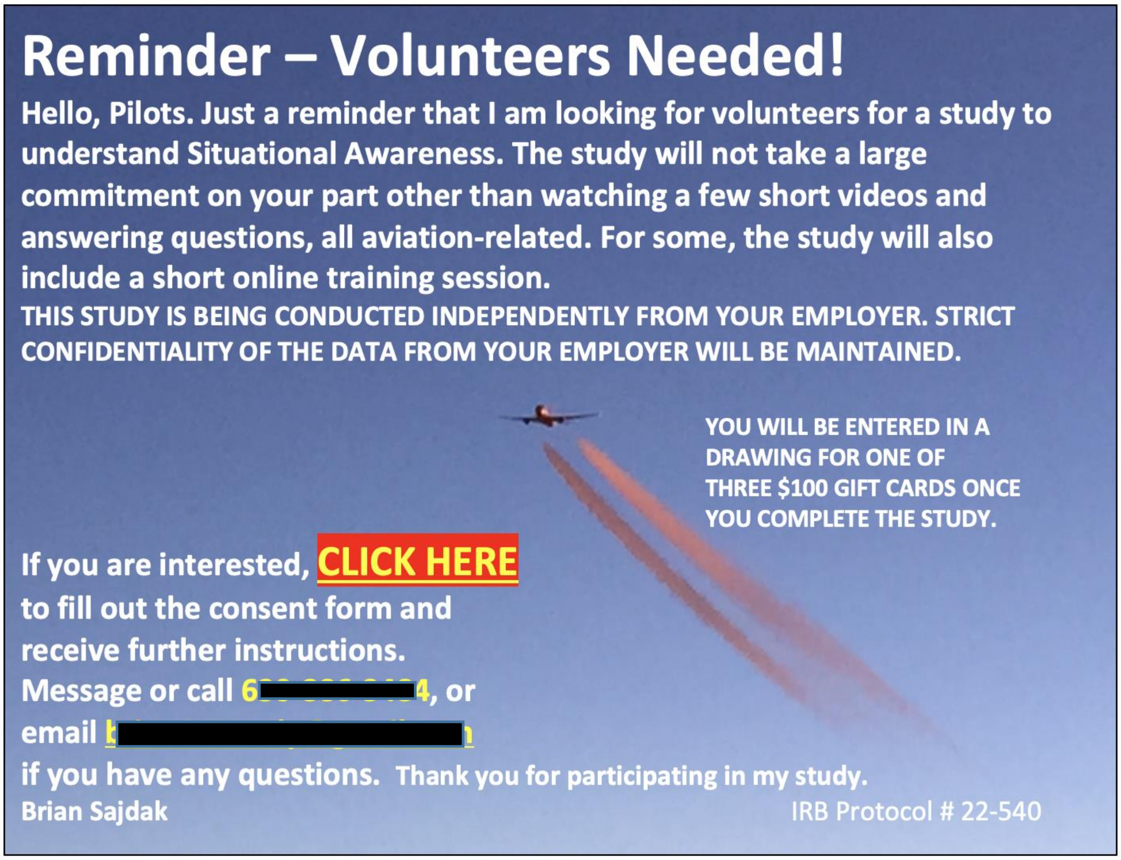
Hello, Pilots.
I am a fellow pilot and student at the University of Southern Mississippi. I am pursuing a doctoral degree in Human Capital Development. I am looking for volunteers for a situational awareness study. You can complete the study while you are on the road during a layover.

The study involves watching some videos and answering some questions. For some, the study will also include a short training LMS. The study will start in the next week and I am asking for your participation. Completing the study enters you in a drawing for a $500 Visa gift card.

If you are interested in participating in the study, **CLICK HERE**

Text, call, or email if you have any questions:
Brian Sajdak
6[redacted]4
b[redacted]n
IRB Protocol # 22-540

APPENDIX F – Facebook Invitation to Participate Message 2



APPENDIX G – Email Invitation to Participate Message 2

Hello Pilots,

Last Call to Participate in a study. I am looking for volunteers for a situational awareness study. You can complete the study while you are on the road during a layover.

The study involves watching some videos and answering some questions. For some, the study will also include a short training LMS. The study will start next week and I am asking for your participation. Completing the study enters you in a drawing for one a $500 Visa gift card.

Thank you for your consideration.

If you are interested in participating, **CLICK HERE**

Text, call, or email if you have any questions:
Brian Sajdak
[redacted]
[redacted]
IRB Protocol # 22-540

APPENDIX H – Consent Form

A Study of Situational Awareness

Thank you for volunteering to participate in this study. In order to begin, there are a few pieces of information that you need to know and then provide consent to participate in the study:

PROJECT INFORMATION

IRB: 22-540
Principal Investigator: Brian Sajdak
Phone: [redacted]
Email: [redacted]
University: The University of Southern Mississippi
College: Business and Economic Development
School: School of Leadership

RESEARCH DESCRIPTION

The purpose of this study is to determine the methods to improve situational awareness training for individual airline flight crew members. The study includes watching three short videos of a simulated flight and answering questions on a survey. There will be at least 360 volunteers for the study. Participation could take approximately 1-2 hours.

Your participation in this study may improve pilot monitoring which may benefit flight safety overall. The study participants who complete the study will be entered into a drawing to win a $500 Visa gift card. All study results will be made available to participants if requested.

There are no known risks associated with this study since the study is being conducted using video and online responses to questions. All personal information for the study will be kept strictly confidential. The researcher will only know all participants' names and email addresses for communications and drawing purposes. The personal data will be secured, per law, and destroyed as per 45 CFR 46.115b. The individual surveys will be retained for 3 years after publication.

Anyone who does not have access to a computer or tablet with internet access who would like to complete the study can contact the researcher at the contact information above to complete the study in the local Memphis, TN metropolitan area.

This project and this consent form have been reviewed by the Institutional Review Board (IRB: 22-540), ensuring that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5125, Hattiesburg, MS, 39406-0001, 601-266-5997.

Any questions about this research project should be directed to the Principal Investigator using the contact information provided above.

Eligibility: I am actively flying and am not out on medical or not in a status other than flying.
Yes ______
No ______

Please enter your **First** and **Last** name
____

Please enter your **Email Address**
____

Confirm your **Email Address**
____

<u>CONSENT TO PARTICIPATE</u>
I understand that participation in this project is completely voluntary, and I may withdraw at any time without penalty, prejudice, or loss of benefits. Unless described above, all personal information will be kept strictly confidential, including name and other identifying information. All procedures to be followed and their purposes were explained to me. Information was given about all benefits, risks, inconveniences, or discomforts that might be expected. Any new information that develops during the project will be provided to me if that information may affect my willingness to continue in the project.
CONSENT TO PARTICIPATE IN RESEARCH

By signing my name below, I give my consent to participate in this research project. Please close this page now if you do not wish to participate in this study.

Please sign here if you agree.

(Electronic Signature box provided)

Brian Sajdak · 4:21 PM

Dr. [redacted]

I forgot to ask. My Institutional Review Board will want me to document that I asked for your permission to use SAGAT in my research. Can I please have your permission to use SAGAT in my research, please?
Brian Sajdak

[redacted] 5:05 PM

Absolutely

APPENDIX J – Scoring Tolerances

Query	Data	Calculate	Scoring Tolerance Band
SA1			
5	Airplane Speed	Airspeed accuracy	+/- 10 knots
6	Airplane change of altitude	Rate of climb/level/descent	Categorical
7	Flight control settings	Flight control position accuracy	Categorical
8	Wind direction	Weather accuracy	Categorical
15	Airplane attitude	Attitude accuracy	+/- 3 degrees pitch +/- 10 degrees bank
16	Airplane Instrumentation	Altimeter setting	+/- .30 inches
17	Air traffic control	ATC organization accuracy	Categorical
18	Glide path	Accuracy to glidepath	Categorical
25	Airplane direction	Heading accuracy	+/- 10 degrees
26	Airplane altitude	Altitude accuracy	+/- 300 feet
27	Airplane fuel load	Fuel amount accuracy	+/- 1000 pounds
28	Nearest airport	Bearing and range	+/- 10 degrees and 30 miles
SA2			
9	Airplane heading	Heading accuracy	Categorical +/- 5 degrees
10	Clearance	Conformance to clearance	Categorical
11	Hazardous weather	Weather accuracy	Categorical
19	Airplane speed	Airspeed accuracy	Categorical +/- 10 knots
20	System degradation	System accuracy	Categorical
21	System degradation impact	System influence on flight	Categorical
29	Fuel state	Fuel accuracy	Categorical +/- 300 pounds
30	Airplane altitude	Altitude accuracy	Categorical +/- 300 feet
31	Configuration	Phase of Flight accuracy	Categorical
SA 3			
12	Obstacles	Flight path change required	Categorical
13	Distance to next waypoint	Location accuracy	Categorical +/- 5 degrees +/- 10 miles
14	Distance to destination	Location accuracy	Categorical +/- 5 degrees +/- 10 miles
22	Traffic conflict	Flight path projection	Categorical
23	Traffic conflict location	Flight path location	+/- 2 positions on a clock +/- 10 miles
24	Traffic conflict path	Flight path intersection	Categorical
32	Restricted airspace	Flight path change required	Categorical
33	Runway touchdown point	Touchdown accuracy	+/- 500 feet
34	Runway stopping point	Stopping accuracy	+/- 500 feet

APPENDIX K – Treatment Group Training Program

This course will familiarize pilots with imagery training to prepare for a flight. Many of you have spent time "chair flying" an event for a recurrent or initial training session. This training takes it a step further by using imagery training to prepare an individual for the entire flight.

- How to Use Imagery? - A Training Session for Pilots
- Imagery in Aviation
- 7 Steps to Visualizing a Flight
- How to Use the 7 Steps to Visualizing a Flight
- References

APPENDIX L – Permission to Use Training Video 1

APR 25

Brian Sajdak • 1:10 PM

Hello [redacted],
I am a doctoral candidate at the University of Southern Mississippi researching imagery. Your video Mental Imagery In Sports - a Complete Guide is outstanding. I would like to ask permission to use your youtube video as an introduction for my treatment group population.

[redacted] 1:11 PM

Hi Brian

Thanks for reaching out and for your kind words on the video.

Yes of course, by all means feel free to use!

Hope it can prove helpful for them.

APPENDIX M – Permission to Use Training Video 2

[redacted] Brian Sajdak

To: [redacted]

Mon 4/11/2022 2:15 PM

Hello Ms. Katlin Forster,

Thank you for discussing with me via text an avenue for gaining permission to use the videos found on YouTube that have the Blue Angels visualizing their flight. Here are the videos I would like permission to use:

https://www.youtube.com/watch?v=3ZNnaXj9SvY

https://www.youtube.com/watch?v=PFxszP-1tHI&t=3s

I am a doctoral candidate at the University of Southern Mississippi and the videos are going to be used for my study. Thank you for your consideration.

Best Regards,
Brian Sajdak

KF [redacted]

To: Brian Sajdak

Thu 4/14/2022 4:10 PM

Cc: [redacted]

Brian,

From our public affairs staff, also CCed above, I have been told both of the Youtube videos can be used for your research for your doctoral dissertation. The videos cannot be used commercially, create a perceived endorsement, or be used to make money; which I do not expect given the academic research goals you have.

Please let us know if you have any questions.

Cheers,
Katlin

[redacted]

APPENDIX N – Control Group Posttest Instructions

Thank you for agreeing to participate in the study. Here is a link to the video and survey:

[POSTTEST LINK CONTROL]

Once you have completed the survey your role in this study is complete. Remember, if you complete the survey, you will be eligible to win a $500 Visa gift card as a thank you for participating. If you have any questions, please feel free to contact me.

Brian Sajdak
[redacted]
IRB Protocol # 22-540

APPENDIX O – Posttest Control Group

1. Please indicate your total years of flying experience (in years as of today):

    Less than 5

    5-10

    11-15

    16-20

    21-25

    More than 25

2. Please indicate your age (in years as of today):

    Less than 29

    30-39

    40-49

    50-59

    60-64

3. Please indicate your flying experience:

    Military

    Civilian

    Combination military and civilian

4. Please estimate your total flight hours (within 1,000 hours)

    Less than 4,000

    4,000-9,000

    10,000-15,000

16,000-20,000

More than 20,000

Freeze 1

SA1

5. What is the indicated airspeed of your aircraft in knots?

(Sliding scale from 200 knots to 300 knots)

6. What is the current rate of climb/descent of your aircraft?

Climbing 1,000 fpm

Climbing 500 fpm

Level

Descending 500 fpm

Descending 1,000 fpm

7. What are your current settings?

Gear Up/Flaps Up/Slats Retracted/Speed Brake Retracted

Gear Up/Flaps Up/Slats Extended/Speed Brake Retracted

Gear Up/Flaps Extended /Slats Extended/Speed Brake Retracted

Gear Up/Flaps Retracted/Slats retracted/ Speed Brake Extended

Gear Down/ Flaps Extended/Slats Extended/Speed Brake Retracted

8. What are the current surface winds?

130 degrees at 4 knots

310 degrees at 4 knots

040 degrees at 8 knots

060 degrees at 8 knots

090 degrees at 6 knots

SA2

9. How does your current heading compare with your planned heading at this point?

More than 10 degrees left of course

More than 10 degrees right of course

Within 5 degrees of on course

More than 5 degrees right of course but less than 10 degrees

10 degrees right of course

10. Are you in conformance with your current clearance for this phase of flight?

Yes

No

11. Is there any hazardous weather along your route in this phase of flight? (You can select one or more answers)

No

Rain

Turbulence

Snow

Hail

Microbursts

Icing

Convective weather

Windshear

SA3

12. Is a change in path or altitude needed to avoid obstacles or terrain?

Yes

No

13. How far to your next waypoint?

10 degrees left and range 20 miles

10 degrees left and range 40 miles

5 degrees left and range 20 miles

On course and range 40 miles

On course and range 25 miles

5 degrees right and range 20 mile

10 degrees right and range 20 miles

14. How far to the destination airport along your planned route of flight?

20 miles

40 miles

60 miles

80 miles

100 miles

Freeze 2

SA1

15. What is the attitude of your aircraft?

Pitch 8 degrees above the horizon in a left bank

Pitch 3 degrees above the horizon wings level

Pitch 0 degrees in a right bank

Pitch 3 degrees below the horizon in a right bank

Pitch 8 degrees below the horizon wings level

16. What is your current altimeter setting (in inches Hg)?

28.99

29.53

29.92

30.54

31.56

17. What ATC organization are you currently in contact with?

Philadelphia Tower

New York Center

Philadelphia Approach

Philadelphia Ground

Washington Center

18. Are you on the proper glide path?

Yes

No

SA2

19. How does your current speed compare with your planned speed at this point?

Faster by 30 knots

Faster by 15 knots

On Speed

Slower by 15 knots

Slower by 30 knots

20. Are there any system degrades/problems affecting flight performance?

Yes

No

21. What is the impact of the system degrade/problem? (if yes to the previous question) Check all that apply.

No impact, mitigation efforts effective

Affecting comfort

Affecting flight safety

Affecting flight schedule

Affecting fuel economy

SA3

22. Is there any conflicting traffic on your current (projected) flight path?

Yes

No

23. Conflicting traffic is currently located at: __ o'clock at __ miles (if yes to 22)

3 o'clock and 5 miles

12 o'clock and 7 miles

2 o'clock and 10 miles

10 o'clock and 7 miles

24. Conflicting traffic is: (if yes to 22)

Crossing my path

Overtaking me

Climbing into me

Descending into me

I am overtaking it

I am climbing into it

I am descending into it

Freeze 3

SA1

25. What is the current heading of your aircraft?

322

292

202

272

342

26. What is the current altitude (MSL) of your aircraft in feet?

11,000 feet

10,000 feet

12,000 feet

9,000 feet

8,000 feet

27. How much fuel do you currently have?

13,700 lbs

13,200 lbs

11,900 lbs

15,200 lbs

15,900 lbs

28. What is the location of the nearest airport?

Philadelphia International

Lehigh Valley International

Newark Liberty International

Dulles International

Pittsburg International

SA2

29. How does your current fuel state compare with your planned fuel at this point?

Ahead by 500 lbs

Even with planned 11,900 on landing

Behind by 500 lbs

30. How does your current altitude compare with your planned altitude at this point?

Higher by 500 feet

Higher by 200 feet

Near or on plan

Lower by 200 feet

Lower by 500 feet

31. Are your instruments and aircraft configurations set up correctly for this phase of flight?

Yes

No

SA3

32. Is a change in path or altitude needed to avoid restricted use airspace?

Yes

No

33. Where on the runway do you think you will touch down?

At the threshold

500 feet from the approach end of the runway

1,000 feet from the approach end of the runway

1,500 feet from the approach end of the runway

2,000 feet from the approach end of the runway

2,500 feet from the approach end of the runway

3,000 feet from the approach end of the runway

3,500 feet from the approach end of the runway

34. Where on the runway do you think you will stop the aircraft?

5,321 feet to make taxiway Y

5,695 feet to make taxiway S7

6256 feet to make taxiway S6

7437 to make taxiway U

8129 to make taxiway S5

APPENDIX P – Control Group Reminder Email

Hello Study Participant,

Just a friendly reminder to please complete the Survey. Here is another link to get to the posttest

Link to Survey

Remember, once you complete the posttest you will be eligible to win a $500 Visa gift card in a drawing. The last day to complete your posttest is XX/XX/XXXX.

Brian Sajdak
Email: [redacted]
Phone: [redacted]
IRB Protocol # 22-540

APPENDIX Q – Treatment Group Training Link and Instructions

Thank you for agreeing to participate in the study. Here is a link to the imagery training:

IMAGERY TRAINING

Please follow the directions provided for the next steps in your participation. Again, thank you for your participation. Remember, at the completion of the 3 weeks of practice and completion of the Survey, you will be eligible to win a $500 Visa gift card as a thank you for participating. If you have any questions, please feel free to contact me.

Brian Sajdak
Email: [redacted]
Phone: [redacted]
IRB Protocol # 22-540

APPENDIX R – Treatment Group Imagery Practice Email 1

Hello Imagery Study Participant,

I hope that you enjoyed the imagery training. The expectation is to practice visualizing a flight from what you learned in the training. Visualize a flight as many times as you would like over the 3 week period. You can use previous flight plans for practice or use them on future flight plans. Please make a log of the number of flights you go on during the study and the number of times you practice imagery. Thank you.

Brian Sajdak
Email: [redacted]
Phone: [redacted]
IRB Protocol # 22-540

APPENDIX S – Treatment Group Imagery Practice Email 2

Thank you for your continued practice of imagery training. Did you know that imagery goes all the way back to the days of Aristotle? You are in good company when using imagery practice for your flights. Just a reminder, please continue to log the number of times you practiced visualizing a flight and the number of flights you go on. Thank you again for your participation during week 2.

Brian Sajdak
Email: [redacted]
Phone: [redacted]
IRB Protocol # 22-540

APPENDIX T – Treatment Group Imagery Practice Email 3

Thank you for your work so far in the study of imagery. We are in the home stretch. You will see an email with a link on [XX/XX/XXXX] to complete the study by watching a video and taking a Survey. Thanks again for participating and keep practicing and logging your number of flights and practice sessions.

Brian Sajdak
Email: [redacted]
Phone: [redacted]
IRB Protocol # 22-540

APPENDIX U – Treatment Posttest Link

Hello Pilot Participants,

Thank you for taking the time to be a part of the imagery study. Here is the link for the Survey.

POSTTEST

Once you have completed the posttest and it has been submitted, your name will be entered into a drawing for a $500 Visa gift card. You will be notified if you are a winner!

Brian Sajdak
Email: [redacted]
Phone: [redacted]
IRB Protocol # 22-540

APPENDIX V – Posttest Treatment Group

1. Please indicate your total years of flying experience (in years as of today):

Less than 5

5-10

11-15

16-20

21-25

More than 25

2. Please indicate your age (in years as of today):

Less than 29

30-39

40-49

50-59

60-64

3. Please indicate your flying experience:

Military

Civilian

Combination military and civilian

4. Please estimate your total flight hours (within 1,000 hours)

Less than 4,000

4,000-9,000

10,000-15,000

16,000-20,000

More than 20,000

Freeze 1

SA1

5. What is the indicated airspeed of your aircraft in knots?

(Sliding scale from 200 knots to 300 knots)

6. What is the current rate of climb/descent of your aircraft?

Climbing 1,000 fpm

Climbing 500 fpm

Level

Descending 500 fpm

Descending 1,000 fpm

7. What are your current settings?

Gear Up/Flaps Up/Slats Retracted/Speed Brake Retracted

Gear Up/Flaps Up/Slats Extended/Speed Brake Retracted

Gear Up/Flaps Extended /Slats Extended/Speed Brake Retracted

Gear Up/Flaps Retracted/Slats retracted/ Speed Brake Extended

Gear Down/ Flaps Extended/Slats Extended/Speed Brake Retracted

8. What are the current surface winds?

130 degrees at 4 knots

310 degrees at 4 knots

040 degrees at 8 knots

060 degrees at 8 knots

090 degrees at 6 knots

SA2

9. How does your current heading compare with your planned heading at this point?

More than 10 degrees left of course

More than 10 degrees right of course

Within 5 degrees of on course

More than 5 degrees right of course but less than 10 degrees

10 degrees right of course

10. Are you in conformance with your current clearance for this phase of flight?

Yes

No

11. Is there any hazardous weather along your route in this phase of flight? (You can select one or more answers)

No

Rain

Turbulence

Snow

Hail

Microbursts

Icing

Convective weather

Windshear

SA3

12. Is a change in path or altitude needed to avoid obstacles or terrain?

Yes

No

13. How far to your next waypoint?

10 degrees left and range 20 miles

10 degrees left and range 40 miles

5 degrees left and range 20 miles

On course and range 40 miles

On course and range 25 miles

5 degrees right and range 20 mile

10 degrees right and range 20 miles

14. How far to the destination airport along your planned route of flight?

20 miles

40 miles

60 miles

80 miles

100 miles

Freeze 2

SA1

15. What is the current heading of your aircraft?

322

292

202

272

342

16. What is the current altitude (MSL) of your aircraft in feet?

11,000 feet

10,000 feet

12,000 feet

9,000 feet

8,000 feet

17. How much fuel do you currently have?

13,700 lbs

13,200 lbs

11,900 lbs

15,200 lbs

15,900 lbs

18. What is the location of the nearest airport?

Philadelphia International

Lehigh Valley International

Newark Liberty International

Dulles International

Pittsburg International

SA2

19. How does your current speed compare with your planned speed at this point?

Faster by 30 knots

Faster by 15 knots

On Speed

Slower by 15 knots

Slower by 30 knots

20. Are there any system degrades/problems affecting flight performance?

Yes

No

21. What is the impact of the system degrade/problem? (if yes to the previous question) Check all that apply.

No impact, mitigation efforts effective

Affecting comfort

Affecting flight safety

Affecting flight schedule

Affecting fuel economy

SA3

22. Is there any conflicting traffic on your current (projected) flight path?

Yes

No

23. Conflicting traffic is currently located at: __ o’clock at __ miles (if yes to 22)

3 o'clock and 5 miles

12 o'clock and 7 miles

2 o'clock and 10 miles

10 o'clock and 7 miles

24. Conflicting traffic is: (if yes to 22)

Crossing my path

Overtaking me

Climbing into me

Descending into me

I am overtaking it

I am climbing into it

I am descending into it

Freeze 3

SA1

25. What is the attitude of your aircraft?

Pitch 8 degrees above the horizon in a left bank

Pitch 3 degrees above the horizon wings level

Pitch 0 degrees in a right bank

Pitch 3 degrees below the horizon in a right bank

Pitch 8 degrees below the horizon wings level

26. What is your current altimeter setting (in inches Hg)?

28.99

29.53

29.92

30.54

31.56

27 What ATC organization are you currently in contact with?

Philadelphia Tower

New York Center

Philadelphia Approach

Philadelphia Ground

Washington Center

28. Are you on the proper glide path?

Yes

No

SA2

29. How does your current fuel state compare with your planned fuel at this point?

Ahead by 500 lbs

Even with planned 11,900 on landing

Behind by 500 lbs

30. How does your current altitude compare with your planned altitude at this point?

Higher by 500 feet

Higher by 200 feet

Near or on plan

Lower by 200 feet

Lower by 500 feet

31. Are your instruments and aircraft configurations set up correctly for this phase of flight?

Yes

No

SA3

32. Is a change in path or altitude needed to avoid restricted use airspace?

Yes

No

33. Where on the runway do you think you will touch down?

At the threshold

500 feet from the approach end of the runway

1,000 feet from the approach end of the runway

1,500 feet from the approach end of the runway

2,000 feet from the approach end of the runway

2,500 feet from the approach end of the runway

3,000 feet from the approach end of the runway

3,500 feet from the approach end of the runway

34. Where on the runway do you think you will stop the aircraft?

5,321 feet to make taxiway Y

5,695 feet to make taxiway S7

6256 feet to make taxiway S6

7437 to make taxiway U

8129 to make taxiway S5

Data Questions for Treatment Group

35. How many flights did you go on once you completed the imagery training?

1

2

3

4

5

6

7

8

9

10 or more

36. How many times did you practice using the imagery technique?

1

2

3

4

5

6

7

8

9

10 or more

APPENDIX W – Posttest Reminder Email

Hello Study Participant,

Just a friendly reminder to please complete the Survey. Here is another link to get to the posttest

Link to Survey

Remember, once you complete the posttest you will be eligible to win a $500 Visa gift card in a drawing. The last day to complete your posttest is XX/XX/XXXX.

Brian Sajdak
Email: [redacted]
Phone: [redacted]
IRB Protocol # 22-540

APPENDIX X – Code Book

Item	Variable	Variable Label	Type	Scale	Scoring Value
1	Total Years Flying	Years_Flying	Numeric	Ordinal	5 < 5–10 11–15 16–20 21–25 25 >
2	Age	Age	Numeric	Ordinal	29 < 30–39 40–49 50–59 60–64
3	Flying Experience Type	Flying_Experience	Numeric	Nominal	Military Civilian Combination
4	Total Flight Hours	Flight_Hours	Numeric	Ordinal	4,000 < 4,000–9,000 10–15k

					16k–20k 20k >
5	Indicated Airspeed	SA1Indicated_Airspeed	Numeric	Nominal	Correct answer Incorrect answer
6	Current Rate of Climb	SA1Rate_of_Climb	Numeric	Nominal	Correct answer Incorrect answer
7	Flight Control Settings	SA1Flight_Controls	Numeric	Nominal	Correct answer Incorrect answer
8	Winds	SA1Winds	Numeric	Nominal	Correct answer Incorrect answer
9	Heading Comparison	SA2Head_Compare	Numeric	Nominal	Correct answer Incorrect answer

10	Clearance Conformance	SA2Clear_Conformance	Numeric	Nominal	Correct answer Incorrect answer
11	Hazardous Weather	SA2Haz_Weather	Numeric	Nominal	Correct answer Incorrect answer
12	Flight Path Obstacles	SA3Obstacles	Numeric	Nominal	Correct answer Incorrect answer
13	Distance Next Waypoint	SA3Next_Waypoint_Dist	Numeric	Nominal	Correct answer Incorrect answer
14	Distance to Destination	SA3Destination_Dist	Numeric	Nominal	Correct answer Incorrect answer
15	Current Heading	SA1Current_Heading	Numeric	Nominal	Correct answer

					Incorrect answer
16	Current Altitude	SA1Current_Altitude	Numeric	Nominal	Correct answer Incorrect answer
17	Current Fuel	SA1Current_Fuel	Numeric	Nominal	Correct answer Incorrect answer
18	Nearest Airport	SA1Nearest_Airport	Numeric	Nominal	Correct answer Incorrect answer
19	Current Speed vs Planned	SA2Speed_CurrentvPla nned	Numeric	Nominal	Correct answer Incorrect answer
20	System Degradation	SA2System_Degradati on	Numeric	Nominal	Correct answer Incorrect answer

21	Degradation Impact	SA2Degradation_Impact	Numeric	Nominal	Correct answer Incorrect answer
22	Traffic Conflict	SA3Traffic_Conflict	Numeric	Nominal	Correct answer Incorrect answer
23	Traffic Location	SA3Traffic_Location	Numeric	Nominal	Correct answer Incorrect answer
24	Traffic Path	SA3Traffic_Path	Numeric	Nominal	Correct answer Incorrect answer
25	Aircraft Attitude	SA1Aircraft_Attitude	Numeric	Nominal	Correct answer Incorrect answer
26	Altimeter Setting	SA1Altimeter_Setting	Numeric	Nominal	Correct answer

					Incorrect answer
27	ATC Organization	SA1ATC_Organization	Numeric	Nominal	Correct answer Incorrect answer
28	Glide Path	SA1Glide_Path	Numeric	Nominal	Correct answer Incorrect answer
29	Fuel State Comparison	SA2Fuel_State_Comparison	Numeric	Nominal	Correct answer Incorrect answer
30	Altitude Comparison	SA2Altitude_Comparison	Numeric	Nominal	Correct answer Incorrect answer
31	Configuration Comparison	SA2Configuration_Comparison	Numeric	Nominal	Correct answer Incorrect answer

32	Restricted Airspace	SA3Restricted_Airspace	Numeric	Nominal	Correct answer Incorrect answer
33	Runway Touchdown	SA3Runway_Touchdown	Numeric	Nominal	Correct answer Incorrect answer
34	Runway Stop	SA3Runway_Stop	Numeric	Nominal	Correct answer Incorrect answer
35	SA 1 Perception Posttest Score	SA1_Posttest_Score	Numeric	Interval	Sum Items: 5 + 6 + 7 + 8 + 15 + 16 +17 + 18 + 19 + 25 + 26 +27 + 28
36	SA 2 Comprehensio	SA2_Posttest_Score	Numeric	Interval	Sum Items: 9 +10 + 11 + 19 + 20 +

	n Posttest Score				21 + 29 + 30 + 31
37	SA 3 Projection Posttest Score	SA3_Posttest_Score	Numeric	Interval	Sum Items: 12 + 13 + 14 + 22 + 23 + 24 + 32 + 33 + 34
38	Total Cumulative Posttest score with imagery practice	Total_Posttest_Score_ with_imagery_practice	Numeric	Interval	Sum Items: 5 + 6 + 7 + 8 + 9 + 10 + 11 + 12 + 13 + 14 + 15 + 16 + 17 + 18 + 19 + 20 + 21 + 22 + 23 + 24 + 25 + 26 + 27 + 28 + 29 + 30 +

					31 + 32 + 33 + 34
39	Treatment Participant number of flights after training.	Number_of_Flights_Treatment_group	Numeric	Ratio	
40	Treatment Participant imagery practice events	Imagery_Practice	Numeric	Ratio	
41	Participant identification	Participant_ID_Number	Numeric	Interval	No Sum of items
42	Participant Email Address	Participant_Email	String	Nominal	
43	Participants Name	Participant_Name	String	Nominal	
44	Total Cumulative Posttest score	Total_Posttest_Score	Numeric	Interval	Sum Items: 5 + 6 + 7 + 8 + 9 + 10 + 11 + 12 + 13 + 14 + 15 + 16 + 17 + 18 + 19 + 20 +

					21 + 22 + 23 + 24 + 25 + 26 + 27 + 28 + 29 + 30 + 31 + 32 + 33 + 34

REFERENCES

A4A. (2021). *Data & Statistics: A4A passenger cost index (PACI).* Airlines for America. https://www.airlines.org/dataset/a4a-quarterly-passenger-airline-cost-index-u-s-passenger-airlines/

Adams, M. J., & Pew, R. W. (1990). *Situational awareness in the commercial aircraft cockpit: a cognitive perspective.* 9th IEEE/AIAA/NASA Conference on Digital Avionics Systems. https://doi.org/10.1109/dasc.1990.111342

Adrangi, B., Chow, G., & Raffie, K. (1997). Airline deregulation, safety, and profitability in the U.S. *Transportation Journal*, *36*(4), 44–52.

Alan, Y., & Lapré, M. A. (2018). Investigating operational predictors of future financial distress in the US airline industry. *Production and Operations Management*, 27(4), 734–755. Portico. https://doi.org/10.1111/poms.12829

American Psychology Association (n.d.) APA dictionary of psychology. Retrieved November 01, 2022, from https://dictionary.apa.org/criterion-validity

Arbuthnott, K. D., Arbuthnott, D. W., & Rossiter, L. (2001). Guided imagery and memory: Implications for psychotherapists. *Journal of Counseling Psychology*, *48*(2), 123–132. https://doi.org/10.1037/0022-0167.48.2.123

Aristotle (1961). *Book III. Aristotle: De Anima.* (W. D. Ross, Ed.). Oxford University Press. https://doi.org/10.1093/oseo/instance.00263607 (Original work published ca. 350 B.C.E)

Ausubel, D. P., & Fitzgerald, D. (1961). The role of discriminability in meaningful learning and retention. *Journal of Educational Psychology, 52*(5), 266–274. https://doi.org/10.1037/h0045701

Aviation Safety Network (2022). *Home: Statistics.* Aviation Safety Network https://aviation-safety.net/statistics/period/stats.php

Baltagi, B. H., Griffin, J. M., & Rich, D. P. (1995). Airline deregulation: The cost pieces of the puzzle. *International Economic Review*, *36*(1), 245–258. https://doi.org/10.2307/2527435

Banker, & Johnston, H. H. (1993). An empirical study of cost drivers in the U.S. airline industry. *The Accounting Review*, *68*(3), 576–601.

Barkin, T. I., Hertzell, O. S., & Young, S. J. (1995). Facing low-cost competitors: lessons from US airlines. *The McKinsey Quarterly*, *4*, 86–87. https://link.gale.com/apps/doc/A55427465/AONE?u=anon~db673bd0&sid=googleScholar&xid=4751fda4

Bilstein, R. E. (1969). Technology and commerce: Aviation in the conduct of American business, 1918–29. *Technology and Culture*, *10*(3), 392-411. https://doi.org/10.2307/3101689

Boeing (n.d.). *About Boeing commercial airplanes.* Boeing. https://www.boeing.com/company/about-bca/

Boeing History. (2021). *Model 307 Stratoliner*. Boeing History. http://www.boeing.com/history/products/model-307-stratoliner.page

Boeing Statistics. (2021). *Statistical summary of commercial jet airplane accidents worldwide operations 1959–2019.* Boeing Resources. http://www.boeing.com/resources/boeingdotcom/company/about_bca/pdf/statsum.pdf

Borochin, P. (2020). The information content of real operating performance measures from the airline industry. *Journal of Financial Markets*, 50, 1–22. https://doi.org/10.1016/j.finmar.2019.100528

Bourgeois-Bougrine, S., Carbon, P., Gounelle, C., Mollard, R., & Coblentz, A. (2003). Perceived fatigue for short and long-haul flights: a survey of 739 airline pilots. *Aviation, Space, and Environmental Medicine*, *74*(10), 1072–1077.

Bradley, J. K. (1994). *The history and development of aircraft instruments – 1909 to 1919.* [Doctoral Dissertation, Imperial College]. Digital Archive.

Britannica, T. (n.d.). *Gestalt psychology*. *Encyclopedia Britannica*. Retrieved September 20, 2022, from https://www.britannica.com/science/Gestalt-psychology

Brown, J. H. (2014). Jimmy Carter, Alfred Kahn, and Airline Deregulation: Anatomy of a Policy Success. *The Independent Review (Oakland, Calif.), 19*(1), 85–99

Brown, J. P. (2017). The effect of automation on human factors in aviation. *The Journal of Instrumentation, Automation and Systems*. 3(2), 31–46. https://doi.org/10.21535/jias.v3i2.916

Buckley, P. J., Pass, C. L., & Prescott, K. (1988). Measures in international competitiveness: a critical survey. *Journal of Marketing Management. 4*(2), 172–200. https://doi.org/10.1080/0267257X.1988.9964068

Bureau of Transportation Statistics (n.d.). *U.S. air carrier safety data.* U.S. Department of Transportation. https://www.bts.gov/content/us-air-carrier-safety-data

Button, K. (2015). A book, the application, and the outcomes: How right was alfred kahn in the economics of regulation about the effects of the deregulation of the US domestic airline market?. *History of Political Economy*, 47 (1), 1–39. https://doi.org/10.1215/00182702-2847303

Calculator.net. (n.d.). *Sample Size Calculator*. https://www.calculator.net/sample-size-calculator.html?type=1&cl=95&ci=5&pp=50&ps=450&x=50&y=23

Callow, N., Roberts, R., Hardy, L., Jiang, D., & Edwards, M. G. (2013). Performance improvements from imagery: evidence that internal visual imagery is superior to external visual imagery for slalom performance. *Frontiers in Human Neuroscience*, 7, 1–10. https://doi.org/10.3389/fnhum.2013.00697

Calmels, C., Holmes, P. S., Berthoumieux, C., & Singer, R. N. (2004). The development of movement imagery vividness through a structured intervention in softball. *Journal of Sport Behavior*, *27*(4), 307–322

Cannon, H.W. (1978). *Airline deregulation act*. U.S. Senate. https://www.congress.gov/bill/95th-congress/senate-bill/2493

Casner, S. M., Geven, R. W., & Williams, K. T. (2012). The effectiveness of airline pilot training for abnormal events. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *55*(3), 477–485. https://doi.org/10.1177/0018720812466893

Casner, S. M., & Schooler, J. W. (2013). Thoughts in flight. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *56*(3), 433–442. https://doi.org/10.1177/0018720813501550

Chang, Y. H., & Yeh, C. H. (2004). A new airline safety index. *Transportation Research Part B: Methodological*, *38*(4), 369–383. https://doi.org/10.1016/S0191-2615(03)00047-X

Chen, M., Grinstein, G., Johnson, C. R., Kennedy, J., & Tory, M. (2017). Pathways for Theoretical Advances in Visualization. *IEEE Computer Graphics and Applications*, *37*(4), 103–112. www.https://doi.org/10.1109/mcg.2017.3271463

Chholak, P., Niso, G., Maksimenko, V. A., Kurkin, S. A., Frolov, N. S., Pitsik, E. N., … Pisarchik, A. N. (2019). Visual and kinesthetic modes affect motor imagery classification in untrained subjects. *Scientific Reports*, *9*(1), 1–12. www.https://doi.org/10.1038/s41598-019-46310-9

Cimini, M. H. (1990). Airline developments. *Monthly Labor Review: U.S. Bureau of Labor Statistics*, *113*(4), 43–44.

Cohen, T. N., Francis, S. E., Wiegmann, D. A., Shappell, S. A., & Gewertz, B. L. (2018). Using HFACS-Healthcare to identify systemic vulnerabilities during surgery. *American Journal of Medical Quality*, *33*(6), 614–622. https://doi.org/10.1177/1062860618764316

Congressional Research Service (2019). *Cockpit automation, flight systems complexity, and aircraft certification: Background and issues for congress.* Congressional Research Service. https://crsreports.congress.gov/search/#/?termsToSearch=Cockpit%20Automation,%20Flight%20Systems%20Complexity,%20and%20Aircraft%20Certification:%20Background%20and%20Issues%20for%20Congress&orderBy=Relevance

Cumming, J., & Ramsey, R. (2008). Imagery interventions in sport. In S. Mellalieu & S. Hanton (Eds.), *Advances in Applied Sport Psychology* (pp. 5–36). Routledge. https://doi.org/10.4324/9780203887073

DeCamp, W., & Herskovitz, K. (2015). The Theories of accident causation. In S. J. Davies, C. A. Hertig, & B. P. Gilbride, (Eds.), *Security Supervision and Management* (4th ed., pp. 71-78). Elsevier. https://doi.org/10.1016/b978-0-12-800113-4.00005-5

Dekker, S. W. A. (2015). The danger of losing situation awareness. *Cognition, Technology & Work*, *17*(2), 159–161. https://doi.org/10.1007/s10111-015-0320-8

Delta Air Lines. (2021). *What it takes to be a delta air lines pilot.* Delta News Hub. https://news.delta.com/what-it-takes-be-delta-air-lines-pilot

Di Corrado, D., Guarnera, M., Vitali, F., Quartiroli, A., & Coco, M. (2019). Imagery ability of elite level athletes from individual vs. team and contact vs. no-contact sports. *PeerJ.* 7, 1–14. https://doi.org/10.7717/peerj.6940

Dinler N., & Rankin, W. (2018). Assessment of the evolving low-cost business model for the future Importance of U.S. secondary airports. *International Journal of Aviation, Aeronautics, and Aerospace*, *5*(4), 1–35. https://doi.org/10.15394/ijaaa.2018.1267

Driskell, J. E., Copper, C., & Moran, A. (1994). Does mental practice enhance performance? *Journal of Applied Psychology*, *79*(4), 481–492. https://doi.org/10.1037/0021-9010.79.4.481

Endsley, M. R. (1990). *Situation awareness in dynamic human decision making: Theory and measurement* [Doctoral dissertation, University of Southern California]. University of Southern California digital library. https://digitallibrary.usc.edu/Archive/University-of-Southern-California-Dissertations-and-Theses-

2A3BF1O15Q2?Flat=1#/SearchResult&VBID=2A3BXZS0PTIC1&PN=1&WS=SearchResults

Endsley, M. R. (1995). Toward a theory of situational awareness in dynamic systems. *Human Factors Journal*, *37*(1), 32–64.

Endsley, M. R., & Robertson, M. M. (2000). Training for situation awareness. In M. R. Endsley & D. J. Garland (Eds.), *Situation Awareness Analysis and Measurement* (pp. 349–365). CRC Press. https://doi.org/10.1201/b12461

Endsley, M. R., & Smith, R. P. (1996). Attention distribution and decision making in tactical air combat. *Human Factors*, *38*(2), 232–249. https://doi.org/10.1518/001872096779047995

Endsley, M. R. (2000). Theoretical underpinnings of situational awareness: A critical review. In M. R. Endsley & D. J. Garland (Eds.), *Situation Awareness Analysis and Measurement* (pp. 3–32). CRC Press. https://doi.org/10.1201/b12461

Endsley, M. R. (2015). Situation awareness: operationally necessary and scientifically grounded. *Cognition, Technology & Work*, *17*(2), 163–167. https://doi.org/10.1007/s10111-015-0323-5

Endsley, M. R. (2017). Direct Measurement of situation awareness: Validity and use of SAGAT. In E. Salas, & A. S. Dietz (Eds.), *Situational Awareness* (pp. 129–156). Routledge. https://doi.org/10.4324/9781315087924-9

Endsley, M. R. (2019). The divergence of objective and subjective situation awareness: A meta-analysis. *Journal of Cognitive Engineering and Decision Making*, *14*(1), 34–53. https://doi.org/10.1177/1555343419874248

Endsley, M. R. (2021). *Situational awareness measurement: How to measure situational awareness in individuals and teams*. Human Factors and Ergonomics Society.

Fabre, E. F., Matton, N., Beltran, F., Baragona, V., Cuny, C., Imbert, J.-P., Voivret, S., Van Der Henst, J. B., & Causse, M. (2022). Hierarchy in the cockpit: How captains influence the decision-making of young and inexperienced first officers. *Safety Science*, *146*, 1–12. https://doi.org/10.1016/j.ssci.2021.105536

Fazel, F., Morris, T., Watt, A., & Maher, R. (2018). The effects of different types of imagery delivery on basketball free-throw shooting performance and self-efficacy. *Psychology of Sport and Exercise*, *39*, 29–37. https://doi.org/10.1016/j.psychsport.2018.07.006

Federal Aviation Administration (1993). *Advisory circular 25.1523.1: Minimum flight crew*. U.S. Department of Transportation. https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_25_1523-1.pdf

Federal Aviation Administration. (1996). *The interface between flightcrews and modern flight deck systems.* U.S. Department of Transportation. https://rosap.ntl.bts.gov/view/dot/8719

Federal Aviation Administration. (2004). *Advisory circular 120–51E: Crew resource management.* U.S. Department of Transportation. https://www.faa.gov/documentlibrary/media/advisory_circular/ac120-51e.pdf

Federal Aviation Administration. (2008). *Advisory circular 25.975–1A: Flightdeck intrusion resistance.* U.S. Department of Transportation.

https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_25.795-1A.pdf

Federal Aviation Administration. (2013). *FAA boosts aviation safety with new pilot qualification standards.* U.S. Department of Transportation. https://www.faa.gov/news/press_releases/news_story.cfm?newsId=14838

Federal Aviation Administration. (2015a). *Safety alert for operators: Roles and responsibilities for pilot flying (PF) and pilot monitoring (PM).* U.S. Department of Transportation. https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/media/2015/safo15011.pdf

Federal Aviation Administration. (2015b). *Advisory circular 120–109A: Stall prevention and recovery*. U.S. Department of Transportation. https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-109A.pdf

Federal Aviation Administration. (2015c). *Order 1320.46D: FAA advisory circular system.* U.S. Department of Transportation. https://www.faa.gov/documentlibrary/media/order/faa_order_1320.46d.pdf

Federal Aviation Administration. (2017a). *Advisory circular 120–54A change 1: Advanced qualification program.* U.S. Department of Transportation. https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-54A_CHG_1.pdf

Federal Aviation Administration. (2017b). *Advisory circular 120–71B: standard operating procedures and pilot monitoring duties for flight deck crewmembers.*

U.S. Department of Transportation.
https://www.faa.gov/documentlibrary/media/advisory_circular/ac_120-71b.pdf

Federal Aviation Administration (2018). *Out front on airline safety: Two decades of continuous evolution*. U.S. Department of Transportation. https://www.faa.gov/newsroom/out-front-airline-safety-two-decades-continuous-evolution

Federal Aviation Administration. (2019). *Airline transport pilot and type rating for airplane: Airman certification standards*. U.S. Department of Transportation. https://www.faa.gov/training_testing/testing/acs/media/atp_acs.pdf

Federal Aviation Administration. (2020a). *Pilot training.* U.S. Department of Transportation. https://www.faa.gov/pilots/training/atp

Federal Aviation Administration. (2020b). *Advisory circular 121–42: leadership and command training for pilots in command.* U.S. Department of Transportation. https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_121-42.pdf

Federal Aviation Administration. (2021). *Timeline of FAA and aerospace history.* U.S. Department of Transportation. https://www.faa.gov/about/history/timeline/

Federal Aviation Administration. (2022a). *Electronic code of federal regulations: Part 91*. U.S. Department of Transportation. https://www.ecfr.gov/cgi-bin/text-idx?node=14:2.0.1.3.10

Federal Aviation Administration. (2022b). *U.S. civil airmen statistics: Annual statistics, 2021 active civil airmen statistics.* U.S. Department of Transportation. https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/

Federal Aviation Administration (n.d.). *What we do: Summary of activities.* U.S. Department of Transportation. https://www.faa.gov/about/mission/activities

Federal Aviation Administration Human Factors. (n.d.). *The role of human factors in the FAA*. U.S. Department of Transportation. https://www.hf.faa.gov/role.aspx#:~:text=In%20the%20Federal%20Aviation%20Administration%20%28FAA%29%2C%20Human%20Factors,comfortable%2C%20and%20effective%20human%20performance%22%20%28FAA%20Order%209550.8A%29

Federal Aviation Administration LOSA (n.d.). *Line operation safety assessment: history.* U.S. Department of Transportation. https://www.faa.gov/about/initiatives/maintenance_hf/losa/history

FedEx. (2021). *FedEx express minimum qualifications.* FedEx Careers. https://careers.fedex.com/pilot-minimum-qualifications

Feltz, D. L., & Landers, D. M. (1983). The Effects of Mental Practice on Motor Skill Learning and Performance: A Meta-analysis. Journal of Sport Psychology, *5*(1), 25–57. https://doi.org/10.1123/jsp.5.1.25

Fennell, K., Sherry, L., & Roberts, R. (2004). *Accessing FMS functionality: The impact of design on learning*. Ames Research Center. https://ntrs.nasa.gov/citations/20060017832

Field, A. (2018). *Discovering statistics using IBM® SPSS® statistics, North American edition.* Sage Publications.

Filgueiras, A., Quintas Conde, E. F., & Hall, C. R. (2017). The neural basis of kinesthetic and visual imagery in sports: an ALE meta-analysis. *Brain Imaging and Behavior*, *12*(5), 1513–1523. https://doi.org/10.1007/s11682-017-9813-9

Fink, A. (2003). *How to manage, analyze, and interpret survey data* (2nd ed.). Sage Publications.

Finke, R. A. (1980). Levels of equivalence in imagery and perception. *Psychological Review*, *87*(2), 113–132. https://doi.org/10.1037/0033-295x.87.2.113

Finke, R. A. (1985). Theories relating mental imagery to perception. *Psychological Bulletin*, *98*(2), 236–259. https://doi.org/10.1037/0033-2909.98.2.236

Flight Safety Foundation (n.d.). *About the foundation: history*. https://flightsafety.org/foundation/history/

Flight Safety Foundation (2014). *A practical guide for improving flight path monitoring: Final report of the active pilot monitoring working group*. Flight Safety Foundation. https://flightsafety.org/wp-content/uploads/2016/09/EPMG.pdf

Ford, D., J. (2010) *Bottom line training: performance-based results* (2nd ed.). Training Education Management.

Forgas, S., Moliner, M. A., Sánchez, J., & Palau, R. (2010). Antecedents of airline passenger loyalty: Low-cost versus traditional airlines. *Journal of Air Transport Management*, *16*(4), 229–233. https://doi.org/10.1016/j.jairtraman.2010.01.001

Foster, M. I., & Keane, M. T. (2015). Why some surprises are more surprising than others: Surprise as a metacognitive sense of explanatory difficulty. *Cognitive Psychology*, *81*, 74–116. https://doi.org/10.1016/j.cogpsych.2015.08.004

Foushee, H. C., & Helmreich, R. L. (1988). Group interaction and flight crew performance. In E. L. Wiener & D. C. Nagel (Eds.), *Human Factors in Aviation* (pp. 189–227). Academic Press. https://doi.org/10.1016/B978-0-08-057090-7.50013-8

Fraher, A. L. (2019). The vulnerability of quasi-professional experts: A study of the changing character of US airline pilots' work. *Economic and Industrial Democracy*, *40*(4), 867–889. https://doi.org/10.1177/0143831X16668580

Frederick-Recascino, C., & Gosiewski, M. (2004). Error and threat detection: A review and evaluation of current literature. *Journal of Aviation/Aerospace Education & Research*. *14*(1), 53–59. https://doi.org/10.15394/jaaer.2004.1535

Ginieis M., Hernández-Lara A. B., & Sánchez-Rebull M. V. (2020). Influence of airlines' size and labour costs on profitability. *Aviation (Vilnius, Lithuania)*, *24*(4), 157-168. https://doi.org/10.3846/aviation.2020.12539

Glasgow, J., & Papadias, D. (1992). Computational imagery. *Cognitive Science*, *16*(3), 355–394. https://doi.org/10.1207/s15516709cog1603_2

Goetz A., R., & Vowles, T. M. (2009). The good, the bad, and the ugly: 30 years of US airline deregulation. *Journal of Transport Geography*, *17*(4), 251–263. https://doi.org/10.1016/j.jtrangeo.2009.02.012

Gozli, D. G. (2020). Imagination in general psychology: thinking with luca tateo's "a theory of imagining, knowing, and understanding." *Integrative Psychological and Behavioral Science*, *54*(4), 920–932. https://doi.org/10.1007/s12124-020-09561-0

GraphPad (2022). *Assign subjects to groups.* Prism. https://www.graphpad.com/quickcalcs/randomize1.cfm

Guildford, J. P. (1973). *Fundamental Statistics in Psychology and Education* (5th ed.). McGraw-Hill.

Hadi, M. S., Doewes, M., & Kunta, S. (2019). Comparison of imagery training with self talk on the results of the accuracy landing in paragliding sports. *International Journal of Multicultural and Multireligious Understanding*, *6*(5), 991–995. https://doi.org/10.18415/ijmmu.v6i5.1148

Hall, C., Mack, D., Paivio, A., & Hausenblas, H. (1998). Imagery use by athletes: Development of the sport imagery questionnaire. *International Journal of Sport Psychology*, *29*(1), 73–89.

Hammond, T., Gregg, M., Hrycaiko, D., Mactavish, J., & Leslie-Toogood, A. (2012). The effects of a motivational general-mastery imagery intervention on the imagery ability and sport confidence of inter-collegiate golfers. *Journal of Imagery Research in Sport and Physical Activity*, *7*(1), 1–22. https://doi.org/10.1515/1932-0191.1066

Haunschild, P. R., & Sullivan, B. N. (2002). Learning from complexity: Effects of prior accidents and incidents on airlines' learning. *Administrative Science Quarterly*, *47*(4), 609–643. https://doi.org/10.2307/3094911

Heinrich, H. W. (1959). *Industrial accident prevention: a scientific approach* (4th ed.). McGraw-Hill.

Helmreich, R. L., Merritt, A. C., & Wilhelm, J. A. (1999). The evolution of crew resource management training in commercial aviation. *The International Journal of Aviation Psychology*, *9*(1), 19–32. https://doi.org/10.1207/s15327108ijap0901_2

Helmreich, R. L., Klinect, J. R., & Wilhelm, J. A. (1999). Models of threat, error, and CRM in flight operations. In, *Proceedings of the Tenth International Symposium on Aviation Psychology* (pp. 677–682). The Ohio State University. https://flightsafety.org/files/models_of_threat_error.pdf

Helmreich, R. L., & Foushee, H. C. (2019). Why CRM? Empirical and theoretical bases of human factors training. In B. G. Kanki, J. Anca, & T. R. Chidester (Eds), *Crew Resource Management* (3rd ed.; pp. 3–52). Elsevier. https://doi.org/10.1016/b978-0-12-812995-1.00001-4

Herkert J., Borenstein, J., & Miller, K. (2020). The Boeing 737 MAX: Lessons for engineering ethics. *Science and Engineering Ethics*, *26*(6), 2957–2974. https://doi.org/10.1007/s11948-020-00252-y

Hollings, E. F. (2001). *Aviation and transportation security act.* 107th U.S. Congress. https://www.congress.gov/bill/107th-congress/senate-bill/1447

Holmes, P. S., & Collins, D. J. (2001). The PETTLEP approach to motor imagery: A functional equivalence model for sport psychologists. *Journal of Applied Sport Psychology*, *13*(1), 60–83. https://doi.org/10.1080/104132001753155958

Howard, C.W. (1978). *Airline deregulation act.* 95th U.S. Congress. https://www.congress.gov/bill/95th-congress/senate-bill/2493

Hsu, Y. L., Li, W. C., & Chen, K. W. (2010). Structuring critical success factors of airline safety management system using a hybrid model. *Transportation Research Part E: Logistics and Transportation Review*, *46*(2), 222–235. https://doi.org/10.1016/j.tre.2009.08.005

Huitt, W. (2003). The information processing approach to cognition. *Educational Psychology Interactive*. Valdosta State University. http://www.edpsycinteractive.org/topics/cogsys/infoproc.html

Hunter, L. (2006). Low cost airlines: Business model and employment relations. *European Management Journal*, *24*(5), 315–321. https://doi.org/10.1016/j.emj.2006.08.001

İnan, T., T. (2018). The evolution of crew resource management concepts in civil aviation. *Journal of Aviation*, *2*(1), 45–55. https://doi.org/10.30518/jav.409931

International Air Transport Association. (2020). *Guidance for managing pilot training and licensing during COVID-19 operations.* International Air Transport Association. https://www.iata.org/contentassets/c0f61fc821dc4f62bb6441d7abedb076/iata-guidance-for-managing-pilot-training-licensing-during-covid19.pdf

International Air Transport Association (2021). *IATA releases 2020 safety report, details airline safety performance.* International Air Transportation Association. https://www.iata.org/en/pressroom/pr/2021-03-25-01/

International Air Transport Association Airline Cost Management Group (2021). *2021 data collection for fiscal year 2020 (FY2020) instructions manual.* International Air Transport Association. https://www.iata.org/contentassets/3b5a413027704ce08976fe1890fb43e2/acmg_instructions_manual.pdf

Israel, D. J. (1987). Some remarks on the place of logic in knowledge representation. In N. Cercone, G. McCalla (Eds.), *The Knowledge Frontier*, (pp. 80–91). Springer. https://doi.org/10.1007/978-1-4612-4792-0_3

Jackson, P. L., Lafleur, M. F., Malouin, F., Richards, C., & Doyon, J. (2001). Potential role of mental practice using motor imagery in neurologic rehabilitation. *Archives of Physical Medicine and Rehabilitation*, *82*(8), 1133–1141. www.https://doi.org/10.1053/apmr.2001.24286

Jane, V. G. (2019). *Human performance and situation awareness measures* (3rd ed.). CRC Press. https://doi.org/10.1201/9780429001024-3

Jenkins, S. (2009). Sport psychology, hypnosis and golf. *International Journal of Sports Science & Coaching*, 4(1), 149–221. https://doi.org/10.1260/174795409789577416

Jentsch, F., Bowers, C., & Salas, E. (1997). Could mental practice and imagery be techniques for enhancing aviation performance? *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *41*(2), 1172–1175. https://doi.org/10.1177/1071181397041002100

Johnson, V. M. H. (2018). Laying foundations: New deal public works and aviation infrastructure. *Journal of Policy History*, *30*(4), 695–726. https://doi.org/10.1017/s089803061800026x

Jones, R. E. T., Connors, E. S., Mossey, M. E., Hyatt, J. R., Hansen, N. J., & Endsley, M. R. (2011). Using fuzzy cognitive mapping techniques to model situation awareness for army infantry platoon leaders. *Computational and Mathematical Organization Theory*, *17*(3), 272–295. https://doi.org/10.1007/s10588-011-9094-6

Jones, D. G., & Endsley, M. R. (1996). Source of situation awareness errors in aviation. *Aviation Space and Environmental Medicine*, *67*(6), 507–512.

Kacperski, C., Ulloa, R., & Hall, C. (2016). Do athletes imagine being the best, or crossing the finish line first? A mixed methods analysis of construal levels in elite athletes' spontaneous imagery. *Journal of Mixed Methods Research*, *13*(2), 216–241. www.https://doi.org/10.1177/1558689816674563

Khoualdi, K., & Algamdi, M. (2019). Factors influencing adoption of learning management systems. *International Journal of Human Potentials Management*, *1*(2), 56–67. http://www.abmjournal.org/index.php/ijhpm/article/view/22

Kirschner, P. A., Sweller, J., Kirschner, F., & Zambrano R., J. (2018). From cognitive load theory to collaborative cognitive load theory. *International Journal of Computer–Supported Collaborative Learning*, *13*(2), 213–233. https://doi.org/10.1007/s11412-018-9277-y

Kelly, D., & Efthymiou, M. (2019). An analysis of human factors in fifty controlled flight into terrain aviation accidents from 2007 to 2017. *Journal of Safety Research*, *69*, 155–165. https://doi.org/10.1016/j.jsr.2019.03.009

Klein, G., Phillips, J. K., Rall, E. L., & Peluso, D. A. (2007). A data-frame theory of sensemaking. In R. R. Hoffman (Ed.), *Expertise out of context: Proceedings of the Sixth International Conference on Naturalistic Decision Making* (pp. 113–155). Lawrence Erlbaum Associates Publishers.

Klein, K. A., Eckberg, H., & Dean, R. H. (2009). *An analysis of low-cost simulated flight management systems for aviation research.* 2009 IEEE/AIAA 28th Digital Avionics Systems Conference. https://doi.org/10.1109/dasc.2009.5347569

Klein, G. (2014). Whose fallacies? *Journal of Cognitive Engineering and Decision Making*, *9*(1), 55–58. https://doi.org/10.1177/1555343414551827

Kosslyn, S. M. (1981). The medium and the message in mental imagery: A theory. *Psychological Review*, *88*(1), 46–66. https://doi.org/10.1037/0033-295x.88.1.46

Kosslyn, S. M. (1994). *Image And Brain.* The MIT Press. https://doi.org/10.7551/mitpress/3653.001.0001

Kunda, M. (2018). Visual mental imagery: A view from artificial intelligence. *Cortex*, *105*, 155–172. https://doi.org/10.1016/j.cortex.2018.01.022

Laerd Statistics (n.d.). *SPSS Statistics*. https://statistics.laerd.com

Landman, A., Groen, E. L., van Paassen, M. M., Bronkhorst, A. W., & Mulder, M. (2017). Dealing with unexpected events on the flight deck: A conceptual model of startle and surprise. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *59*(8), 1161–1172. https://doi.org/10.1177/0018720817723428

Lauber, J. (1984). Resource management in the cockpit. *Air Line Pilot*, *53*, 20–30.

Lee, D., & Singer, E. (2014). *What's your number? Interpreting the "fair and equitable" standard in seniority integration for airlines and other industries.* Economics of Transportation, *3*(1), 2–15. https://doi.org/10.1016/j.ecotra.2013.12.002

Lesiuk, T. (2010). The effect of preferred music on mood and performance in a high–cognitive demand occupation. *Journal of Music Therapy*, *47*(2), 137–154. https://doi.org/10.1093/jmt/47.2.137

Lipshitz, R. (1993). Converging themes in the study of decision making in realistic settings. In G. A. Klein (Ed.), *Decision making in action: Models and methods* (pp. 103–137). Ablex.

Lotze, M. (2013). Kinesthetic imagery of musical performance. *Frontiers in Human National Neuroscience*, *7*, 1–9. https://doi.org/10.3389/fnhum.2013.00280

MacArthur, J. B. (2020). Cost savings versus redundant systems: The case of the Boeing 737 Max debacle. *Journal of Business and Accounting*, *13*(1), 4–21.

Madsen, P., Dillon, R. L., & Tinsley, C. H. (2016). Airline safety improvement through experience with near-misses: A cautionary tale. *Risk Analysis*, *36*(5), 1054–1066. https://doi.org/10.1111/risa.12503

Makarowski, R., Makarowski, P., Smolicz, T., & Plopa, M. (2016). Risk profiling of airline pilots: Experience, temperamental traits and aggression. *Journal of Air Transport Management*, *57*, 298–305. https://doi.org/10.1016/j.jairtraman.2016.08.013

Maloo, M. C., & Darrow, W. P. (2001). Potential liabilities of U.S. airlines: Management concerns for cost and consequences of code sharing alliances in civil aviation. *American Business Review*, *19*(2), 121–129.

Martin, W. L. (2019). Crew Resource Management and Individual Resilience. In B. G. Kanki, J. Anca, & T. R. Chidester (Eds), *Crew Resource Management* (3rd ed.; pp. 207–226). Elsevier. https://doi.org/10.1016/b978-0-12-812995-1.00007-5

Martinetti, A., Chatzimichailidou, M. M., Maida, L., & van Dongen, L. (2018). Safety I–II, resilience and antifragility engineering: a debate explained through an accident occurring on a mobile elevating work platform. *International Journal of*

Occupational Safety and Ergonomics, *25*(1), 66–75. https://doi.org/10.1080/10803548.2018.1444724

Marks, D. F. (2019). I am conscious, therefore, I am: Imagery, affect, action, and a general theory of behavior. *Brain Sciences*, *9*(5), 107. https://doi.org/10.3390/brainsci9050107

Mazareanu, E. (2019). *Number of active pilots in the airline industry in 2019 and 2029*. Statista. https://www.statista.com/statistics/740147/active-pilots-airline-industry/

McLeod, S. A. (2008). *Information processing*. Simple Psychology. https://www.simplypsychology.org/information-processing.html

Meltzoff, J., & Cooper, H. (2018). *Critical thinking about research: Psychology and related fields* (2nd ed.). American Psychological Association.

Merritt, A., & Klinect, J. (2006). Defensive Flying for Pilots: An Introduction to Threat and Error Management. *The University of Texas Human Factors Research Project–The LOSA Collaborative*. http://homepage.psy.utexas.edu/homepage/group/HelmreichLAB/Publications/pubfiles/TEM.Paper.12.6.06.pdf.

MindTools. (n.d.). *Cognitive load theory: Helping people learn effectively*. https://www.mindtools.com/pages/article/cognitive-load-theory.htm

Miranda, A. T. (2018). Understanding human error in naval aviation mishaps. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *60*(6), 763–777. https://doi.org/10.1177/0018720818771904

Mizuguchi, N., Nakamura, M., & Kanosue, K. (2017). Task–dependent engagements of the primary visual cortex during kinesthetic and visual motor imagery. *Neuroscience Letters*, *636*, 108–112. https://doi.org/10.1016/j.neulet.2016.10.064

Morrison, S. A., & Winston, C. (1989). Airline deregulation and public policy. *Science*, *245*(4919), 707–711. https://doi.org/10.1126/science.245.4919.707

Munzert, J., Lorey, B., & Zentgraf, K. (2009). Cognitive motor processes: The role of motor imagery in the study of motor representations. *Brain Research Reviews*, *60*(2), 306–326. https://doi.org/10.1016/j.brainresrev.2008.12.024

Myers, P. L., Starr, A. W., & Mullins, K. (2018). Flight simulator fidelity, training transfer, and the role of instructors in optimizing learning. *International Journal of Aviation, Aeronautics, and Aerospace*, *5*(1), 1–26. https://doi.org/10.15394/ijaaa.2018.1203

Nanay, B. (2018). Multimodal mental imagery. *Cortex*, *105*, 125–134. https://doi.org/10.1016/j.cortex.2017.07.006

National Archives, 14 CFR § 121(2022a) https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-121?toc=1

National Archives, 14 CFR § 121(2022b) https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-121/subpart-O/section-121.436

National Archives, 14 CFR § 121(2022c) https://www.ecfr.gov/current/title-49/subtitle-B/chapter-VIII/part-830/subpart-A/section-830.2

National Archives, 14 CFR § 121(2022d) https://www.ecfr.gov/current/title-45/subtitle-A/subchapter-A/part-46

Neuper, C., Scherer, R., Reiner, M., & Pfurtscheller, G. (2005). *Imagery of motor actions: Differential effects of kinesthetic and visual–motor mode of imagery in single-trial EEG*. Cognitive Brain Research, 25(3), 668–677. https://doi.org/10.1016/j.cogbrainres.2005.08.014

Nicholas, J. S., Butler, G. C., Lackland, D. T., Tessier, G. S., Mohr Jr., L. C, & Hoel, D., G. (2001). Health among commercial pilots. *Aviation, Space, and Environmental Medicine, 72*(9), 821–826.

Norman, D. A. (1981). Categorization of action slips. *Psychological Review, 88*(1), 1–15. https://doi.org/10.1037/0033-295X.88.1.1

Norouzi, E., Hossini, R. N. S., Afroozeh, M. S., Vaezmosavi, M., Gerber, M., Puehse, U., & Brand, S. (2019). Examining the Effectiveness of a PETTLEP Imagery Intervention on the Football Skill Performance of Novice Athletes. *Journal of Imagery Research in Sport and Physical Activity, 14*(1). https://doi.org/10.1515/jirspa-2018-0010

National Transportation Safety Board. (n.d.). *About the NTSB.* National Transportation Safety Board. https://www.ntsb.gov/about/Pages/default.aspx

National Transportation Safety Board. (1979). *Aircraft accident report: United Airlines McDonnell-Douglas, dc-8-61, N8082.* National Transportation Safety Board. https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR7907.pdf

National Transportation Safety Board. (1991). *Aircraft accident report: Avianca, the airline of Columbia Boeing 707-321b, HK2016.* National Transportation Safety Board. https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR9104.pdf

National Transportation Safety Board. (1994). *Safety study: A review of flightcrew-involved major accidents of U.S. air carriers, 1978 through 1990.* National Transportation Safety Board. https://www.ntsb.gov/safety/safety-studies/Documents/SS9401.pdf

National Transportation Safety Board. (2010). *Aircraft accident report: loss of control on approach Colgan Air, Inc. operating as continental connection flight 3407 Bombardier DHC-8-400, N200WQ Clarence center New York, February 12, 2009.* National Transportation Safety Board. https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR1001.pdf

National Transportation Safety Board. (2019). *Assumptions used in the safety assessment process and the effects of multiple alerts and indications on pilot performance.* National Transportation Safety Board. *https://www.ntsb.gov/investigations/AccidentReports/Reports/ASR1901.pdf*

Nguyen, T., Lim, C. P., Nguyen, N. D., Gordon-Brown, L., & Nahavandi, S. (2019). A review of situation awareness assessment approaches in aviation environments. *IEEE Systems Journal*, *13*(3), 3590–3603. https://doi.org/10.1109/jsyst.2019.2918283

Öhman, M., Hiltunen, M., Virtanen, K., & Holmström, J. (2020). Frontlog scheduling in aircraft line maintenance: From explorative solution design to theoretical insight into buffer management. *Journal of Operations Management*, *67*(2), 120–151. https://doi.org/10.1002/joom.1108

Onestak, D. M. (1991). The effects of progressive relaxation, mental practice, and hypnosis on athletic performance: A review. *Journal of Sport Behavior*, *14*(4) 247.

Orasanu-Engel, J., & Mosier, K. L. (2019). Flight crew decision-making. In B. G. Kanki, J. Anca, & T. R. Chidester (Eds.), *Crew resource management* (pp. 139–183). Elsevier Academic Press. https://doi.org/10.1016/B978-0-12-812995-1.00005-1

Paivio, A., & Csapo, K. (1971). Short-term sequential memory for pictures and words. *Psychonomic Science*, *24*(2), 50–51. https://doi.org/10.3758/bf03337887

Pearson, J., Rademaker, R. L., & Tong, F. (2011). Evaluating the mind's eye. *Psychological Science*, *22*(12), 1535–1542. https://doi.org/10.1177/0956797611417134

Pels, E. (2008). Airline network competition: Full-service airlines, low-cost airlines and long-haul markets. *Research in Transportation Economics*, *24*(1), 68–74. https://doi.org/10.1016/j.retrec.2009.01.009

Petre, M. (2010). Mental imagery and software visualization in high-performance software development teams. *Journal of Visual Languages & Computing*, *21*(3), 171–183. https://doi.org/10.1016/j.jvlc.2009.11.001

Pike, B. (2015). *Master trainer handbook: Tips, tactics, and how-tos for delivering effective instructor-led, participant-centered training*. HRD Press.

Popp, R. K. (2016). Commercial pacification: Airline advertising, fear of flight, and the shaping of popular emotion. *Journal of Consumer Culture*, *16*(1), 61–79. https://doi.org/10.1177/1469540513509640

Post, P. G., Williams, C. D., Simpson, D., & Berning, J. M. (2015). The effects of a PETTLEP imagery intervention on the learning of a complex motor skill. *Journal of Imagery Research in Sport and Physical Activity*, *10*(1). 1–12. https://doi.org/10.1515/jirspa-2015-0007

Rantz, W. (2002). Using applied behavior to complement error management in crew resource management education. *Journal of Aviation/Aerospace Education & Research*. *11*(3), 41–47. https://doi.org/10.15394/jaaer.2002.1310

Reason, J. (1990). *Human Error*. Cambridge University Press. https://doi.org/10.1017/CBO9781139062367

Reynolds, R., & Blickensderfer, E. (2009). Crew resource management and shared mental models: A proposal. *Journal of Aviation/Aerospace Education & Research*. *19*(1), 15–23. https://doi.org/10.15394/jaaer.2009.1380

Roberts, C., & Hyatt, L. (2019) *The dissertation journey: A practical and comprehensive guide to planning, writing, and defending your dissertation.* Sage Publications.

Rose, N. L. (2012). After airline deregulation and Alfred E. Kahn. *The American Economic Review*, *102*(3), 376–380. https://doi.org/10.1257/aer.102.3.376

Ridderinkhof, R.K., & Brass, M. (2015). How kinesthetic motor imagery works: A predictive–processing theory of visualization in sports and motor expertise. *Journal of Physiology-Paris*, *109*(1–3), 53–63. https://doi.org/10.1016/j.jphysparis.2015.02.003

Roumbou, S. (2017). Aristotle's concept of mental imagery in sports. *Psychological Thought*, *10*(1), 49–59. https://doi.org/10.5964/psyct.v10i1.200

Salas E., Prince, C., Bowers, C. A., Stout, R. J., Oser, R. L., & Cannon-Bowers, J. A. (1999). A methodology for enhancing crew resource management training. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *41*(1), 161–172. https://doi.org/10.1518/001872099779577255

Salas, E., Prince, C., Baker, D. P., & Shrestha, L. (2017). Situation awareness in team performance: Implications for measurement and training. In E. Salas, & A. S. Dietz (Eds.), *Situational Awareness* (pp. 63–76). Routledge. https://doi.org/10.4324/9781315087924-5

Salas, E., Rhodenizer, L., & Bowers, C. A. (2000). The design and delivery of crew resource management training: Exploiting available resources. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *42*(3), 490–511. https://doi.org/10.1518/001872000779698196

Salas, E., Wilson, K. A., Burke, C. S., Wightman, D. C., & Howse, W. R. (2006). Crew resource management training research, practice, and lessons learned. *Reviews of Human Factors and Ergonomics*, *2*(1), 35–73. https://doi.org/10.1177/1557234x0600200103

Segal, S. J., & Fusella, V. (1970). Influence of imaged pictures and sounds on detection of visual and auditory signals. *Journal of Experimental Psychology*, *83*(3, Pt.1), 458–464. https://doi.org/10.1037/h0028840

Sellen, A. J. (1994), Detection of everyday errors. *Applied Psychology*, *43*, 475–498. https://doi.org/10.1111/j.1464-0597.1994.tb00841.x

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experiential designs for generalized causal inference*. Wadsworth.

Shen, C. (2017). The effects of major U.S. domestic airline code sharing and profit sharing rule. *Journal of Economics & Management Strategy*, *26*(3), 590–609. https://doi.org/10.1111/jems.12202

Sherry L., Feary M., Polson P., & Palmer E. (2001, March). *What's it doing now? Taking the covers off autopilot behavior*. [Paper presentation]. 11th International Symposium on Aviation Psychology, Columbus, OH.

Squalli, J., & Saad, M. (2006). Accidents, airline safety perceptions and consumer demand. *Journal of Economics and Finances. 30*(3), 297–305. https://doi.org/10.1007/bf02752736

Sweller, J., & Sweller, S. (2006). Natural information processing systems. *Evolutionary Psychology*, *4*(1), 434–458. https://doi.org/10.1177/147470490600400135

Swanson, R., & Holton, E. III. (2009). *Foundations of human resource development* (2nd ed.). Berrett-Koehler. https://doi.org/10.1108/00197851011022760

Swanson, R. A. (2001). Human resource development and its underlying theory. *Human Resource Development International*, *4*(3), 299–312. https://doi.org/10.1080/13678860110059311

Thomas, N. J. T. (1999). Are theories of imagery theories of imagination? An active perception approach to conscious mental content. *Cognitive Science*, *23*(2), 207–245. https://doi.org/10.1207/s15516709cog2302_3

Tokumaru, O. (2003). EEG activity of aviators during imagery flight training. *Clinical Neurophysiology*, *114*(10), 1926–1935. www.https://doi.org/10.1016/s1388-2457(03)00172-x

Tolman, E.C. (1932). *Purposive behavior in animals and men.* Appleton-Century.

Trevethan, R. (2017). Sensitivity, specificity, and predictive values: Foundations, liabilities, and pitfalls in research and practice. *Frontiers in Public Health*, *5*, 1–7. https://doi.org/10.3389/fpubh.2017.00307

Toth, A. J., McNeill, E., Hayes, K., Moran, A. P., & Campbell, M. (2020). Does mental practice still enhance performance? A 24 year follow-up and meta-analytic replication and extension. *Psychology of Sport and Exercise*, *48*, 1–13. https://doi.org/10.1016/j.psychsport.2020.101672

Trochim, W. M. K. (n.d.). *Research methods knowledge base*. Conjoint.ly. Retrieved May 10, 2022, from https://www.conjointly.com/kb

Tsikriktsis, N. (2007). The effect of operational performance and focus on profitability: a longitudinal study of the U.S. Airline Industry. *Manufacturing & Service Operations Management*, *9*(4), 506–517. https://doi.org/10.1287/msom.1060.0133

U.S. Bureau of Labor Statistics. (2021). *Occupational employment and wages: 53–2011 airline pilots, copilots, and flight engineers.* U.S. Department of Labor. https://www.bls.gov/oes/current/oes532011.htm

U.S. Bureau of Labor Statistics. (2022). *Occupational outlook handbook, airline and commercial pilots*. U.S. Department of Labor. https://www.bls.gov/ooh/transportation-and-material-moving/airline-and-commercial-pilots.htm

Van der Linden, F. R. (2002). *Airlines and air mail: the post office and the birth of the commercial aviation.* The University Press of Kentucky.

Van Vleck, J. (2013). *Empire of the air: Aviation and the American ascendancy*. Harvard University Press. https://doi.org/10.4159/harvard.9780674726246

Van Tiem, D., Moseley, J., & Dessinger, J. (2012). *Fundamentals of performance improvement: Optimizing results through people, process, and organizations* (3rd ed.). John Wiley & Sons.

Wagener, F., & Ison, D. C. (2014). Crew resource management: An application in commercial aviation. *Journal of Aviation Technology and Engineering*, *3*(2), 2–13. https://doi.org/10.7771/2159-6670.1077

Walker, T. J., Walker, M. G., Thiengtham, D. N., & Pukthuanthong, K. (2014). The role of aviation laws and legal liability in aviation disasters: A financial market perspective. *International Review of Law and Economics*, *37*, 51–65. https://doi.org/10.1016/j.irle.2013.07.004

Walker, G. (2017). Redefining the incidents to learn from: Safety science insights acquired on the journey from black boxes to flight data monitoring. *Safety Science*, *99*, 14–22. https://doi.org/10.1016/j.ssci.2017.05.010

Walsh, D. J. (1988). Accounting for the proliferation of two-tier wage settlements in the U.S. airline industry, 1983–1986. *Industrial & Labor Relations Review*, *42*(1), 50–62. https://doi.org/10.1177/001979398804200104

Wang, Z., Hofer, C., & Dresner, M. E. (2013). Financial condition, safety investment and accident propensity in the US airline industry: *A structural analysis. Transportation Research Part E: Logistics and Transportation Review*, *49*(1), 24–32. https://doi.org/10.1016/j.tre.2012.07.001

Wang, Z., Jiang, Z., & Blackman, A. (2021). Linking emotional intelligence to safety performance: The roles of situational awareness and safety training. *Journal of Safety Research*, *78*, 210–220. https://doi.org/10.1016/j.jsr.2021.06.005

Watson, J. B. (1913). Image and Affection in Behavior. *The Journal of Philosophy, Psychology and Scientific Methods*, *10*(16), 421–428. https://doi.org/10.2307/2012899

Wessel, J. R., & Aron, A. R. (2013). Unexpected events induce motor slowing via a brain mechanism for action-stopping with global suppressive effects. *Journal of Neuroscience*, *33*(47), 18481–18491. https://doi.org/10.1523/jneurosci.3456-13.2013

White, A. R. (1990). *The language of imagination.* Blackwell.

Wiegmann D. A., & Shappell, S. A. (2003). *A human error approach to aviation accident analysis: The human factors analysis and classification system*. Ashgate Publishing.

Williams, S. E., & Cumming, J. (2011). Measuring athlete imagery ability: The sport imagery ability questionnaire. *Journal of Sport and Exercise Psychology*, *33*(3), 416–440. https://doi.org/10.1123/jsep.33.3.416

Woods, D., & Sarter, N. (2000). Learning from automation surprises and going sour accidents. In N. Sarter & R. Amalberti (Eds.), *Cognitive Engineering in the Aviation Domain* (pp. 327–354). Lawrence Erlbaum. https://doi.org/10.1201/b12462

Wright, C. J., & Smith, D. (2009). The effect of PETTLEP imagery on strength performance. *International Journal of Sport and Exercise Psychology*, 7(1), 18–31. https://doi.org/10.1080/1612197x.2009.9671890

Wright, C. J., Hogard, E., Ellis, R., Smith, D., & Kelly, C. (2008). Effect of PETTLEP imagery training on performance of nursing skills: Pilot study. *Journal of Advanced Nursing*, 63(3), 259–265. https://doi.org/10.1111/j.1365-2648.2008.04706.x

Xuan, X. , Khan, K., Su, C. W., & Khurshid, A. (2021). Will COVID-19 Threaten the Survival of the Airline Industry? *Sustainability (Basel, Switzerland)*, *13*(21), 1–18. https://doi.org/10.3390/su132111666

Yeh, Y. P. (2014). Exploring the impacts of employee advocacy on job satisfaction and organizational commitment: Case of Taiwanese airlines. *Journal of Air Transport Management*, *36*, 94–100. https://doi.org/10.1016/j.jairtraman.2014.01.002

You, X., Ji, M., & Han, H. (2013). The effects of risk perception and flight experience on airline pilots' locus of control with regard to safety operation behaviors. *Accident Analysis & Prevention*, *57*, 131–139. https://doi.org/10.1016/j.aap.2013.03.036

Yu, Q. H., Fu, A. S. N., Kho, A., Li, J., Sun, X. H., & Chan, C. C. H. (2016). Imagery perspective among young athletes: Differentiation between external and internal visual imagery. *Journal of Sport and Health Science*, *5*(2), 211–218. https://doi.org/10.1016/j.jshs.2014.12.008

Yurmalia, D., & Herman, T. (2021). Student visualization in solving geometry problem: the case of reflection. *Journal of Physics: Conference Series, 1806*(1), 1–5. https://doi.org/10.1088/1742-6596/1806/1/012052