SAINT LOUIS UNIVERSITY

Program-Level Assessment: Annual Report

Program: Master of Science in Aviation	Department: Aviation Science
Degree or Certificate Level: Master's	College/School: Parks College of Engineering, Aviation and Technology
Date (Month/Year): August 2021	Primary Assessment Contact: Stephen G. Magoc
In what year was the data upon which this report is based collected? August 2020 – May 2021	
In what year was the program's assessment plan most recently reviewed/updated? 2020	

1. Student Learning Outcomes

Which of the program's student learning outcomes were assessed in this annual assessment cycle?

SLO 1. Assess relevant literature or scholarly contributions in the aviation field of study.
SLO 2. Apply the major practices, theories, or research methodologies in the aviation field of study.

2. Assessment Methods: Student Artifacts

Which student artifacts were used to determine if students achieved this outcome? Please identify the course(s) in which these artifacts were collected. Clarify if any such courses were offered a) online, b) at the Madrid campus, or c) at any other off-campus location.

Student artifacts to be used will include, but are not limited to the following:

- Assignments
- Quizzes
- Tests

Student artifacts will be collected from the following courses.

SLO 1. Assess relevant literature or scholarly contributions in the aviation field of study.

ASCI 5010 Introduction to Aviation Research Methods (online)
ASCI 5150 Aviation Incident and Accident Analysis (online)
ASCI 5220 Aviation Safety (online)
ASCI 6020 Flight Operations Business and Administrations (online)

SLO 2. Apply the major practices, theories, or research methodologies in the aviation field of study.

ASCI 5010 Introduction to Aviation Research Methods (online)
ASCI 5150 Aviation Incident and Accident Analysis (online)
ASCI 5470 Quantitative Data Analysis (online)

3. Assessment Methods: Evaluation Process

What process was used to evaluate the student artifacts, and by whom? Please identify the tools(s) (e.g., a rubric) used in the process and include them in/with this report.

The department faculty (Drs. Stephen Belt, Terrence Kelly and Gajapriya Tamilselvan, and Mr. Stephen Magoc) met on 07/21/2021 to discuss the results and findings of student artifacts. The department faculty used course assessment forms and examples of student artifacts in the evaluation.

See Appendix A for the course assessment forms used for the evaluation of the courses and artifacts.

4. Data/Results

What were the results of the assessment of the learning outcomes? Please be specific. Does achievement differ by teaching modality (e.g., online vs. face-to-face) or on-ground location (e.g., STL campus, Madrid campus, other off-campus site)?

The result of the assessment of the above student learning outcomes is that the graduates are currently meeting the student learning outcomes. The result of the assessment does not differ by modality as all course are taught online.

5. Findings: Interpretations & Conclusions

What have you learned from these results? What does the data tell you?

The data collected and evaluated by the department reveals the following.

- The department needs to further refine the performance indicator rubrics to make better assessments of the student learning outcomes.
- The department needs to continue improving the examples of assignments and papers so that students better understand what is required of them to meet the student learning outcomes.

6. Closing the Loop: Dissemination and Use of Current Assessment Findings

A. When and how did your program faculty share and discuss these results and findings from this cycle of assessment?

The department faculty and the Assistant Chief Instructor met on 07/21/2021 to share and discuss the scheduled student learning outcomes, the relevant performance indicator rubrics, and the relevant course evidence.

B. How specifically have you decided to use findings to improve teaching and learning in your program? For example, perhaps you've initiated one or more of the following:

Changes to the Curriculum or Pedagogies	• Course content • Teaching techniques • Improvements in technology • Prerequisites	• Course sequence • New courses • Deletion of courses • Changes in frequency or scheduling of course offerings
Changes to the Assessment Plan	• Student learning outcomes • Student artifacts collected • Evaluation process	• Evaluation tools (e.g., rubrics) • Data collection methods • Frequency of data collection

Please describe the actions you are taking as a result of the findings.

The actions being taken as a result of the findings are to continue to improve upon the course content and teaching techniques.

If no changes are being made, please explain why.

N/A

7. Closing the Loop: Review of Previous Assessment Findings and Changes

A. What is at least one change your program has implemented in recent years as a result of assessment data?

For the SLO's that did not sufficiently meet expectations in the 2018-2019 cycle, the department faculty discussed how to best make course changes designed to improve the graduates' abilities to achieve the student learning outcomes. The department faculty determined that it would implement the following changes and continue the assessment process to determine whether the changes being implemented were effective during the 2020-2021 cycle:

SLO 1. Assess relevant literature or scholarly contributions in the aviation field of study.

- Changes to be made to the ASCI 5010 Introduction to Aviation Research Methods included the requirement of a minimum of three cited and referenced sources to support assertions made in the precis required of students.

SLO 2. Apply the major practices, theories, or research methodologies in the aviation field of study.

- Changes to be made to the ASCI 5010 Introduction to Aviation Research Methods included expanding the expectations of the course mini proposal by requiring a more comprehensive methodologies section.
- Changes to be made to the ASCI 5470 Quantitative Data Analysis course included using the same elements of assessment found in "SPSS Assignments and LMR Design" but providing more structured examples to increase the students' level of competency.

B. How has this change/have these changes been assessed?

The department implemented the changes and assessed the impact of these changes during the 2020-2021 assessment cycle.

C. What were the findings of the assessment?

The department determined that the changes implemented since the last assessment cycle have been successfully implemented. However, the department realizes that additional revision to the methods of instruction used will be necessary in the context of continuous improvement in the program.

D. How do you plan to (continue to) use this information moving forward?

The department will continue to monitor the student learning outcomes to determine if over time the changes that were implemented continue to assist with students achieving the desired outcomes.

IMPORTANT: Please submit any assessment tools and/or revised/updated assessment plans along with this report.

Appendix A

Department of Aviation Science

2020-2021 Graduate Program Assessment Course Assessment Forms

The following pages contain the course forms and evidence used in the 2020-2021 assessment of the following Student Learning Outcomes.

Spring 2021 (Assessment meeting held 07-21-2021)

SLO 1. Assess relevant literature or scholarly contributions in the aviation field of study.

SLO 2. Apply the major practices, theories, or research methodologies in the aviation field of study.

Graduate Course Assessment Form

Spring 2020 – Assess Student Learning Outcomes #1 and #2

Course: ASCI 5010 Introduction to Aviation Research Methods
Semester Taught: Fall 2019
Number of Students in Course: 8

Student Learning Outcome Assessed	Assessment Results: (Indicate what % of class achieved a minimum score of 70%)	Benchmark achieved? (Benchmark: 80% of students will score a minimum of 80% = "B")
1. Assess relevant literature or scholarly contributions to the aviation field of study.	Precis: 1 2 3 4 7/7 7/7 7/7 7/7 100% 100% 100% 100%	Precis: 1 2 3 4 5/7 7/7 7/7 7/7 71% 100% 100% 100%
2. Apply the major practices, theories or research methodologies in the aviation field of study.	Mini Proposal 7/7 100%	Mini Proposal 7/7 100%

ASCI 5010 Introduction to Aviation Research Methods is intended (currently) to be the introduction to research methodologies course for both masters and PhD students. Historically, this course followed a both a qualitative and quantitative course. Most of the students in this course are enrolled in the PhD program (5/7).

SLO 1, suggests students demonstrate the ability to assess relevant literature. Assignments for the course include several Precis essays based on the literature. Student performance on this SLO are outstanding as evidence by the scores achieved. While I do not think any remedial action is necessary, for the sake of continuous improvement, I intent to require a minimum of three cited and referenced sources to support assertions in each precis.

SLO 2 success is demonstrated by mini-proposal submissions made by each student. The mini proposal =required each student to demonstrate an application of a research method to a proposed project. Students did quite well on the assignment 100% of the course achieving a score above 80%. As a matter of continuous improvement, I intend to expand the expectations of the mini proposal to include a more comprehensive methodologies section.

Instructions for Precis
Creating a Precis

Dr. Ross Matsueda from the University of Washington published a very useful guide for preparing a Precis. Below find a slightly edited copy of Dr. Matsueda's suggestions:

An important skill that academic researchers inevitably acquire is a way of writing a brief synopsis, or précis, summarizing a research article. This can be enormously useful for conducting research, as one does not have to re-read the same key articles repeatedly, but rather refresh one's memory by reading their synopsis. It is a crucial step when writing a review article, such as for the Annual Review of Sociology, in which the objective is to summarize and critically evaluate the state of research on a given topic. It is also a handy skill to have when serving as an anonymous reviewer for a journal.

There are several ways of writing a précis, and individuals typically develop their own style based on what works for them. Nevertheless, there are a few features that are common among virtually all good summaries.

Note that most of this is just commonsense. Note also that these recommendations suggest efficient ways of reading articles and are based on accepted normative models of how to write a research article.

Begin by reading the abstract, and the stated objectives of the paper. You may then flip to the substantive conclusions to get a sense of where the paper is heading, and if it is an empirical paper, check the data and methods quickly before returning to page one. Highlight as you read, and make quick comments, like "yuck," "good," "great point," "dumb," "important claim," etc. For an important paper highlight the key points, so the next time you want to read the paper, all you must do is read the highlighted passages. (I hate reading an article the second time with no highlights—it's just as much work as reading the first time.) In evaluating an article, flip back to the "objectives of the paper" section to determine if they are consistent with data, models, hypotheses, conclusions, etc.

The first step in writing a précis is to summarize the main points of the paper. What is the paper about? What is it trying to accomplish and why is this important? What are the key advances claimed by the authors? How do they do this? Here is a quick skeleton of a summary:

A. Introductory paragraph:

- What is the topic of the paper, why is it important (as argued by the authors), and how do they claim to advance our knowledge?

- What are the specific objectives of the paper that presumably advance our knowledge of this important topic?

- Usually there is a single key finding or theoretical argument that contributes to the body of knowledge. What is this finding or argument? State this early, and then use the summary to show how the authors come up with the finding or make the argument.

B. Summary of Steps Leading to Conclusions

For Empirical Studies

1. Theoretical background (if different from above)
2. Hypotheses: Are they listed? Do they follow from the theory/literature review?
3. Methods: Are they an improvement over prior research (e.g., sample drawn, statistical methods used, cases analyzed?)
4. Models used. (Do they follow from the theory discussed or prior findings reviewed?)
5. Findings.
6. Substantive conclusions: do they follow from the findings?

For Theoretical Essays:
1. Theoretical background: What is the theoretical issue(s) raised? Why important?
2. Deficit in the literature: What issue has been inadequately raised or solved in prior literature (which will be raised or solved here)?
3. Major argument: What is the author(s) major argument(s)?
4. Conclusions: Do they follow from the major arguments, theoretical background, and deficit in the literature?

C. Critical Evaluation

- Here you critique the reading or set of readings, picking out the most important issue and working down from there to the least important issue (if you still have space).
- This critique is highly variable, depending on your reading, the style of research, and the strengths or weaknesses of the reading.
- You probably want to mention the strengths of the reading before moving to a critique, and then end with a balanced conclusion (e.g., great dataset, good idea, strong analysis, interesting theoretical framework, innovative theory or methods).

Here are some examples:

General Criticisms:

- This has been done before
- Inadequate literature review
- Misunderstands the literature
- This isn't important
- Conclusions do not follow from analysis.

Theoretical Criticisms:

- The theories have not been presented accurately
- The key concepts are poorly articulated, misunderstood, or incorrectly characterized
- The key hypotheses are not discussed or tested
- The key hypotheses are not shown to derive from the theory's propositions.

Methodological Criticisms:

- The sample is not representative of the key population needed to be examined
- The sample is too small
- The sample is not random and sample selection bias could compromise results
- Measures are of poor quality (unreliable or invalid) or fail to capture theoretical Concepts
- Effects are too small to be meaningful.

Criticisms of Writing and Organization:

- Writing is not clear or grammatically correct
- The structure of the presentation is confusing
- Appropriate headings are not used in helpful ways
- Paragraphs do not follow from each other
- Theory or methods are not presented in a clear way

All of this can be boiled down to a very concise 2-page précis! Note that you can do this for a group of readings, making the summary very terse and restricting your critical comments to the most important issues and issues that cross-cut individual readings. I test my précis by reading it over and checking to see if I have captured the essence of the paper and described both the major strengths and weaknesses. Doing this well will allow you to write book reviews, critical essays, and reviews of articles.

Example Precis’

Example Precis 1

Introduction

This article presents an update on a research teaching tool oriented toward graduate learners in research methods coursework. In the report he describes results of a 2017 follow up study to the author’s online, interactive tool developed in 2015. This tool, termed “Hopscotch” was designed to assist graduate level learners and researchers in both teaching and learning the qualitative research design process. Jorrin-Abellan emphasizes the target audience as educational professionals and researchers who use research methodologies for “betterment of their practices” (pg. 6), especially in learning and designing qualitative research. The author describes use of a responsive evaluative case study as the evaluation method.

Background Summary

The author cites education and research design literature surrounding teaching and learning qualitative research frameworks (Hazzan & Nutov, 2014; Günter, 2008; Breuer & Schreier, 2007; Hammersley, 2004 among others) pointing to a need for more deliberate, iterative models to assist new researchers or graduate learners in the qualitative research design process. The author describes the original Version 1 online framework as a nine-step tool to guide learners through key components of qualitative research design. The steps include: Worldview of the researcher, Topic & Goals, Conceptual framework, Research Design, Research Questions, Data Gathering, Data Analysis, Trustworthiness & Validity and Ethics (pg. 6). For the paper reviewed here, the author highlighted two research questions for the study (Pg. 8):

1. Is the Hopscotch Model helping the teaching and learning of qualitative research method? and,
2. In which ways should the Hopscotch Model and web-tool be modified/enhanced to respond to the needs of its users?

Methodology

The author described his methodology of *purposeful sampling* of 86 users of the Hopscotch model. Methodologiesy included personal interviews, surveys and online quantitative analytics data from Google Analytics. The data was analyzed using Atlas.ti which the author asserted assisted in more accurate coding and triangulation of data.

Evaluation

This paper was a formal evaluation of the author's Hopscotch qualitative and, now in Version 2 includes a quantitative, assistive research teaching and learning tool. This paper seemed at first slightly lean in the front-end literature review, specifically in showing support for the need for better teaching tools and the gap proposed by the author. However, reading further it became evident this is essentially a "part II" follow up on an earlier design model from the author, where more substantive literature review was accomplished. Regardless, a slightly more in-depth

review section of supporting research would have been helpful to get into the mindset and direction for the paper.

The author does an excellent job laying out and articulating the evaluation approach used in this report, using established and well referenced methods (Jorrin-Abellan, pgs. 7-8). He specifically laid out the evaluation focus on utility and model contribution to teaching and learning qualitative research methods. I particularly like the analysis figure display (Figure 1 – Components of the Evaluation Design, pg. 9). Its layout and content are easy to read and identify relationship to other criteria areas.

Results the author reports include improvements made in five areas surrounding attributes of the online tool sections as well as language conversion capabilities. The author lays out results clearly in table formats and does a very good job interpreting, assessing and follow up from both positive and negative limitations from learner and teacher data responses. The author clearly establishes both in his assessment and treats both as valuable information for refining the current data tool into the Hopsctoch 2.0 version with its improved attributes. There is some bias language in the positive summary where he cites "copious use" (pg. 18) of his Hopscotch 2.0 tool. This is being perhaps too picky on my part – he clearly has the data to back it up. However, the word "copious' on its own in the text is difficult to quantify or envision within the context of a journal style research paper.

Overall this was a well written paper, especially in the latter sections describing the author's assessment methods and tools used with well cited supporting literature. In fact, I will likely return to Jorrin-Abellan's assessment set up and overall methodology described in this paper to assist in documenting my own future evaluation designs.

References:

Breuer, F., Schreier, M. (2007). Issues in learning about and teaching qualitative research methods and methodology in the social sciences. *Forum: Qualitative Sozialforschung*, Vol. 8:Iss. 1(1).

Günter, M. (2008). A lesson learned? Difficulties in teaching and learning qualitative research methods. *Journal Für Psychologie*, Vol 1:Iss. 5.

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Example Precis 2

Chuang, S., Ou, J-C & Ma, H-P, (2019). Measurement of resilience potentials in emergency departments: Applications of a tailored resilience assessment grid. *Safety Science, 121*(2020), 385-393. DOI: https://doilorg/10.1016/j.ssci.2019.09.012

This paper reported on the authors' adaptation of an existing resilience assessment grid (RAG), assessing organizational resilience across four area 'potentials' described by the authors: respond, monitor, learn and anticipate (Chuang et al., 2019, pg.385) based on a model from resilience engineering first put forward by Hollnagel (2011). The study quantitatively mapped and compared resilience readiness of emergency departments at four hospitals within a modern major metropolitan city in Taiwan. Tailoring Hollnagel's *four potentials* model, the purpose of the research was to comparatively test feasibility of a quantitatively scored adapted assessment tool measuring the four key potentials of resilience in four Emergency Departments (ED). The goal was to gauge ability of the adapted assessment tool to provide a statistically based visual assessment of readiness for sustaining operations during routine and unexpected conditions (Chuang et al., 2019, pg.386). This report was very intriguing, utilizing qualitative interview data, then scoring and translating results into statistical rankings used to produce quantitatively derived radar charts (Chuang et al., 2019, pgs. 387;388). The data was first collected from scored survey questions via direct focus group interviews. Then a four-point ordinal scale was used to rank and present resilience performance (Pg.387). The authors address a potential argument in this approach early on acknowledging that ordinal data at first glance would not provide mean values. They went at length into a statistical method-backed description articulating their design methodology for summing scores that laid out their line of thinking and logic.

For purposes of example and review, this report represents a challenging mix of qualitative and quantitative approaches. It was rightfully data and method "dense" which was necessary to describe the strategic statistical approaches and interpretations. However for this researcher personally, it was very challenging to read and review and, in honesty, struggled to follow it based on its sheer detailed depth and use of statistical tools and tabling, coupled with this researcher's low fluency in statistics. The quality of the data resented and writing however were very good. From an overall report presentation, at the beginning of the paper they speak of resilience in Emergency Departments for the study, but were not very clear on the positive and negative impacts of presence/lack of resilience until several paragraphs later in the paper (pg.

385) which made the reader flip back and forth initially to pull together that particular part of the context. A sharper focus up front on implications of resilience readiness would have helped. They do however do an excellent job explaining the nature of the RAG as a guide for measuring resilience (pg. 385).

The paper demonstrates a study that transitioned from a qualitative assessment using thematic analysis of open-ended interview questions, which were then coded using two researchers reviewing and on a scored 4-point scale (pg. 387), ultimately translating this data into statistically useful form. To that end the authors do an outstanding job describing the preparation and measures used (ordinal with calculation of the means). The resulting radar charts displaying the resilience readiness in the four categories was compelling and one would assume quite useful for assessing operational safety culture. One of the prominent takeaways from this very recent article on resilience is from the authors' Discussion section on the study and view of resilience in dynamic, risk-sensitive environments - very similar to the aviation area in which this researcher is engaged:

> "ED's are dynamic, open, high-risk systems that function under considerable uncertainty and economic pressure. Their ability to perform in a resilient manner is therefore critical. Although identification of metrics and standards for measuring organizational resilience…remains challenging, it is necessary for a system…to harbor these four potentials in order to be able to perform in a resilient manner." (Chuang et al., 2019, pg. 391).

Mini Proposal Example

Mixed Methods Research Methodology
Justification

PROBLEM STATEMENT

Graduates from aviation education and training programs lack fluency in essential problem-solving resilience competencies required in the industry. It is hypothesized that desirable behavioral attributes related to resilience during adversity and challenging problem- based coursework – sometimes called 'capstone' learning designed to resemble industry problems - can be identified, taught and measured within the context of a collegiate learning environment.

Research questions

Literature review of positive resilience behavioral responses from other research across multiple domains resulted in the following research questions forming the basis of the proposed research study: 1) How could the notion of resilience be taught, developed, and measured in

terms of more concrete observable competencies and behaviors salient to the industry's needs and within an aviation academic program? 2) What are resilience competency transfer paths from the learning to working environments? Because the nature of behavior/performance-based learning and outcome measures in aviation academia must be both qualitatively and quantitatively measured, these questions lend themselves to a mixed methods approach for developing and assessing key resilience behavioral traits. If these can be indexed into a teaching, performance and assessment model, results could be generalized into the larger industry.

PURPOSE

The purpose of this study is to identify is to develop and test efficacy of a theoretical

model for teaching and mentoring key behavioral learner attributes of resilience as they relate to the aviation learning and workforce environments. Because human behavior is subject to numerous variables including culture and a variety of human factors that can influence decision making and performance, a singular methodological approach would not provide the depth and

breadth of data required to accurately set up a study and effectively generalize results. Proposed is therefore a Mixed Methods approach using an *Exploratory Sequential Design* as described by Creswell & Creswell (2018, pg. 218-220).

Qualitative data collection and analysis

Beginning with a qualitative assessment of learner resilience attitudes and self-reflective responses to adversity during learning, a phenomenological study of learners within a senior capstone aviation course which routinely incorporates problem-based learning will be conducted first in order to refine focus for helping to then create quantitative survey assessment and performance scoring assessments of learner resilience behavioral responses during adverse or challenging problem-based learning experiences. The qualitative interview portion will include a sample of convenience using a targeted senior capstone course within a collegiate aeronautical engineering technology program. Design and data collection activities will follow a structured process flow described by Creswell & Poth (2018, pg. 149) which includes: Locating site/individual, Gaining access / developing rapport, Sampling purposefully, Collecting data using individual narrative interview as well as observational measures described by Creswell & Poth (2018, pgs. 165-166;169) and Recording information using Complete Participant data capturing and recoding approaches described by Creswell & Poth (2018, pg. 167). Finally Exploring field issues and ethical considerations including bias, power asymmetry and ensuring human subjects and data storage/security through CITI training of key researchers involved will also be addressed.

Participants will be asked questions related to personal resilience behavior responses using open ended interview questions developed around the six factors from the Resiliency

Scale for Adults (RSA) by Friborg et al., (2003) including:

1. Perception of self
2. Perception of future
3. Structured style
4. Social Competence
5. Family cohesion, and
6. Social resources.

Quantitative data collection and analysis

The design and data collection activities will then proceed to an instructor scored observational behavioral performance scale and participant's self-scoring survey of before and after performance using a 5-point Likert scale. These scored scales will utilize T-Test scores to assess if explicit training and performance of identified resilience behaviors impact project outcomes as well as learner perception of their own learning empowerment and capabilities.

MIXED METHOD APPROACH

Mixed method approach has been defined by listing "core characteristics" by Creswell & Creswell (2018, pg. 214): Involving collection of both qualitative and quantitative data, rigorous methods and both methods clearly integrated into the design by careful merging and explaining the collaborative or embedded data sets. This is congruent with earlier definitions of mixed methods. Haines (2011) also uses Creswell – a prominent and reliable source in the qualitative and mixed method fields – to define the approach as,

> “mixture of qualitative and quantitative approaches in many phases in the research process. As a method it focuses on collecting, analyzing, and mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone” (Creswell & Plano Clark, 2007, pg. 5).

The value of mixed methods studies has been recognized for ability to find richer meanings and clarity for understanding findings and improving accuracy and completeness, thereby helping to establish overall validity (Haines, 2011). Previous mixed methods research consistently supports the importance of accounting for social and cognitive psychological phenomenon which can influence performance data and quantitative results. Malina et al. (2011) emphasize mixed methods as providing “the best opportunity for addressing research questions” (pg.59-60) and

Euske et al. (2010) notes specifically the important role of incorporating both quantitative and qualitative data when it comes to integrated human performance research where people interact and influence the performance outcomes. This is especially true in the context of complex and dynamic environments like aviation learning environments where learners must grapple with knowledge, hands-on technical and collaborative problem solving competencies simultaneously.

Therefore, her it behooves the researcher to set up a test that can richly assess and analyze both qualitative and quantitative evaluations and data. Given the proposed study a mixed methods assessment strategy could be employed and provide a better sight picture of the theory and future test cases. Creswell & Creswell (2018, pg. 218) illustrate an exploratory sequential mixed method design framework consisting of three phases: 1) Qualitative data collection and analysis 2) Identifying features for testing (tailored new instruments or experiments informed by the initial qualitative database), and 3) Quantitatively testing the designed feature. After this, results are interpreted. The power of this particular mixed methodology is that the quantitative feature can be tailored more directly to the needs and characteristics of the participants. This mixed method has precedent in global health care design for better understanding the population before administering test instruments (Creswell & Creswell, 2018, pg. 224).

A mixed method approach combines the strengths of both quantitative and qualitative approaches and also bridges weaknesses associated with each. Haines (2011) notes quantitative methodology often lacks contextual information (setting, conditions, cultural influence) which qualitative can richly fill in. Likewise, qualitative data can vary and carry with it a propensity for researcher bias to which the quantitative approach can impart rigor to control. With mixed methods, the literature shows that several data collection methods can be used which can help answer additional question and yield more supporting evidence and deeper insights on research questions.

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Graduate Course Assessment Form

Assess Student Learning Outcomes

Course : ASCI 5150-01 Aviation Incident & Accident Analysis
Semester Taught: Spring 2021
Number of Students in Course: 3

Student Learning Outcome Assessed	Assessment Results: (Indicate what % of class achieved a minimum score of 80%)	Benchmark achieved? (Benchmark: 80% of students will score a minimum of 80% = "B")
1. Assess relevant literature or scholarly contributions in the aviation field of study.	DB1 – 100%; DB2 – 100%; DB3 – 100%; DB4 – 100%; DB5 – 100%; DB6 – 100%; DB7 – 100%; DB8 – 100%; DB9 – 100%; DB10 – 100%; DB11 – 100%; DB12 – 93.33%; AVG = 99.4%	Elements of Assessment (Discussion Boards) yielded 99.4% and exceeded the desired benchmark of 80%.
2. Apply the major practices, theories or research methodologies in the aviation field of study.	Assignment 1 (Accident Causation Model) – 98.3%; Assignment 2 (Witness Interviewing) – 100%; AVG = 99.15%	Elements of Assessment (Assignments) yielded 99.5% and exceeded the desired benchmark of 80%.
5. Evidence of scholarly and/or professional integrity in the aviation field of study.	Accident Case Study – 100%; Aviation Accident Report – 98.3%; AVG = 99.15%	Elements of Assessment (Accident Case Study & Aviation Accident Report) yielded 99.15% and exceeded the desired benchmark of 80%.

Course Assessment (Intended Use of Results)
The following will be used for recommendations to improve the quality of course delivery based on assessment results. These recommendations may include prerequisite change; changing course outline and adding more topics; adding a third assessment; changing the course sequence, etc.

The assessment of student learning outcome (5) – evidence of scholarly and/or professional integrity in the aviation field of study – did meet the benchmark of 80%, where the students presented their scholarly and/or professional integrity on different aspects: exploring aviation safety databases, analyze an aviation accident case in its entirety, analyze several pieces of accident data, and present their analyses, cases, findings, and recommendations in standard ICAO format. For the upcoming semesters, the same elements of assessment "Accident Case Study & Aviation Accident Report" will be used for evaluating the student performance in class.

Gulfstream G650 Flight Test Accident: An Organizational Disaster

[redacted]

St. Louis University

ASCI 5150 Aviation Incident and Accident Analysis

Dr. Gajapriya Tamilselvan

February 24, 2021

Gulfstream G650 Flight Test Accident: An Organizational Disaster

The Gulfstream G650 is one of the fastest and most luxurious corporate jets available today. The large swept-wing jet is not only fast, holding world records for speed and range (Gulfstream Aerospace Corporation, 2021), it is also the 2014 Robert J. Collier trophy winner, an award "for the greatest achievement in aeronautics or astronautics in America, with respect to improving the performance, efficiency, and safety of air or space vehicles" (NAA, 2021). However, these accolades came at a steep price. The design's development history was deeply and permanently scarred on April 2, 2011, when serial number 6002, one of the five experimental prototype aircraft, was destroyed in a fiery takeoff accident during flight testing in Roswell, New Mexico, killing all four crew members on board. While a cursory glance of the accident sequence may point to a degree of pilot error or a simple loss of control, the NTSB analysis did not directly implicate the flight crew in the accident, but rather, Gulfstream as an organization (NTSB, 2012).

This paper examines the accident against the framework of James Reason's classic accident causation theory, the "Swiss Cheese" model. While other models of accident causation, such as the SHELL model and the 5-Factor model, focus primarily on the human-machine-environment interface, Reason's model was originally designed to uncover latent errors in organizational accidents (Cusick, Cortes & Rodrigues, 2017). Therefore, it seemed most appropriate for the study of this event.

Background: The Purpose of the Flight and the Accident Sequence

Takeoff safety speed (V_2) is the minimum speed a twin-engine jet aircraft can safely climb if one engine fails during the takeoff run past V_1, which is the maximum speed at which the aircraft can safely stop on the remaining runway. V_2 is effectively the best single-engine angle of climb speed, which must be attained at 35 feet above the runway surface and continued until reaching 400 feet above the ground (SKYbrary, 2017). It is a critical performance number that is used to determine the minimum runway length required for takeoff in Part 25 transport category aircraft. Gulfstream had been advertising a 6,000-foot "takeoff performance guarantee" (NTSB, 2012, p. 12), so keeping the aircraft at or below the calculated V_2 speed was crucial to keep the required runway length at 6,000 feet or less (NTSB, 2012).

On April 2, 2011, the Gulfstream flight crew, which consisted of two pilots (PIC and SIC) and two flight test engineers, attempted to takeoff from Runway 21 at Roswell International Air Center on a short flight to test a one-engine-inoperative (OEI) takeoff technique in the last of many attempts to climb out at the target V_2 speed calculated by Gulfstream engineers. The OEI takeoff technique required very precise pitch settings, to within 1 degree, to achieve the target V_2 at 35 feet above the runway surface without exceeding it, but also remain below the wing's critical angle-of-attack (AOA). The flight test department had tried numerous times, and developed increasingly precise and aggressive rotation techniques to capture the V_2 speed, but the aircraft had consistently exceeded the target speed.

In addition to the flight crew, a small team of engineers occupied a telemetry trailer on the airport to gather measurements on wind and real-time flight data. At approximately 9:33 AM, during the takeoff roll, upon reaching V_1, the SIC cut power to the right engine as planned. At V_R (rotation speed), the PIC pulled the yoke back to lift the nose to the predetermined pitch attitude for liftoff. During the liftoff sequence, an increasing right bank developed, which surprised the flight crew. Despite the restoration of thrust to the right engine and full-left aileron and rudder control inputs, the bank was unrecoverable. The yaw forces to the right initially induced by the inoperative engine, combined with a light crosswind from the left and the stalled wing on the right side, forced the right wingtip to contact the runway surface. The 99,000-pound aircraft careened off the side of the runway, bounced, and struck a concrete runway maintenance structure, severely damaging the center section and fuel tank in the wing structure and igniting a massive fire. The big jet ultimately slid to rest on its belly near the Roswell control tower and burned. Although the impact was deemed survivable, none of the occupants made it to the exit door before being overcome by smoke and fire (NTSB, 2012).

The NTSB identified several key factors that contributed to the accident, all of which can be grounded in Reason's model for organizational accident causality. While flight crew error during a hazardous single-engine takeoff may have been an early and logical presumption, any blame on the pilots paled in comparison with the uncovered faults of Gulfstream management.

A Series of Latent Errors

Reason's model is useful for uncovering latent errors in an organization. Even though accidents are often caused directly by "active errors" between the man/machine interface, there are almost always organizational factors and "latent" errors that created an environment or set of circumstances that allowed the active errors to occur (Reason, 1990, p. 173). In this case, yes, the flight crew made an active error by stalling the aircraft on takeoff. But if one simply asks "why," they can trace the root cause all the way back up the chain to upper management, where errors in decision-making had slowly eroded safety. Reason's model consists of several layers of the typical production organization, namely management, environment, operators, and defenses. Normally, accidents are absorbed by the layers through good decision making, risk management, refined skills through training, good maintenance practices, and safeguards such as technology and protective equipment. But when unsafe acts are able to slip through the inherent defenses of each layer, accidents can happen. Reason's visual depiction of this model looks like several layers of Swiss cheese, which is why it is commonly known as the Swiss Cheese model. The safety lapses are holes in the cheese. When the holes line up in often unforeseen or random ways, accidents occur (Cusick, Cortes & Rodrigues, 2017). The Gulfstream accident was likely due to the complex and flawed interactions of these organizational layers. If we walk back through the layers after the accident, we can trace both active errors and latent errors all the way back to the top of the heap at Gulfstream. Some active errors by engineers developed into latent errors, as they were not discovered until after the accident had occurred.

According to the NTSB (2012), several key factors contributed to the loss of 6002 and her crew. When held up against the framework of Reason's model, they look like this. Note that a second layer of "unsafe acts" was added to the model for this accident, as the actions and errors of the flight crew were separate, but intricately linked to those of the engineers. The model and the NTSB accident factors are diagrammed in Figure 1.

- ***Defenses:*** The primary defenses against a stall, the stick shaker and the Pitch Limit Indicator (PLI), did not activate on the accident flight until the wing was well past the point of stall. Investigators determined that Gulfstream engineers had overestimated the in-ground-effect stall angle-of-attack (AOA) of the G650 wing by nearly 2 degrees. As a result, the thresholds for both stall-warning devices were set too high to be of any use.
- ***Unsafe acts of the flight crew:*** The NTSB reported that the flight crew's response to the uncommanded roll were "understandable" (NTSB, p. 25), but they were faulted for continued aggressive focus on achieving the target V_2 airspeed, despite the indications that the speed was too low. Additionally, the lead flight test engineer exacerbated the V_2 overspeed problem by lowering the target pitch attitude during the takeoff maneuver in previous test flights without a corresponding increase in takeoff speeds.

- ***Unsafe acts of engineering:*** Serious errors were made by Gulfstream engineers during the calculation of stall AOA and takeoff speeds.
    - The ground-effect stall AOA was based on wind-tunnel testing and an assumption that the difference between ground-effect stall AOA and free-air stall AOA was 2 degrees, a theoretical value agreed upon by the engineering teams, and the value that was used during certification of an older Gulfstream jet, the GIV. After the accident, detailed analysis found that the actual ground-effect stall AOA during the accident was 3.25 degrees less than the free-air stall AOA. This error manifested itself in the inaccurate limits programmed into the stick shaker and the PLI.
    - The V_2 target was the minimum speed allowed by rule, 1.13 times the stall reference speed (V_{SR}). The engineering team assumed that the G650 would perform the same as the G550, which was able to demonstrate V_2 speeds below the minimum allowed values. Had the engineers based their takeoff speed calculations on actual flight test data of the model being tested, instead of a different model altogether, they would have realized that the target V_2 speed was impossible to achieve with the G650.
- ***Psychological preconditions:*** Reason (1990) stated that within his model, there is a layer in between the frontline worker and the line managers. This is the layer where the stage is set for acts to follow, where psychology and environmental factors play a role. Cusick, Cortes and Rodrigues further elaborated on this layer as one of "Preconditions for Unsafe Acts" (2017, p. 57), where high workload, time pressure, and ignorance can affect the performance of an operator. Before the G650 accident, there were significant pressures

placed upon the flight test team to not only finish testing on time, but also meet the design expectations of Gulfstream's advertised 6,000-foot runway performance guarantee (NTSB, 2012). Despite suggestions from the FAA that they file for an extension of the five-year window for certification, the company refused until after the accident. A time extension would have required additional effort to bring the aircraft up to certification standards valid during the year of the extension application, instead of the year of original application. The NTSB final report alluded to instances where assumptions were possibly made in haste to save time, and staff, including the lead flight test engineer on the accident flight, appeared overworked. The FAA had told the team just two days before the accident that their flight testing timeline was unrealistic (NTSB, 2012).

- ***Line management deficiencies:*** During the months preceding the accident, the G650 flight test team had two separate incidents of "uncommanded roll" to the right that did not result in damage during OEI takeoff testing. The flight test team concluded that the first event was due to over-rotation during liftoff by the PIC, and the second incident was due to the absence of the yaw damper. Had management investigated the root cause of these incidents, together with the existing flight test data already gathered, the NTSB feels that the errors in the calculated V_2 and ground-effect stall AOA could have been detected before the accident.
- ***Fallible decisions:*** These decisions lie with senior management and shape all of the actions and environments in the company. The NTSB was particularly harsh with management in their final report, stating that Gulfstream management "failed to establish adequate flight test operating procedures, adjust the G650 flight test schedule to account for program delays, and develop an effective flight test safety management program"

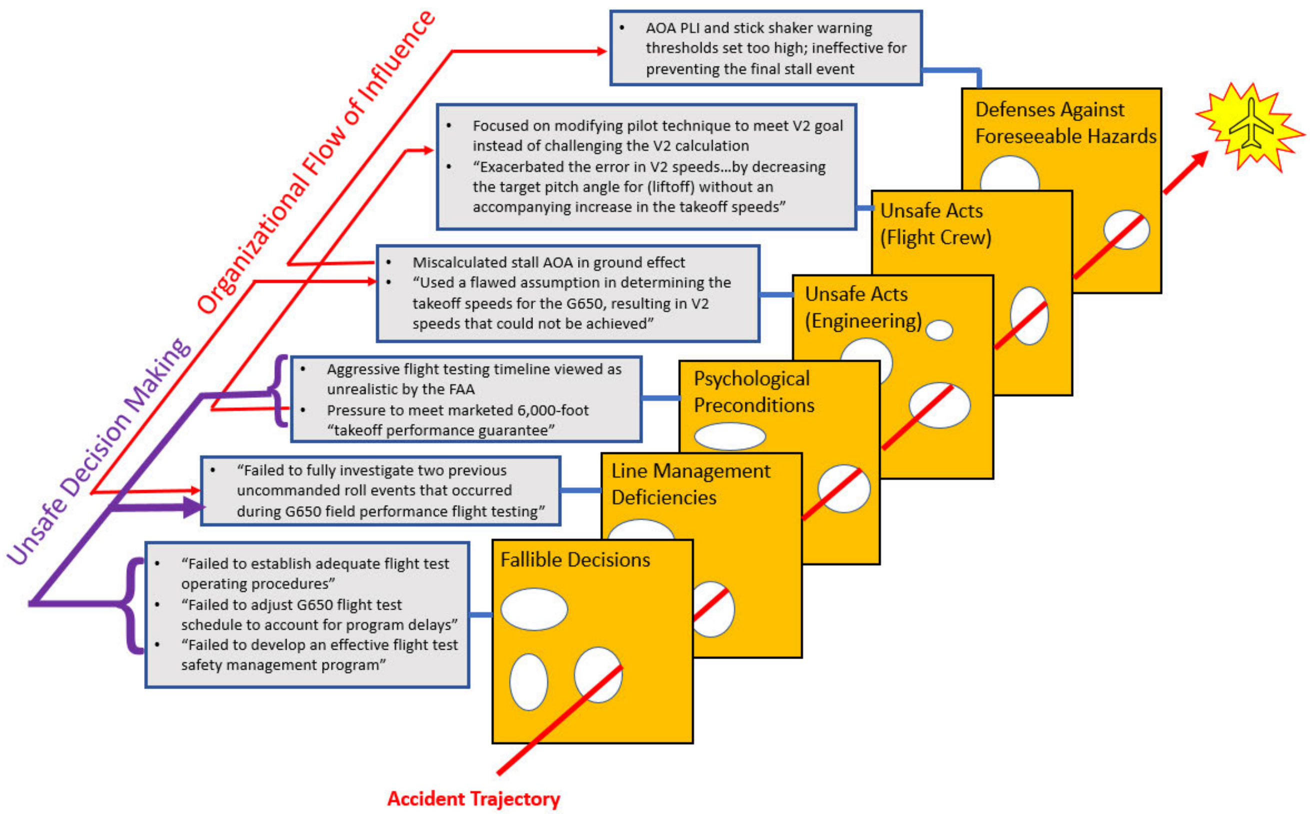
(NTSB, 2012, p. 26). These decisions, or lack thereof, helped to shape the errors that appeared downstream. The push to certify on time created an undue sense of urgency. A lax attitude about previously-established flight test procedures prevented a rigorous, data-driven approach to establishment of takeoff speeds. The lack of a safety management program allowed the testing program to continue uninterrupted after two uncommanded-roll incidents because they were not properly investigated. If they had been investigated, the engineers would have discovered that the right wing experienced a stall during those events, but miniscule factors of pitch angle and wind likely prevented them from becoming accidents.

Conclusion

Hindsight is a powerful thing, and while some of these conclusions may seem obvious, it was likely that people at Gulfstream did not see that they had set themselves up for disaster. The crash of the experimental Gulfstream G650 in flight testing appears to be a classic example of an organizational accident as described by James Reason. By examining the errors identified by the NTSB in the context of Reason's "Swiss Cheese" model of organizational accident causality, we can understand how organizational errors in decision and judgment at Gulfstream combined with critical miscalculations and misguided assumptions to set up a deadly lapse in safety. Reason (1990) wrote that the interaction of organizational factors and human errors is often intertwined, random and complex; this accident was no exception, with engineering and management decisions combining together to create a very hazardous situation that could have been prevented, but was not fully understood until it was too late.

Figure 1

"Swiss Cheese" model applied to the Gulfstream G650 flight test accident at Roswell



This diagram was created to frame the particular factors called out by the NTSB as events and conditions that shaped the accident against the layers of Reason's accident causality model. To the left of the textual descriptions is an addition to Reason's original model. The lines represent some of the complex influences at work within the organization, with purple showing the pressure of decision making from management, and red arrows diagraming the interaction of factors from management down to the operators and safety defenses.

Note: Quoted text is from NTSB, 2012, p. 25-26.

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Assignment 2 – Witness Reporting

Helicopter Down

[redacted]
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May 4, 2021

1. Brief Description of the accident scenario

(a) In this accident, there was a tourism helicopter flying over water. The helicopter lost altitude, at which time, somebody on a nearby ferry began filming the helicopter. The helicopter hovered over the water. Unable to generate lift, it could not return to a proper flying altitude. The tail end of the aircraft then went up in the air, and like a cartwheel, went into the water, turning the helicopter "belly" up. In the water, the water the passengers were able to escape into the water and appear like little coconut heads toward the end of the video, heads bobbing in the water.

2. Witness report

(b) The witness begins her testimony, "Sorry I'm just a little shakin' up about what I saw. It was 35 minutes ago." She begins to tell her story, "We were on a floating catamaran, what do you call it, a, I saw a helicopter or submarine bobbing, propeller counter clockwise. Floatation tanks seemed *"odd."* Somebody pointed to me look over there, it was bouncing around. Is it swimming? The it started *dipping* into water, propeller clockwise motion." Without interruption by the interviewer, she goes on to say and self analyze, "maybe too much weight. Front end can see people. Hovering above like a bobbing for apples situation. Then it flips over into the water." After thinking about what she saw, she then starts to question what she saw, "I don't know if I saw people get out. I was at the Ferry back. I did not have binoculars." Going on to describe the situation, "People in rafts heading over there. Honestly, it was like the helicopter belonged to the water, apples bobbing." The self analysis comes back, she describes, "It was surreal, subtle. You should get. Very unnerving. I need a drink after." Back to the accident, "Machine failure, the wind, waves, sucked it in like a seamonster tradgedy. Like I said, unnerving" She goes on to describe after the crash, "I don't know if people made it out. Doesn't seem like there's enough time. There was people more in the front end of our ship, but they missed. I saw what more happened beforehand. The pointed it out to me. I can't really speak to that." Here the witness realizes that she missed the start of the event, but somebody pointed it out to her. She goes on, "I can't really speak to that. It's almost like one electromagnetic force, you know, the propellers are going it up, and then the wave, then got lifted to *sky, dipped* in water. Was still kind of *floating* at the same time." After describing the *final* moments of the accident, the witness notes, "There was a fishing or whaling raft nearby." She goes back to the accident, "Then it started sinking like an elevator or escalator out of the sea." Giving insight into how the witness couldn't tell what she was looking at, "Model, floating above, floatation devices, become a land to air vehicle, I mean transport. There was subtlety. A fisherman, some rafts there the back end lifts more as front end down propellers spinning, counter class basically, suddenly, aircraft upside down, descending slowly into the water."

3. Personal reflection

(c) English and Kuzel introduce their audience to the concept of Double Translation with a foray into 1960's-era Aviation Accident Investigation. English doctor, Dr. Percy Walker of the Ministry of Aviation notes "that eyewitnesses to aviation accidents are 'almost always wrong' (p. 8). (2014, p 1). In the same article, in which that was sourced, The Sunday Times notes that Walker was said "to have researched more crashes than anybody else in the world (Air Correspondent, 1962)" (English, D. & Kuzel, M, 2014, p.1). This logic was used and developed to explain the nature of inaccuracies in eye-witness testimony. As early as 1906, researchers identified problems with eye-witness testimony and recollection, using the 1908 Münstenberg study in which a revolver was fired during a theatrical scene, a scene conducted by actors (English, D. & Kuzel, M, 2014, p.1). This problem with eye witness translation and theater could really be felt during my interview. The strongest example I have is that my witness could not discern whether she was looking at a helicopter or submarine, yet was discussing the event with terms like “electromagnetic interference.” The witness used very flowery language, *some*thing, that as a researcher I have *all* but *learned* must be avoided, due to having been *taught* that. The idea of using a term like “subtlety” or “like bobbing apples” to describe an aviation accident I found *pretty* astounding and astonishing. English and Kuzel explain Double Translation as the process through which a witness experiences something and then tries to explain it, perhaps even using technical language, to an interviewer or researcher. In this event, the witness describes the motion of the propeller and the direction of, but it changes direction throughout her story. Realistically, I think this was very difficult to discern while watching the event, but perhaps, given how the water looked, she projected that possibility of direction, though this is complete speculation. The mixing of this type of information is typical during eyewitness recall events. Katherine Puddifoot writes about this phenomenon of eye witness inaccuracy in the Cambridge University Press, article, “Re-evaluating the credibility of eyewitness testimony: the misinformation effect and the overcritical juror.” She states, “Because jurors tend to □find eyewitness testimony compelling and persuasive, it is argued that jurors are likely to give inappropriate credence to eyewitness testimony, judging it to be reliable when it is not” (Puddifoot, K., 2014, p. 255). Having witnessed this witness testimony be given, from the researcher perspective, this was completely the case. The witnesses description was emotional, compelling, and theatrical. When I was doing the witness interview, I had not seen the video, and having completed the interview, I had no idea what to expect. The interviewer couldn’t tell if this was a helicopter or a submarine during her testimony. After I saw the video, though, I do understand how that’s possible. As the event starts when the witness sees a helicopter, which has lost its ability to generate life effectively, hovering just feet and inches above water. Because of the waves, which were about as tall as how high from the surface the it was hovering, it did look like it was bobbing, even though, a helicopter cannot bob. When the helicopter crashes, the tail flips up into the air and then over the head, before entering the water. This change in the helicopter may explain why the spinning rotation of the blades was described as clockwise in part of the *story* and counter clockwise in another. It seems her story was right on. The witness did a very *thourough* job describing what she saw, but because of double translation and issues with witness accuracy and theatrics fueled difficulties with discerning what happened by listening to a non-technical witness describe crash. Getting through the *wall* and learning to do this interview was really cool and a process that I recommend.

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Accident Case Study: Left Engine Failure and Subsequent Depressurization

Southwest Airlines Flight 1380

[redacted]

Parks College of Engineering, Aviation, and Technology

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ASCI 5150: Aviation Incident and Accident Analysis

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March 20, 2021

Brief Description of the Accident Scenario

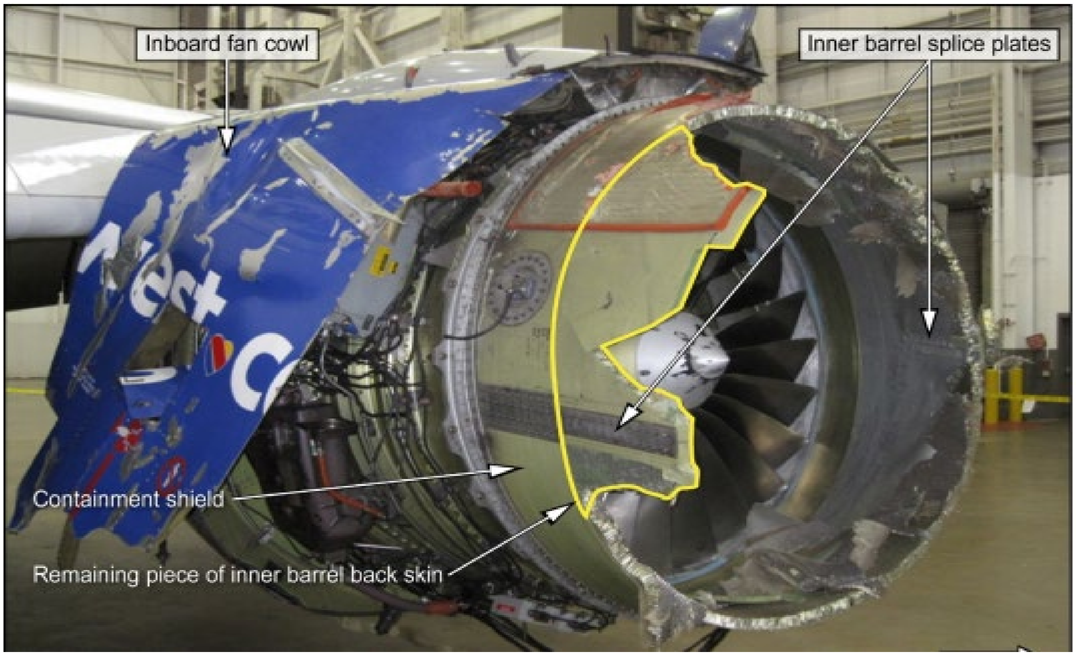
This paper is an overview of the findings, causes, and recommendations reported by the National Transportation Safety Board regarding the accident experienced by Southwest Airlines Flight 1380 on April 17, 2018.

Southwest Airlines Flight 1380, operated by a Boeing 737-7H4, was a domestic flight regularly scheduled from New York–LaGuardia Airport to Dallas Love Field. After a moment having departed from LaGuardia Airport at about 1103 EDT on April 17, 2018, flight 1380 experienced an engine failure in the left engine. The engine fan cowl was broken into several pieces and separated from the airplane in-flight. Some of the separated cowl pieces badly damaged the airplane's left-side fuselage near a cabin window, while others did severe damage to the airplane's wing. After suffering the cabin window damage, the airplane experienced rapid depressurization. Thus, the flight crew declared an emergency and requested the controller change the flight's direction to the nearest airport, Philadelphia International Airport (PHL), Philadelphia, Pennsylvania (National Transportation Safety Board, 2019).

The flight crew was able to land the airplane safely at PHL, albeit the left engine failed. Nevertheless, due to a rapid drop in aircraft cabin pressure, five crew members and one passenger were fatally injured, and eight other passengers received minor injuries. The airplane sustained substantial damage in the accident (National Transportation Safety Board, 2019). The NTSB's investigation images associated with the engine and the fuselage damage are depicted in Figure 1 and Figure 2.

Figure 1

The disabled left engine by the broken fan blade



Source: (National Transportation Safety Board, 2019, p.21)

Figure 2

Damaged aircraft fuselage by the broken fan cowl

Source: (National Transportation Safety Board, 2019, p.19)

Investigator Information and Analytical Techniques

The NTSB's investigators were officially communicated about the accident of flight 1380 at 13:07 EDT on April 17, 2018. The investigative team consisting of "the *Federal Aviation Administration (FAA), Boeing, CFM International, Southwest Airlines (SWA), Southwest Airlines Pilots Association, Collins Aerospace, Transport Workers Union Local 556, and Aircraft Mechanics Fraternal Association"* arrived the scene at Philadelphia International Airport (PHL) at about 16:30 EDT (National Transportation Safety Board, 2019, p.93). The investigative team was then divided into various technical areas, such as operation, power plants, structures, and survival factors, to collect data regarding their investigative tasks. Following the on-scene investigation, the NTSB performed an investigative hearing for the accident of flight 1380 on November 14, 2018. The main issues discussed at the investigative hearing contained as follows: "(a) CFM56-7-series engine fan blade design and development history, (b) CFM56-7-series engine fan blade inspection methods and procedures, and (c) engine fan blade-out containment design and certification criteria" (National Transportation Safety Board, 2019, p.93).

Based on the issues discussed at the investigative hearing, the accident investigators' analytical techniques centered around the CFM56-7-series engine to understand the impact of a fan-blade-out (FBO) event, an occurrence of engine failure when one of the fan blades broken at its root (National Transportation Safety Board, 2019). Within the context of this investigation, the new analytical techniques were jointly developed by Boeing and CFM International, a jet engine manufacturer, to grasp the nexus between the CFM56-7B engine and the 737-700 airplane structure during the accident FBO event. The newly developed analytical techniques primarily focused on "the operating conditions that the accident engine, inlet, and fan cowl experienced when the fan blade separation occurred as well as the certification test results." National Transportation Safety Board, 2019, p.81).

It was pointed out that thanks to the analytical models developed by Boeing and CFM, the investigative team could accurately assess the following elements: “(a) the effects of the fan blade fragments’ impact with the fan case, (b) the effects of the resulting displacement wave, (c) the progressive failure of the inlet and the fan cowl, and (d) the relationship between the inlet and fan cowl failure sequences.” (National Transportation Safety Board, 2019, p.81).

Major Findings

At the end of the NTSB's accident investigation process, a total of 13 findings were reported based on the field notes. Major investigative findings were listed in Table 1.

Table 1

Major Investigative Findings the Crash of Southwest Airlines Flight 1370

• Due to dovetail stresses higher than expected levels under normal operating loads, low-cycle fatigue cracking in the fan blade dovetail occurred. It was most unlikely to detect low-cycle cracks during the fluorescent penetrant inspection at the time of maintenance performance tasks regarding the fan blade set's last overhaul and fan blade relubrications.
• Fan blade pieces moving forward from the fan case due to the displacement wave caused by the fan blade's impingement damaged the structural integrity of the inlet, causing the inlet parts to separate from the airplane.

• Some parts of the fan cowl departed from the airplane because (1) the effect of broken fan blade placed significant loads on the fan cowl through the radial restriction assembly, and (2) the residual strength of the fan cowl could not show resistance against the associated stresses in the fan cowl structure, which caused left engine failure.
• The airplane's window separated from the airplane by impacting the inboard fan cowl aft latch keeper with the fuselage. Subsequently, the cabin rapidly depressurized, and one passenger was fatally injured.
• The crash of flight 1380 revealed the susceptibility of the fan cowl put on the Boeing 737 next-generation aircraft to a fan-blade-out impact location near the radial restraint fitting and how such an impact would break the fan cowl into pieces.
• The flight attendants could not sit down on their assigned jump seats during the emergency landing.

Source: (National Transportation Safety Board, 2019, p.89-90)

Probable Cause of the Accident

"A low-cycle fatigue crack in the dovetail of fan blade" was determined as the probable cause of the crash of Southwest Airlines flight 1380 by the NTSB. The low-cycle fatigue crack caused the fan blade to separate from the airplane in flight and stressed the engine fan case, which is crucial for the fan cowl's structural integrity. The isolated fan cowl fragments violently hit the fuselage near the cabin window and led the window to detach from the aircraft. Consequently, a rapid depressurization of the cabin and subsequent passenger fatality occurred (National Transportation Safety Board, p. 90).

Major Recommendations

As a consequence of this investigation, the NTSB made various safety recommendations to the Federal Aviation Administration (FAA), Southwest Airlines, and the European Aviation Safety Agency (EASA) (National Transportation Safety Board, 2019). Table 2 listed the NTSB's safety recommendations for each aviation organization.

Table 2

The NTSB's Major Recommendations related to the Crash of Flight 1380

The Federal Aviation Administration (FAA)	• To ensure the structural integrity of the fan cowl after a fan-blade-out event, it was recommended for the FAA to make Boeing "determine the critical fan blade impact location(s) on the CFM56-7B engine fan case and redesign the fan cowl structure on all Boeing 737 next-generation series airplanes." • It was recommended for the FAA" to expand its certifications to mandate that airplane and engine manufacturers work collaboratively for the analysis of the critical fan blade impact locations on all engine operating conditions." • It was recommended for the FAA to develop and issue guidance so that "airlines can mitigate hazards to passengers affected by an in-flight loss of seating capacity."
Southwest Airlines	• To show the importance of being secured in a jump seat during emergency landings, it was recommended for Southwest Airlines "to include the lessons learned from the accident in initial and recurrent flight attendant training."

The European Aviation Safety Agency (EASA)	• It was recommended for the EASA "to expand its certification requirements to mandate that airplane and engine manufacturers work collaboratively at the time of the analysis of the critical fan blade impact locations on all engine operating conditions."

Source: (National Transportation Safety Board, 2019, p.91)

General Thoughts and Reflections

It is interesting to note that metal fatigue can still cause airlines incidents and accidents even if today's airplanes are manufactured with the latest technology. Campbell's academic research published in 1981 indicated that metal fatigue was a related cause of most aircraft accidents between the years 1934 and 1980 (Campbell, 1981). Although it has passed several decades since the publication of Campbell's research, many researchers have still shared similarities with Campbell's research findings. For example, Bhamik, Sujata, and Venkataswamy (2008) suggest metal fatigue leads to the majority of service failures in aircraft components, and it amounts to about 60% of the total failures. Likewise, Molent and Dixon (2020) assert that in-service failures from mechanical fatigue still occur in metallic airframe components despite numerous research studies conducted to prevent such failures. Airplanes' metallic parts become weakened over time because of repetitive flight cycles and frequent use (JETechnology Staff, 2019). Taken together, the NTSB's investigative findings would seem to suggest that low-cost carriers' high flight frequencies seriously weaken the endurance of aircraft's metal components.

Another noteworthy point in the accident report of flight 1380 is the NTSB's recommendation made to the European Aviation Safety Agency (EASA). Although the NTSB's primary role is to investigate civil aviation accidents in the United States, its safety recommendations made as a whole, in my view, have a beneficial influence on aviation safety improvements.

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Serious Injury to Flight Crewmember During Emergency Evacuation of FedEx Flight 1407

An accident report writing exercise

[redacted]

St. Louis University

ASCI 5150 Aviation Incident and Accident Analysis

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May 9, 2021

Serious Injury to Flight Crewmember During Emergency Evacuation of FedEx Flight 1407

Synopsis

On February 24, 2015, at approximately 0600 central standard time, a FedEx MD-11F, N584FE, operating as FedEx Flight 1407, a 14 CFR Part 121 cargo flight, experienced an automatic fire suppression system (FSS) deployment in the cargo hold. The flight crew made an emergency diversion and landing at Lambert St. Louis International Airport, St. Louis, Missouri. During the emergency egress, the L1 evacuation slide failed to support the weight of the first officer for undetermined reasons, and he sustained serious injuries. The captain and two jumpseaters exited after the first officer with additional help from fire personnel and sustained no injuries.

Body

1. Factual Information

1.1. History of Flight

On February 24, 2015, at approximately 0600 central standard time, a FedEx MD-11F, N584FE, was in normal cruise flight at FL360 enroute from MEM to MSP when it experienced an automatic fire suppression system (FSS) deployment in cargo hold 1C/1R. The captain was the pilot flying (PF). The cockpit CAS messages were confirmed to the crew by two FedEx jumpseaters who heard a very loud bang, "as if a door fell off one of the cans," and saw the red FSS warning lights in the 1C/1R cargo hold through the cargo bay window. They reported to the flight crew that they did not observe any smoke, flames or fumes. The flight crew followed the MD-11 QRH emergency fire/smoke checklist and made the decision to divert to Lambert St. Louis International Airport (STL), about 80 miles south.

After an uneventful diversion, approach and landing, the first officer coordinated with ATC to evacuate the aircraft on the taxiway as soon as possible after landing on Runway 12L. Using the QRH emergency evacuation checklist, the captain determined that they would evacuate using door 1L and the emergency slide, with the first officer going first, followed by the two jumpseaters, and then himself. The first officer opened the door, and the captain heard the slide inflate. The first officer and the two jumpseaters, who were closer to the slide, reported later that the slide did not look as if it was fully inflated, and hung up on its straps in a partially-inflated position. The first officer "tugged on the slide where it looked like it had hung up" as fire personnel pulled on it from the bottom, and it appeared to inflate normally. After a short exchange with fire personnel, he jumped onto the slide in accordance with standard emergency egress training, but the slide seemed to give way as he was halfway down. He hit the ground and rolled away from the slide, but did not get up. The fire fighters pulled the slide taut and supported it while the jumpseaters, and finally the captain, evacuated uneventfully.

1.2. Injuries to Persons

The first officer sustained serious injuries to his back. There were no other injuries.

1.3 Damage to Aircraft

The aircraft was not damaged during the event.

1.4. Other Damage

No property damage was reported during this accident.

1.5. Personnel Information

The flight crew and passengers consisted of two crew members and two FedEx pilots who were riding in the jumpseats.

The captain was age 55 and held an Airline Transport Pilot certificate and valid Class 1 medical certificate. His last Part 121 check was June 3, 2014 in the MD-11.

The first officer was age 51 and held an Airline Transport Pilot certificate and valid Class 1 medical certificate. His last Part 121 check was November 14, 2012 in the MD-11.

1.6. Aircraft Information

N584FE was a McDonnell-Douglas MD-11F, serial number 48436, manufactured in 1992. The aircraft was equipped with three General Electric CF6-80 turbofan engines.

1.7. Meteorological Information

No weather data was available at the time of this report.

1.8. Aids to Navigation

No aids to navigation were in use at the time of the accident.

1.9. Communications

No communications were recorded during the time of the accident.

1.10. Aerodrome Information

Lambert St. Louis International Airport (STL) is an international airport in St. Louis, Missouri, USA. The runway used by the accident flight was 12L, a 9,003 foot long by 150-foot wide concrete grooved runway. The evacuation took place on Taxiway K.

1.11. Flight Recorders

No flight recorder data was available at the time of this report.

1.12. Wreckage and Impact Information

The aircraft was not damaged during the accident. The slide/raft used during the evacuation was removed from the aircraft for evaluation and testing.

1.13. Medical and Pathological Information

Other than the serious injury to the first officer sustained in the evacuation, there were no medical issues, pathological testing or drug/alcohol testing made available to the NTSB.

1.14. Fire

After investigation of the cargo compartment where the fire suppression system had discharged, it was determined there was no fire on board the aircraft. The fire suppression system discharged as a false alarm for unknown reasons.

1.15. Survival Aspects

The evacuation slide did not work as designed during the evacuation sequence. Because it did not fully inflate, the first officer's body was not properly supported during his egress, and he subsequently impacted the taxiway, leading to serious injury. Firefighters on scene were able to assist the other crew members by supporting the slide at the bottom while they sat on the slide and gently slid down.

1.16. Tests and Research

The slide/raft assembly that was involved in the evacuation, Fed Ex Evacuation System 60289-117, serial number 0406, was shipped to Air Cruisers Company in Wall Township, NJ for examination by qualified personnel and the Survival Aspects working group. The slide/raft assembly, along with its carrying case, was found to have some areas of minor damage to various components, but nothing that would preclude normal operation. The inflatable unit was partially inflated with compressed air, and no leaks or unusual damage was found, although the re-entry/mooring lines were not routed correctly. There was a loose section in the left side middle of the inflatable, but no discoloration or marks that would indicate ingestion into the aspirator. The reservoir and valve assembly were pressurized and leak checked, with no leaks found. After the reservoir and valve assembly were reinstalled to the inflatable, a flat fire inflation was performed successfully, with 2.54 psi measured in the upper tube and 2.43 psi measured in the lower tube. No obvious leaks were found in either chamber. The valve regulator calibration check recorded a peak value of 497 psi, with a CMM requirement of 550 psi, +/- 50.

1.17. Organizational and Management Information

The accident flight was operated by Federal Express as a 14 CFR Part 121 cargo flight. No organizational or systemic factors were found to contribute to this accident.

1.18. Additional Information

None available at the time of this report.

2. Analysis

The flight crewmembers and jumpseaters each submitted reports of the accident. All of them, with slight variations, reported the same sequence of events. The flight crew was qualified for the flight, and followed the procedures set forth in the QRH appropriately for the fire suppression system discharge by making an immediate decision to divert and land at the nearest suitable airport. The captain made the correct decision to evacuate the aircraft despite the lack of physical evidence of a fire. Although the slide/raft functioned as designed during testing after the accident, for undetermined reasons it did not fully inflate during the evacuation, leading to the serious injury sustained by the first officer.

Figure 1 maps out the events and causal factors analysis, adapted from Wood and Sweginnis (2006, p. 464).

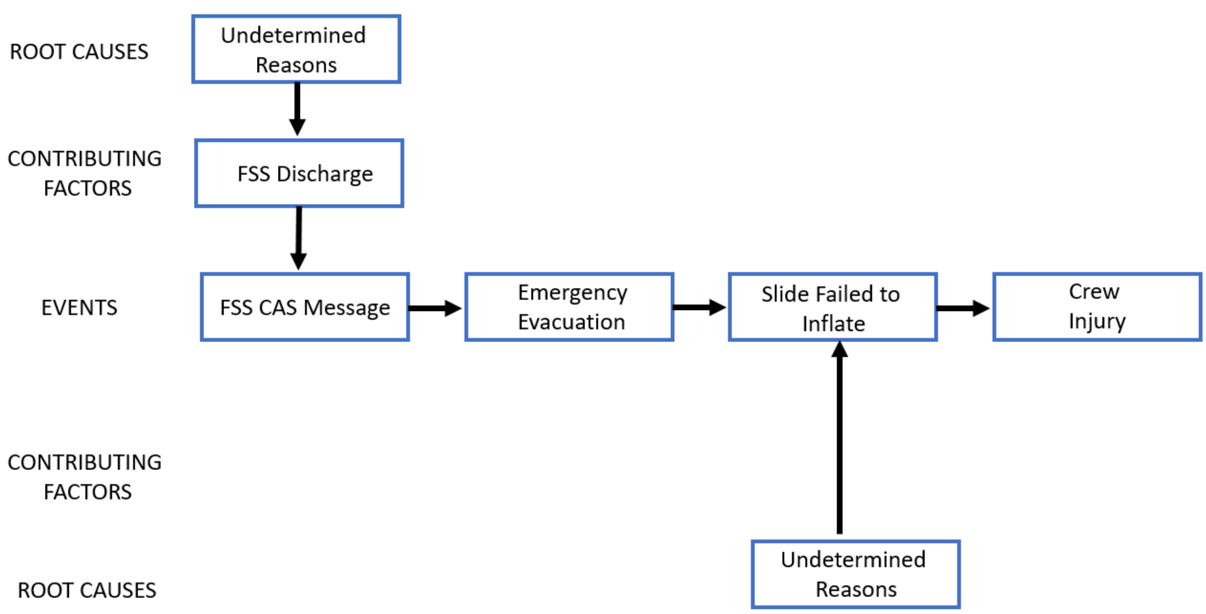


Figure 1: Events and causal factors analysis

3. Conclusions - Findings and Causes

The probable cause of this accident was the failure of the emergency slide/raft to fully inflate during the evacuation process for undetermined reasons, leading to an uncontrolled descent of the first officer to the surface of the taxiway and a resulting serious injury. Contributing to the accident was the inadvertent false-alarm discharge of the fire suppression system in the cargo hold.

4. Safety Recommendations

Recommendation A: The FAA should allow for use of additional training and deviated procedures in situations where there is clear evidence of a false alarm. This accident is a reminder that fire suppression systems and emergency equipment do not always function as intended. These systems must be properly maintained in accordance with manufacturer instructions. Airlines and their governing regulations provide strict procedures to follow in the event a safety device such as fire suppression system is deployed. However, should there be a false alarm or failure of such a system, the resulting situation can lead to additional difficulty and, in this case, needless injury.

Although the captain made decisions according to the QRH and airline procedures during this event, the lack of fire on the right side of the aircraft may have justified using the slide on the right side when it was observed that the left-side slide looked like it was not fully inflated. Flight crews should make informed decisions based not only on the procedures, but also physical evidence of a threat in these types of situations.

Recommendation B: Airports should strive to improve EMS response times. While it was not included in the body of the report, it was reported that it took EMS crews 10-15 minutes to reach the first officer and render aid. The fire crew was preoccupied with helping the remaining three people out of the aircraft and did not render aid immediately, despite his debilitating injury and his immobility on the concrete in freezing temperatures. Airports should evaluate their first responder teams to provide faster response for EMS and/or larger fire crews able to handle more timely trauma relief.

References

National Transportation Safety Board [NTSB]. (2017, February 17). Aviation Investigation - 12 Docket Items - DCA15FA073. https://data.ntsb.gov/Docket?ProjectID=90773

Wood, R.H. & Sweginnis, R.W. (2006). *Aircraft accident investigation*. Endeavor Books: Casper, WY.

Graduate Course Assessment Form

Assess Student Learning Outcomes

Course: ASCI 5220 Aviation Safety
Programs Semester Taught: Fall 2020
Number of Students in Course: 3

Student Learning Outcome Assessed	Assessment Results: (Indicate what % of class achieved a minimum score of 80%)	Benchmark achieved? (Benchmark: 80% of students will score a minimum of 80% = "B")
1. Assess relevant literature or scholarly contributions in the aviation field of study.	100%	Yes
3. Apply knowledge from the aviation field of study to address problems in broader contexts.	100%	Yes

Course Assessment (Intended Use of Results)
The following will be used for recommendations to improve the quality of course delivery based on assessment results. These recommendations may include prerequisite change; changing course outline and adding more topics; adding a third assessment; changing the course sequence, etc.

**Attach description of assignment used for assessment and samples of student work.*

Graduate Course Assessment Form

Assess Student Learning Outcomes

Course : ASCI 5470-01 Quantitative Data Analysis
Semester Taught: Spring 2021
Number of Students in Course: 1

Student Learning Outcome Assessed	Assessment Results: (Indicate what % of class achieved a minimum score of 80%)	Benchmark achieved? (Benchmark: 80% of students will score a minimum of 80% = "B")
2. Apply the major practices, theories or research methodologies in the aviation field of study.	SPSS 1 – 100%; SPSS 2 – 100%; SPSS 3 – 0%; SPSS 4 – 0%; SPSS 5 – 0%; LMR Design – 100%: AVG = 50%	Elements of Assessment (SPSS Assignments & LMR Design) yielded 50% and did not exceed the desired benchmark of 80%.
5. Evidence of scholarly and/or professional integrity in the aviation field of study.	SPSS 1 – 100%; SPSS 2 – 100%; SPSS 3 – 0%; SPSS 4 – 0%; SPSS 5 – 0%; LMR Design – 100%: AVG = 50%	Elements of Assessment (SPSS Assignments & LMR Design) yielded 50% and did not exceed the desired benchmark of 80%.

Course Assessment (Intended Use of Results)
The following will be used for recommendations to improve the quality of course delivery based on assessment results. These recommendations may include prerequisite change; changing course outline and adding more topics; adding a third assessment; changing the course sequence, etc.

The assessment of student learning outcome (5) – evidence of scholarly and/or professional integrity in the aviation field of study – did not meet the benchmark of 80%, where the students presented their scholarly and/or professional integrity on different aspects: statistical research design, using statistical software to analyze aviation/aerospace data, interpreting statistical data from their own research studies, exploring published research findings, interpreting published research findings, and presenting the research findings in APA format. Specific elements of assessment include: Frequency Distribution (SPSS 1), Measures of Central Tendency (SPSS 2), independent *t* test (SPSS 3), Analysis of Variance (ANOVA – SPSS 4), Pearson Correlation (SPSS 5), and Linear Multiple Regression (LMR) design. For the upcoming semesters, the same elements of assessment "SPSS Assignments & LMR Design" will be used and more participation from the students will be encouraged.

**Attach description of assignment used for assessment and samples of student work.*

Evaluating Non-Fatal Accidents During the Landing Phase

Saint Louis University

One of the most important flying skills a pilot must develop is landing. According to the Federal Aviation Administration (FAA), the landing phase represents nearly half of all general aviation accidents (FAA, 2008). Many types of accidents and factors can occur during the approach and landing phase of flight. The most common types of factors include controlled flight into terrain (CFIT), loss of control (LOC), and runway excursions (FAA, 2008). Due to the inherent risks, there is a concentrated effort across international safety experts to address all aspects of approach and landing accidents (Skybrary, 2020).

Pilots across all levels recognize the approach to landing as a critical phase of flight. Critical phases of flight require the flight crew to perform only the duties required for the safe operation of the aircraft. It is during this phase that pilots should be the most attentive to their environment and operation of their aircraft. Awareness of the highest risk phase of flight is important for operators to prepare themselves for any factors and lead to the safest outcome. The purpose of this research is to identify the number of landing accidents leading to non-fatal injuries.

Method of Analysis

Data Source

The National Transportation Safety Board (NTSB) is an independent U.S government investigative agency responsible for civil transportation accident investigation. According to the NTSB, the aviation accident database contains civil aviation accidents and selected incidents within the United States from 1962 (NTSB, 2021). This database was used for searching and grouping of data for data analysis.

Verification on type of data

For this research, the search query utilized the term “forced landings” to identify relevant accidents in the NTSB database. Since the NTSB records accidents from 1962, this research restricted the dataset to the most recent periods of 2003-2007. Injury severity was limited to non-fatal outcomes. There was no consideration for the operation classification between Part 91, 135, or 137. The phase of flight that was considered was the landing phase. The discrete dataset was classified by these groups and were determined to be categorical variables. The initial query and subsequent screening resulted in 1681 valid occurrences.

Research Question

For the period of 2003-2007, how many accidents resulted in non-fatal injuries during the landing phase?

Data Analysis

The dataset was obtained in the .XML format, prescreened in Microsoft excel, and imported in the SPSS program for analysis. The data is discrete because the occurrences and categorical variables were measured numerically. Frequency analysis was used to identify the number of occurrences of incidents for each phase of flight. Table 1 represents the dataset as a table form and initially organized to compile the findings and determine the cumulative distribution. According to this view, cruise flight represents a significant frequency of occurrences. Figure 1 presents this distribution as a bar graph. Figure 2 better represents this percentage difference as a pie chart compared to the other phases of flight.

Results

The results of the study showed that the cruise phase of flight represents 38% of non-fatal forced landings during the period of 2003-2007. During the landing phase of flight, 25 total accidents resulted in non-fatal injuries to the occupants. This total combined with the approach phase of flight led to 258 occurrences leading to non-fatal injuries which accounts for 15.4% of the total accidents from this period. Unsurprisingly, ground operations such as the taxi phase of flight or other did not have a higher percentage of events.

Limitations included in this study were the conditions that each event occurred in. The retrievable data from the NTSB database did not fully explain the nature of each of these occurrences. Combined with the factor of a large dataset, it would be time consuming to evaluate each case report to determine the factors into each event. Future research on this topic should the effects of the safety recommendations made by international and domestic authorities to minimize these occurrences.

References

Federal Aviation Association. (2008). On Landings Part 1. Retrieved from https://www.faasafety.gov/gslac/ALC/libview_normal.aspx?id=56408

NTSB Accidents Database. (2021). Aviation Accident Database & Synoposes. Retrieved from http://www.aviationdb.com/Aviation/AccidentQuery.shtm

Skybrary. (2020). Approach and Landing Accidents (ALA). Retrieved from https://skybrary.aero/index.php/Approach_and_Landing_Accidents_(ALA)

Tables

Table 1. Data Summary and Cumulative Percent

Broad Phase Of Flight

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		40	2.4	2.4	2.4
	APPROACH	233	13.9	13.9	16.2
	CLIMB	76	4.5	4.5	20.8
	CRUISE	644	38.3	38.3	59.1
	DESCENT	104	6.2	6.2	65.3
	GO-AROUND	23	1.4	1.4	66.6
	LANDING	25	1.5	1.5	68.1
	MANEUVERING	172	10.2	10.2	78.3
	OTHER	1	.1	.1	78.4
	TAKEOFF	361	21.5	21.5	99.9
	TAXI	2	.1	.1	100.0
	Total	1681	100.0	100.0	

Figures

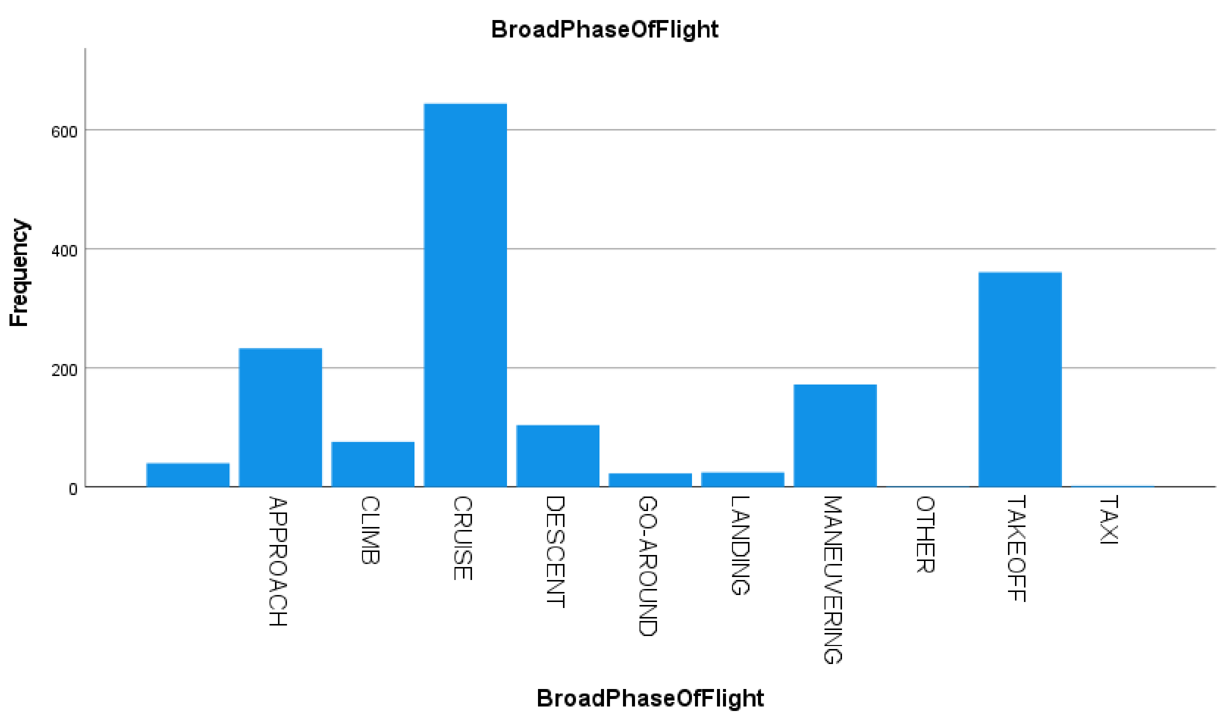


Figure 1. Frequency Distribution of Non-Fatal Accidents

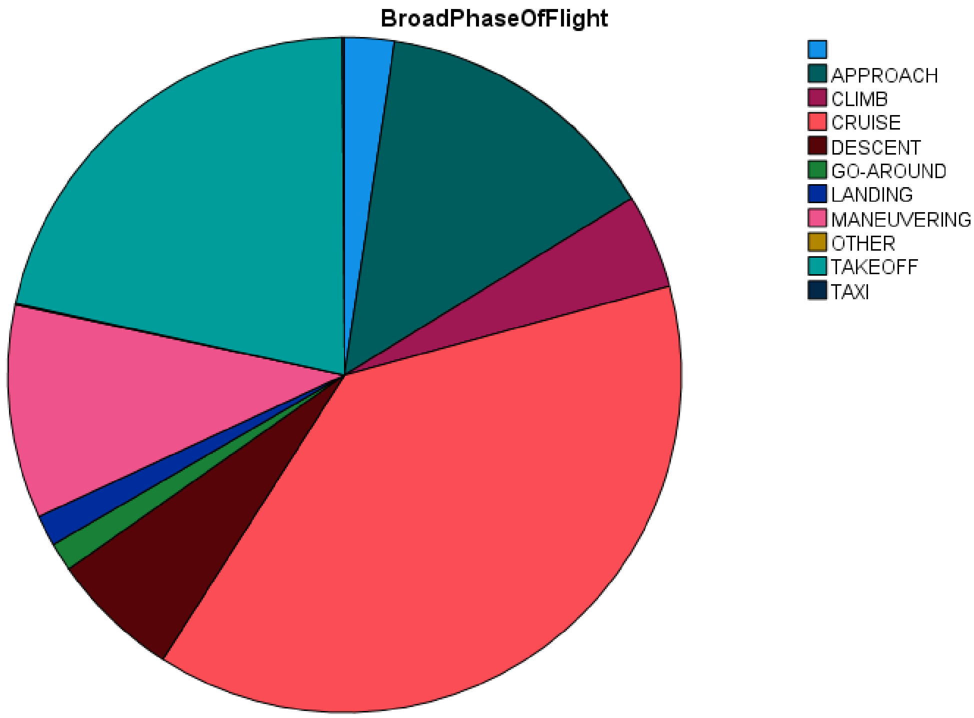


Figure 2. Percentage of Non-Fatal Accidents

Analysis of Pilot Experience to Time Under Pressure

Saint Louis University

Pilots who have earned their airline transport pilot (ATP) certificate have accumulated a minimum of 1,500 recorded flight hours. This experience represents a wealth of knowledge inside the cockpit however, does this experience translate into efficiency under pressure? A pilot's skill, competence, and qualifications for new ratings is largely based on logged experience. The knowledge and skills of a student pilot compared to a seasoned flight instructor is far apart. For example, to earn your flight instructor certification accumulation of experience is not only a legal requirement but a safety one as well. A key factor that may assist pilots in performing the task safely in highly demanding and stressful situations is their level of expertise, especially their prior experience with the situation (Limor, 2020, pg 39). According to Limor, studies have shown that "inexperienced pilots tend to possess higher levels of mental workload than experienced ones" (Limor, 2020, pg 39). Therefore, the requirements to earn an ATP certification exists as a benchmark of safety. In theory, more experienced pilots should have the capacity to handle highly demanding and stressful situations. A pilot's expertise should allow them to recall more information relevant to the task. In a study evaluating the effects of flight experience of captains and first officers suggests this conclusion. As expected, the results of the study pointed that pilots with lower levels of experience were more likely to be involved in a safety incident compared to pilots with higher levels of experience. The question arises whether the experience of an ATP certificated pilot outweighs the ability of a pilot with this certification to handle an emergency.

Method of Analysis

Data Source

The National Transportation Safety Board (NTSB) is an independent U.S government investigative agency responsible for civil transportation accident investigation. According to the NTSB, the aviation accident database contains civil aviation accidents and selected incidents within the United States from 1962 (NTSB, 2021). This database was used for searching and grouping of data for data analysis.

Verification on type of data

The data represents values from the moment an inflight emergency occurred to the flight crew's response time to safely land the plane. The dataset being analyzed is a fictitious data set created to represent the efficiency of a flight crew when an emergency emerged. A random number and classification of the pilot's experience was used to obtain the dataset values. The pilot category held or did not hold an ATP certification at the time of the emergency. Time under pressure is represented in minutes taken from the fictitious timestamp since the emergency occurred.

The independent variable is the pilot's experience defined by attaining ATP minimums. The dependent variable is efficiency under pressure to handle an emergency defined as time in minutes.

Research Question

Does a pilots' experience lead to efficiency under pressure when handling an emergency?

Data Analysis

The data was created in Microsoft Excel spreadsheet. Values were obtained through the random value generator with set limits. This data was then imported into SPSS and descriptive statistics were utilized. The results generated is available in Figure 1. The results obtained includes the range, minimum, maximum, sum, mean, standard deviation, and variance. This data was then used to interpret the efficiency of pilot's experience under pressure.

Results

After processing a sample size of 25 pilots through the SPSS software, the descriptive statistics yielded a range statistic of 47. Time to handle an emergency ranged from a minimum statistic of 10 minutes to a maximum statistic of 57 minutes. ATPs reported a mean time of 32.48 minutes to handle an emergency under pressure. There was a standard deviation of 15.213 minutes to handle an emergency under pressure amongst the datasets. The variance statistic was 231.427.

The output of the descriptive statistic table indicates a wide discrepancy amongst pilots with and without an ATP certification. Limitations of this study include several factors which affected a more useful outcome. Factors such as type of emergency, aircraft complexity, crew resource management, phase of flight, standard operation procedures, and others influence the time pilots take to handle a given emergency. Experience alone cannot be the only factor in this experiment.

Further research into this study should include additional training for pilots to maintain proficiency for any given emergency. Scenario based training can provide additional training for pilots without the need for a real emergency. Equipment such as flight simulators provide the best replications for emergency situations which pilots can practice for.

References

Limor, J., Borowsky, A. (2020). Does specific flight experience matter? The relations between flight experience of commercial aviation aircrews and missed approach incidents. The international journal of aerospace psychology. 30:1-2, pg. 38-53.

NTSB Accidents Database. (2021). Aviation Accident Database & Synoposes. Retrieved from http://www.aviationdb.com/Aviation/AccidentQuery.shtm

Figures

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Time under pressure after occurrence in Flight (in minutes)	25	47	10	57	812	32.48	3.043	15.213	231.427
Valid N (listwise)	25								

Figure 1. Table of descriptive statistics of pilot's experience in relation to time under pressure after an occurrence in flight.

Linear Multiple Regression

1. Purpose Statement

    The purpose of this study was to determine the relationship between the total of non-fatal injuries among aviation accidents/incidents and several variables like accident location, aircraft category and class, engine type, FAR operation, purpose of flight, broad phase of flight, and weather condition.

2. Variables (Predictors)

    Predictors

    - Accident location
    - Aircraft Category
    - Aircraft Class
    - Engine Type
    - FAR operation
    - Purpose of flight
    - Broad phase of flight
    - Weather condition

3. Dependent Measure

    The total number of non-fatal injuries among aviation accidents/incidents recorded in the National Transportation Safety Board (NTSB) database.

4. Operational Definitions

    The accident location indicates the primary state and airport the accident took place over. Aircraft category refers to lighter than air, rotorcraft, airplane, or glider. Aircraft class indicates single-engine land, single-engine sea, multi-engine land, or multi-engine sea for airplanes. The engine type refers to the classification such as reciprocating, turboprop, turbojet, turboshaft, and turbo fan. The FAR operation indicates whether the flight operated under part 91, part 121, or part 135. The purpose of flight refers to the reason the flight was taken classified into personal, scheduled air carrier operation, or charter. The broad phase of flight is focused on the different phases of flight such as takeoff, cruise, maneuvering, approach, and landing. The weather conditions are categorized as visual meteorological conditions or instrument meteorological conditions at the time of event.

5. Research Question

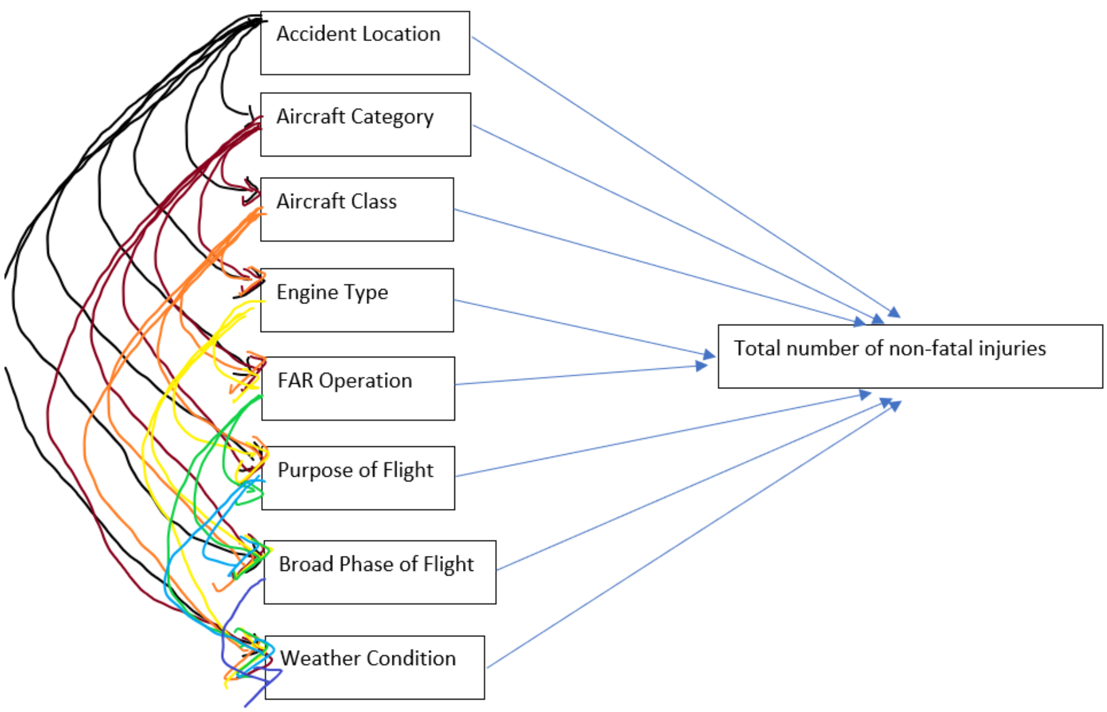
    What is the relationship between the total of non-fatal injuries among aviation accidents/incidents and several variables like accident location, aircraft category and class, engine type, FAR operation, purpose of flight, broad phase of flight, and weather condition?

6. Statistical Hypothesis

H0: p = 0, There is no significant relationship between the total of non-fatal injuries among aviation accidents/incidents and several variables like accident location, aircraft category and class, engine type, FAR operation, purpose of flight, broad phase of flight, and weather condition.

H1: p ≠ 0, There is a significant relationship between the total number of non-fatal injuries among aviation accidents/incidents and several factors like accident location, aircraft category and class, engine type, FAR operation, purpose of flight, broad phase of flight, and weather condition.

7. Path Display



Graduate Course Performance Indicator Rubric

Assess Student Learning Outcomes

Course: ASCI 6020 Flight Operations Business and Administration Course Instructor: ___Janice McCall___________________________

Semester Taught: _Spring 2021_____________ Number of Students in Course: ___3___

Student Learning Outcome Assessed	Assessment Results: (Indicate what % of class achieved a minimum score of 80%)	Benchmark achieved? (Benchmark: 80% of students will score a minimum of 80% = "B")
SLO 1: Assess relevant literature or scholarly contributions to the aviation field of study.	100%	Yes

Course Assessment (Intended Use of Results)
The following will be used for recommendations to improve the quality of course delivery based on assessment results. These recommendations may include prerequisite change; changing course outline and adding more topics; adding a third assessment; changing the course sequence, etc.

**Attach description of assignment used for assessment and samples of student work.*

Assignment Description

White paper introducing planned topic for final paper

Blackboard Assignment Information: Complete the white paper as a proposal for your final paper by following the sample, guidance, and rubric in the Syllabus, Schedule, & Resources folder. This assignment is worth up to 50 points and is due on 25 February 2021, by 11:59 pm. Submit the white paper by attaching it as a Word document to this assignment.

Points Possible: 50

Due Date: 25 February 2021

Notification thru: Syllabus, Schedule, Announcement, Early Warning, and Module lesson plan

Submission: Microsoft Word (or equivalent) document via Blackboard assignment link

Guidance and resources: Guidance paper with sample topics, Paper Formatting Requirements for white paper, short, and long papers. Grading Rubric for Writing Assignment/Essay, link to “Writing a white paper” (University of Arizona, n.d.), link to Purdue Online Writing Lab, and link to SLU Graduate Writing Center.

> ***NOTE:*** For this white paper, a reference page is only required if you cannot provide a weblink to the source. Whenever possible use the weblink feature in Word to link citations to the source website. If a link cannot be provided, then you must include a Reference page formatting in APA 7th style.

[redacted]
ASCI 6020-01
2/25/2021

The Economic Viability of Airline Environmental Sustainability Post-COVID-19

The global airline industry is in the midst of a historic downturn due to the ongoing COVID-19 pandemic, and the necessity for the intervention of environmentally damaging operational practices must not be ignored while resuscitating struggling companies. Due to extreme financial losses within the industry, governments worldwide have loosened environmental requirements meaning that airlines have an economic foothold at the expense of neglecting prior environmental responsibilities. In order to avoid the potential reversal of environmental progress within commercial aviation, it is imperative for governments and airlines to continue to support carbon-offset measures, biofuel research and powerplant advancement, energy reduction, hazardous waste reform, and overall resource conservation measures.

Through an unyielding push to eliminate the carbon footprint of the transportation industry, International Civil Aviation Organization (ICAO) members' voluntary carbon-offset agreements have the potential to eliminate 80% of carbon dioxide emission growth by 2035 (IATA, 2016). In 2016, ICAO produced the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), and there are currently 87 participating countries which are responsible for 77% of aviation emissions (IATA, 2020). Due to the pandemic, CORSIA was reevaluated in June of 2020 in order to avoid setting unrealistic assumptions that the offsetting is effective when in reality it was merely a reduction in air travel (IATA, 2020). Airlines such as United Airlines are furthering sustainability efforts by partnering with conservation organizations that protect ecosystems that collect carbon, and through determined carbon offsetting as well as modern carbon capture technology, airlines may significantly lower carbon emissions (Ecowatch, 2021).

Biofuels and energy reduction are essential steps in reducing the detrimental consequences of airline travel. Beyond the enormous expenditure which contributes to 27% of global airline's operating costs on average, the aviation industry is anticipating the growth of fuel consumption to rise 1.5% annually (EIA, 2017; IATA, 2016). The United States Energy Information Administration (EIA) reported that the U.S. aviation industry consumed over 5.1 billion barrels of petroleum (EIA, 2017). In 2009, the International Air Transport Association (IATA) announced a progressive goal to reduce carbon emissions in half by 2050 compared to 2005 emission levels. This is projected to be possible due to the improvement of biofuel and technological advancements of aircraft engines (IATA, 2015). The predominant feedstocks for biofuels are classified into three generations of sources. Edible crops such as wheat and corn, non-edible crops such as cooking oils and waste animal fats (WAFs), and an algal feedstock are all being manufactured to replace existing jet fuel (Wei et al., 2019). There are a number of concerns with the various processes that are involved in efforts to find a replacement for current Jet-A fuel such as production of greenhouse gas (GHG) emissions, water and land depletion, food scarcity, unreasonable financial costs, and reduction in soil quality (Wei et al., 2019). An alternative to jet fuel and increasingly more efficient engines are essential in the pursuit of reducing airline carbon emissions, and global government and airline support is critical in helping establish the infrastructure for this necessary endeavor.

A crucial component of environmental sustainability is waste management. Prior to the pandemic, airlines began to push for sustainable waste management. Ryanair committed to completely eliminating plastic use by 2023, and Air New Zealand sought to eliminate all waste from Auckland ground operations from entering landfills by the end of 2020, divert 75% of waste from non-Auckland ground locations by the end of 2019, and divert 50% of domestic jet inflight waste from landfills by the end of 2019 (Wei et al., 2019,Baxter, 2020). Unfortunately, the pandemic has heightened single-use plastic consumption, and the multifaceted effects of COVID-19 must be delicately mitigated. Businesses are now forced to shift priorities away from sustainability in order to survive due to regulations and policies restricting former practices. The United States

Environmental Protection Agency (EPA) has reduced regulatory enforcement to reduce financial burdens on struggling organizations (Davis-Peccoud & van den Branden, 2020). The culmination of personal protective equipment (PPE) and single-use plastics will certainly leave a lasting environmental impact on future generations, and it is necessary to reduce the consumption of harmful plastics (Flint, 2020).

Energy reduction is a key component in airline sustainability. British Airways was the first airline to adopt environmental procedures in order to increase fuel efficiency and reduce emissions, and airlines continue to adapt practices in order to reduce fuel consumption through more advantageous routes and strict aircraft control (Reals, 2007). Additionally, the improvements to the United States National Airspace System will provide many benefits that will help reduce both environmental and financial burdens (FAA, 2020). Increased fuel efficiency is a continuous goal of airlines and governments, and the benefits of technological and procedural advancements will be felt in the global economy and the environment.

COVID-19 has proven to be a devastating exercise of the potentiality that is the ongoing environmental crisis. The global aviation industry has been reactive to the consequences of the pandemic, and proactive sustainability actions taken in this era will reduce the impact of climate change. Environmental trends leave no room for misidentifying the role that the aviation industry plays, and the pandemic allows for a global understanding that identified weaknesses must be attended to before they leave unrecoverable effects (Vetter, 2020). It will take significant investment from both government agencies and airlines to integrate carbon-offset measures, biofuel research and powerplant advancement, energy reduction, hazardous waste reform, and overall resource conservation measures, but by doing so, the impact of climate change may not be catastrophic.

[redacted]
ASCI 6020
February 25, 2021

The Looming Pilot Shortage:

The global pandemic the world is currently engulfed in has wreaked havoc on the aviation industry. In one year, the Transportation Security Administration (TSA) reported that only 87,534 people flew during one Monday in April of 2020, when on that preceding date last year, 2,644,981 passengers crossed through security checkpoints (Compton, 2020). Airlines were forced to reduce their fleets and downsize to avoid the loss of revenue, however globally the industry had a net loss of 118.5 billion dollars and is expected to lose another 38.7 billion in 2021 (IATA, 2020). This drop in revenue has cause many airlines to downsize and furlough pilots to help stabilize their bank accounts. This has created an industry wide surplus of pilots, as airlines have ceased hiring. The problem is that once flying demand starts to increase as passengers start flying more regularly, the industry will run out of qualified pilots and a severe pilot shortage will emerge.

The airline industry is no stranger to furloughs. After the terrorist attacks in New York on September 11, 2001 the industry suffered a large reduction in flying. This caused the airlines to furlough pilots similar to the current pandemic. Furloughing pilots can cause pilots to pursue a different career, as some pilots saw the risk of another furlough as reason enough to change career paths (Munoz, 2021). If we apply the same principles to the current ongoing global pandemic, we cannot assume that all of the furloughed pilots will be able to be recalled once flying returns to the 2019 numbers being recorded. Boeing has revised a study they did on the outlook for the total number of pilots, mechanics, and cabin crew members needed between 2020 and 2039. They found that the total number dropped approximately five percent for pilots, but still would require 804,000 new pilots trained and ready to operate commercially (Tulis, 2020). This number is still significant, as training this number of qualified crew members will already be difficult.

The demand for pilots and qualified crew is however widely debated. One study found that the active pilot population would return to 2019 levels as early as 2022 (CAE, 2020). This situation is further complicated by the differences between leisure travel and business travel, as the two have very different implications for airlines and potential revenue. Business travel is suspected to pick up until late 2022, which would severely effect airlines abilities to turn profits even with the harsh cost cutting measures that have been implemented (Russell, 2020). The International Air Transport Association does not foresee 2019 levels of travel until 2024, with domestic operations increasing before international travel (Russell, 2020). The differences between domestic and international travel have significant impacts on the types of aircraft that airlines will utilize, as well as the amount of crew members required to man them.

Some research suggests that recovery will be quick, as they anticipate a rebound in traffic as the Gross Domestic Product (GDP) of the United States and the world reach pre Covid levels of 2019 during 2021 (Stanley, 2020). As researchers and airlines try to determine when passenger traffic will increase, a significant number of pilots are reaching the mandatory retirement age and having to be removed from the pilot pool (Munoz, 2020). During this time, the airlines are not hiring any more pilots, so as demand picks up, the supply will be increasingly diminished. This reduced number of pilots will create a supply issue that could potentially dwarf the pilot shortage felt in 2019.

The looming pilot shortage ahead of the industry has potential to stunt the growth and recovery of the industry right when the industry needs it most. This problem can be mitigated by training pilots and crews ahead of demand, instead of waiting for demand to increase. The problem with the industry and training pilots is that they can only train so many pilots at a time with the number of simulators and instructors available. The more financially viable option would be to train pilots ahead of demand instead of trying to acquire more simulators and instructors qualified to train new commercial pilots.

[redacted]

ASCI 6020
White Paper 21 Feb. 2021

Understanding Automation

It will be interesting to see how newer generations of pilots utilize and manage automation in aircraft. As automation entered the cockpit, the pilots had to learn how to utilize this technology with no prior knowledge of advanced aviation technological systems. As for the newer generations and generations to come, interacting with sophisticated technology is introduced at a very early point in most people's lives and continues to advance further with more modern technology, and is much more accessible now, than it was in the '40s, '50s, and even '80s. The in-depth understanding of aircraft automated systems, and how to manage them, is superficial and has led pilots to getting into undesired and unexpected situations.

People of newer generations have had an earlier introduction to technology than their Silent Gen and Baby Boomer counterparts, with 98% of households with small children under the age of eight having mobile devices, such as smartphones and tablets (Kamenetz, 2017). Having been accustomed to technology and other types of automation from an earlier age, the pilot generations to come will have fewer incidents and accidents involved with mismanagement of aircraft automation.

The human mind – and body – has proven to be quite remarkable and capable of accomplishing extraordinary feats. In our history, humans have figured out that there are other worlds in the cosmos, the speeds at which light and sound travels, and how to keep a few hundreds of thousands of pounds in the air, and to do so with automation. Automation has limitations. Even with these limitations, though, we have gained understanding in how accurate, precise, and useful this technology can be – sometimes even more so than humans – to do such things as Category III instrument landing system approaches to a runway safely with practically zero visibility outside the aircraft.

It is when operators do not understand these limitations that terrible things happen. A deathly example of when limitations were not understood was with Air France Flight 447, when an Airbus A330 stalled 35,000 feet into the ocean below. In the moments leading to the accident, the flight crew did not understand that the aircraft automation logic had reverted to a lower mode, called Alternate Law in Airbus systems (Airbus, 2011), because all of the aircraft's pitot tubes had gotten iced over. From the cockpit voice recordings, the crew realized the aircraft was in a stalled state. Under Normal Law, Airbus automation limits the angle of attack value, even if either sidestick is fully deflected aft (AirbusDriver, 2021), making it virtually impossible to stall the aircraft. In Alternate Law and Direct Law, however, the aircraft loses stall protection. Throughout aviation, it is taught and practiced to recover from a stall by decreasing the angle of attack, which usually comes about by pushing forward on the control stick. The pilot in the right seat of Air France Flight 447 did not understand that the aircraft was in this reversionary mode, thus he did not know that the stall protection, that is usually afforded to the crew, was lost when he held his sidestick fully aft the entire time, keeping the aircraft in the stalled state (BEA, 2011).

Technology, when monitored correctly and prompt corrective action is taken when needed, has proven to be useful. Technology and automation in the manufacturing industry, for example, has proven to increase productivity, and is even projected to continue to increase globally 0.8 – 1.4% annually (McKinsey Global Institute, 2017). Also according to McKinsey, about 60% of occupations have at least 30% of their activities that are automatable (2017). With aviation having utilized some form of automation since the late 1940s with Lear's F-5 autopilot (NationalAviaton, 2020), and has continuously increased the use of automation within aircraft since its inception, those statistics hold true to pilots.

Mr. Lear had a quick "run in with the law" when he had penetrated the western Air Defense Identification Zone, at the time, without permission and was soon intercepted by fighter aircraft because he had assumed the airplane was fine while he tended to his wife and son, sitting in the passenger seat next to him (NationalAviation, 2020). But with this new addition to aviation and of lack of familiarity and overreliance on it, automation – the notion of autopilot, in particular – has led to pilots to get themselves into undesired and even dire situations, like mentioned earlier. While automation may take away a lot of the physical work of flying the aircraft, there is essentially a trade-off with more mental work to be done by the pilot to ensure that the automation is controlling the aircraft as desired.

The commonality of aircraft being equipped with more technically advanced components such as an electronic primary flight display, electric multifunction display, and two axis autopilot,

Graduate Course Assessment Form

Assess Student Learning Outcomes

Course: ASCI 6990 Dissertation Research
Semester Taught: Spring 2021
Number of Students in Course: 4

Student Learning Outcome Assessed	Assessment Results: (Indicate what % of class achieved a minimum score of 80%)	Benchmark achieved? (Benchmark: 80% of students will score a minimum of 80% = "B")
4. Articulate arguments or explanations to both a disciplinary or professional aviation audience and to a general audience, in both oral and written forms.	100%	Yes

Course Assessment (Intended Use of Results)
The following will be used for recommendations to improve the quality of course delivery based on assessment results. These recommendations may include prerequisite change; changing course outline and adding more topics; adding a third assessment; changing the course sequence, etc.

All students preformed to expected standards, given their various stages of dissertation work. No changes in the course are indicated by this assessment.

**Attach description of assignment used for assessment and samples of student work.*

SAINT LOUIS UNIVERSITY

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NOTICE OF INSTITUTIONAL REVIEW BOARD APPROVAL

Date:	April 09, 2021
To:	[redacted], Aviation Science-General
	Belt, Stephen, Aviation Science-General
From:	Kisselev, Oleg,Chairperson, Professor, Minimal Risk #4
Protocol Number:	31663
Protocol Title:	DIVERSITY IN AVIATION: PERSPECTIVES OF HIGH SCHOOL TEACHERS TOWARDS MINORITY STUDENTS IN AVIATION PATHWAY PROGRAMS AT HIGH SCHOOLS IN THE UNITED STATES

Sponsor Protocol Version Number and Version Date : Not Applicable

The above-listed protocol was reviewed and approved by the Saint Louis University Institutional Review Board.
Assurance No: FWA00005304

Below are specifics of approval:

Form Type:	NEW
Level of Review:	EXEMPT #2
Form Approval Date:	April 06, 2021
HIPAA Compliance:	Not Applicable

The Saint Louis University Institutional Review Board complies with the regulations outlined in 45 CFR 46, 45 CFR 164, 21 CFR 50 and 21 CFR 56 and has determined the specific components above to be in compliance with these regulations, as applicable.

Approved Study Documents Include: References.pdf; CITI IRB 1.pdf; [redacted]_Interview Questions.pdf; Approved_3166[redacted]Categories Worksheet Final.pd[redacted] Statement.pdf; Approved_31663[redacted]Participant Recruitment Statement_Version 2.pdf

ALIGNING RESILIENCE COMPETECIES IN AVIATION STUDENTS

TO INDUSTRY WORKFORCE REQUIREMENTS:

A STUDY OF AVIATION LEARNER PERSPECTIVES ON RESILIENCE

[redacted]

[redacted] Dissertation Proposal Presented to the Graduate Faculty of

Saint Louis University in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy in Aviation

2021

2021

COMMITTEE IN CHARGE OF CANDIDACY:

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Assistant Professor Gajapriya Tamilselvan, Ph.D.

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CHAPTER 1: INTRODUCTION

The onset of the 2020 COVID-19 global pandemic demonstrated the essential roles of emotional strength, adaptability, and a persevering mindset – hallmarks of the concept of individual resilience - when normal life is completely disrupted. Many shared societal frameworks of daily life, including vocational work and education, were impacted. Whether self-employed or formally part of a large organization, work goals, communication, job roles and the manner in which tasks were accomplished changed almost literally overnight, with familiar routines suddenly fractured and distributed (Mickeler, 2020).

In educational settings, students and educators faced similar disruptive challenges. Focusing on education, and aviation education specifically, Bjerregaard (2020) noted a seismic paradigm shift for educators and learners during the pandemic crisis in 2020, who were forced to rapidly adapt to new blended learning strategies, e-learning platforms and adjusted outcome metrics where none had existed.

Interestingly, workforce studies prior to the 2020 pandemic already highlighted growing competency gaps in valuable worker characteristics grouped under the heading of term *resilience*. Behavioral and emotional trait descriptors for describing this overarching term include: ability to thrive in the midst of disruptive change, adapting to new job roles, "bouncing back" from hardship (Smith et al., 2008); possessing emotional intelligence - defined in workforce and employee performance research as the ability to identify and discriminate one's own and others' emotions (Goleman, 1996) to guide thinking and behavior in a positive manner with willingness to change (Munir & Azam, 2019); an attitude of continuous learning and adaptability necessary for occupational viability (Garett, 2017; International Labour Organization, 2020; Saxena, 2016). Colfax, et al., (2010, p. 95) reported resilience-like competencies account for 58% of key performance metrics in all types of jobs and were the single biggest predictors of job performance success. Likewise, resilience competencies characterized as "non-technical" but essential, were ranked of equal or greater importance than rote memory knowledge, vocational training and skills alone, and were viewed as stronger predicators of career success or failure (Adkere, 2020; Anderson, 2020).

This report will further focus on these and other commonly cited attributes of desirable resilience competency specific to the aviation and aerospace workforce. It will culminate on the critical role of educators in aviation and aerospace education in facilitating resilience competency abilities in learners, and gap in aviation education where the future aviation and aerospace workforce is equipped with this important competency. A study on how aviation and aerospace students experience resilience, their motivation for incorporating resilience competencies into learning is proposed. data from a learner's perspective will be used to inform and focus resilience teaching strategies with specific resilience categories identified in literature (Ropp & Belt, 2020). This in turn will help educators sharpen the pedagogy for mentoring specific professional resilience competencies called for the by the industry.

Background of the Study

Resilience challenges for the aviation and aerospace workforce

Much of global societal life is structured around the speed of commerce, defense, on-demand leisure activity, access to goods, services and other vital connections to the world afforded by aviation and aerospace. In fact, these industries contribute to daily personal and business life, economic development and growth worldwide, generating $3.5 Trillion in economic contribution, 87.7 million jobs and 4.1% of the global Gross Domestic Product (GDP).

If the aviation industry was a country it would be the 17th largest economy in the world (Air Transport Action Group, 2020, p.10).

At the same time, disruptive advances in computing technology, shifting global trade and supply chains, regulation and political climates, constantly reshaping business and operating models now demand a more resilient, agile workforce (Hedden, 2020). One aerospace workforce model emphasizes interpersonal competencies that explicitly include "inquisitive, resilient, critical thinking approaches" to open-ended, problem-based scenarios (U.S. Dept. of Labor, 2018). Even more urgently, recent research asserts lack of these competencies to be a direct threat to safety, reliability and economic viability of these industries (Gohardani, 2018; Hedden, 2020; Mickeler, 2020).

Implications for collegiate aviation and aerospace education

The scope of resilience needs and current workforce deficit implies that responsibility for resilience competency preparation - for graduates as well as the existing workforce - cannot rest with companies alone. Speaking at a data science summit on new challenges facing college graduates, corporate leaders from aerospace, pharmaceutical, and high-tech manufacturing sectors all expressed similar needs for graduates with preexisting skills in resilience competencies:

A lead technology industry economist expressed the key role these higher-level competencies play, in addition to core degree knowledge, in early career success from day one on the job:

> Learning agility…being able to do fast, quick-learning research on the job instead of a three-to-five-year traditional idea of research…there is a growing skills gap in the local labor force who need to blend these and collaboration skills into daily routines and it is important to cross-train people in how to problem solve, understand and use data. (Simkins, 2019)

Eric Acton (2019), Head of Innovation Ecosystems for the Applied Technology Group at Rolls-Royce stated similarly, "workers, graduates coming in, need to become *second-domain* experts in other skills complimentary to their technical skills to take on expected problem-solving", while Sherry Aaholm, Vice President and Chief Information Officer, Cummins Inc. said of today's technical workers involved in evolving, sensor-embedded equipment and a global workforce, "the individual must be resilient…willing to re-learn and upgrade their certifications. They need to persist when things fail and persist against the nay-sayers. Those skills are what we're looking for" (Aaholm, 2019).

Graduates in collegiate aviation and aerospace programs in particular face a growing resilience competency skill gap. This competency in particular is crucial in order to leverage core degree knowledge and skills at levels required by the industry. This need is expressed repeatedly across various studies with emphasis on the gap growing faster than educational institutions, who supply the future global workforce, can adapt (Bjerregaard, 2020; Bok, 2020; Garett, 2017; Hedden, 2020; Tepeli-Temiz & Tari-Comert, 2018; Turner et al., 2017). As an example, a resilience competency gap was directly described as a "chasm between academia and industry" from lack of understanding by academia of the evolving and precise competencies required of modern graduates (Gohardani, 2018). Competencies cited included innovation, assimilating evolving job roles and ability to envision multidisciplinary "skill fusion" for adapting to new technologies, new business development and new management tactics (Gohardani, 2018). Gohardani states the U.S. aerospace workforce specifically is in need of prominent leaders with these specific traits.

A resilience competency gap is reported from within colleges and universities themselves, challenging learners and existing teaching and learning structures (Bok, 2020; Crow

& Dabars, 2020). Using nearly identical resilience competency language as aviation and aerospace reports, and emphasizing undergraduate education in particular, academia report mounting pressure to evolve and innovate the *way* in which education is delivered – refocusing the purpose, pedagogical rationale and modeling critical competency practices in modernized higher education (Bok, 2020; Crow & Dabars, 2020; Garett, 2017; Hedden, 2020). Bok (2020, pp. 18-19) reported criticism of universities not developing intellectual mastery in students, having instead migrated into specialized "boutique" subject matter coursework with limited application and transfer. To survive, higher education must prove its continued value proposition for the cost, demonstrating ability to prepare the next generation workforce in fields where company CEOs now place higher priorities on "competencies, knowledge and qualities of mind" (Bok, 2020). Those leading educational transformation concurred graduates must possess resilience competencies sufficient to self-learn, adapt, fluently leverage basic degree skill sets to meet ever-new twists on problems (Billett, 2009; Stirling, et al., 2014) and to think and act as continuous learners the global workforce needs them to be (Crow & Dabars, 2020).

In their writing on the fifth wave evolution of American universities, Crow & Dabars (2020) further referred to the need for pedagogical innovation, emphasizing the important role of university education's resilient learning format. They called for transformation of traditional academy practices to become more deliberately outward facing resources for "continuing education to society, acting as providers of retraining and upskilling for learners" (pg. 23). They characterize the vision for the university evolving to that of a knowledge enterprise, partnered with industry and businesses in new learning models, seeding continuous learning as a key competency, redesigning teaching and learning paradigms to "meet contemporary needs for accessible education through technologically enabled massive-scale delivery" (Crow & Dabars, 2020, pp. 7, 28). They point to alternative learning platforms like massive open online courses (MOOCs) where universities supply content with adaptive learning enabling personalized on-demand learning experiences and adaptive teaching through the use of rapidly expanding and disruptive Artificial Intelligence technology (Crow & Dabars, 2020).

The issue of more qualified graduates equipped with resilience competencies from university/collegiate curriculum, and which they transfer effectively into society, is also noted by those in government leadership and those who influence and set policy. Gingrich, (2021) wrote of a "coming revolution" and transformation in the American higher education system, asserting collegiate education is rapidly becoming viewed as less necessary, as companies seeking a more malleable worker use new active learning apprenticeships. Challenging collegiate/university education, Gingrich shared that the message given to young people from companies today is "they'll train them for the job role, and incorporate online learning to supplement their education as they go" (Gingrich, 2021).

The value of transferring and expanding learning experiences into broader life skills and societal application was certainly not lost on early educational theorists and academia. Pedagogical foundations are still used today using principles such as Knowles' emphasis on experiential and collaborative teacher/student learning (Knowles, 1975), Bloom's progressive and comprehensive learning taxonomy (Bloom, 1956) and even further back to the likes of Dewey (1916) who emphasized *enduring* and *undergoing* deep struggle during problem-solving as essential components for achieving effective learning transfer. This is not to say Colleges and universities have not recognized and incorporated problem-based and capstone learning approaches. Numerous rubric examples exist emphasizing problem solving, team work, ethical decision making, and engaging in lifelong learning (Association of American Colleges and

Universities, 2007; 2009; Hedden, 2020; McNeill, 2019). These in fact have evolved into applied learning experiences like capstone or problem-based projects designed to replicate complex situations learners will face in the industry (Flummerfelt et al., 2015; O'Brien, 2012). The goal of these learning platforms remains to ensure likelihood of professional level preparation (Sum, 2015) so that graduates are work-ready and able to contribute effectively (Turner et al. 2017, pp. 387). Unfortunately this approach, while on track, has not kept on pace with the needs of the industry.

Literature continues to indicate a gap in student resilience competency capabilities adding to a growing resilience competency skill deficit in the professional workforce (Hedden, 2020). Traditional academic approaches are not producing graduates with competencies that meet current industry needs representing not only a problem for students, but a growing challenge for modern educators as well (Bok, 2020; Gingrich, 2021; Hernandez et al., 2018, pp. 3-4).

Work-integrated learning described by Stirling et al. (2016; 2014) is a variant used in colleges and universities to help facilitate competency and skill transfer. They describe partnered learning experiences blending educational and workplace settings, a variation of the classic internship. However, it was found that even traditional workplace internships with their familiarity and wide-spread use in secondary education-industry partnerships yielded varying degrees of effectiveness due to variation in student comfort with ambiguous job roles and other competencies influencing rapid assimilation. These variations and gaps were described as "discrepancies" causing non-standard approaches to work-integrated learning and desired outcomes, which were classified as significant challenges to the learning process (Stirling et al., 2014 pp. 23, 26). The biggest challenge facing work-integrated learning, capstone and other problem-based learning was facilitating students' integration of theory into practice in consistent fashion (Stirling et al., 2016, pg. 88).

Compounding this problem is the reported decline in perception of value of today's college degree. Higher education reports rapidly shifting viewpoints and questions from students, parents, and even industry, on the value proposition of traditional formal education arising within public, industry and among students themselves (Crow & Dabars, 2020). They report the need for radical change from traditional teaching and learning paradigms to meet growing competency shortfalls in graduates across professional domains (Bok, 2020).

Resilience competency development in teaching and learning models

Companies today - aviation and aerospace in particular- expect graduates to be what they describe as 'work-ready', a concept delineated as being fluent in "inquisitive, resilient, critical thinking approaches to open-ended, problem-solving situations" in order to function within aviation companies which are themselves evolving to become flexible learning organizations (Bjerregaard, 2020). Organizations report on new and urgent needs for employees who are open to routine reskilling or upgrading and learning new skills, taking advantage of open access to what is described as a continuous learning evolution "24X7 through entirely new processes and technologies" (Bjerregaard, 2020, p. 15).

A gap in resilience competency preparation in aviation and aerospace education, enabling its transfer from university/collegiate aviation programs into the industry workforce, exacerbates these resilience competency deficits identified by the industry (Ropp, et al., 2020). On the positive side, specific workforce resilience competency areas important to industry have been identified (Ropp & Belt, 2020), and resilience competencies in this context are believed capable of being taught, learned, and developed (Colfax et al., 2010). A study is needed to identify key resilience perspectives and practices from the viewpoint of the student within collegiate aviation or aerospace curriculum. This data can be used to inform redesign of existing teaching and learning models to incorporate more deliberate and effective resilience competency practice better aligned with industry requirements identified.

Problem

A deficit in student resilience competency preparation within university/collegiate aviation adds to a growing resilience competency workforce deficit identified in the literature. In the context of aviation and aerospace, this growing gap is especially urgent given that the college/university setting is where a majority of this specialized technical-professional workforce is shaped. As a result, graduates are at risk of emerging with weak or lack of resilience competency traits below what industry requires.

Purpose

Addressing a resilience competency development gap in aviation and aerospace education, where the aviation workforce is shaped and prepared, is the focus of this dissertation study. The purpose of this study is to assess how college students experience resilience and their motivations for engaging and practicing resilience competency behaviors

A survey assessing student experiences and views of resilience as part of a problem-solving competency is necessary to obtain key perspective on resilience from the learner's perspective. Proposed is a study of undergraduate aviation students in a university aviation program. The purpose is to assess learner experiences and perceptions of resilience within the context of applied learning, problem-solving coursework in an aviation curriculum, and their motivation to practice resilience competencies salient to identified aviation and aerospace industry requirements. This is a necessary first step to inform future development of a new resilience teaching and learning model for aviation learners needed to close the identified gap.

Significance of the Study

Current teaching and applied learning practices for practicing and transferring essential resilience competencies in collegiate aviation programs are insufficient to meet the needs of the 21st century aviation and aerospace workforce. A teaching and learning model of behavioral resilience traits that collegiate learners relate to and specific to the aviation and aerospace industries could help close the resilience competency gaps expressed.

Understanding students' perspective on resilience, what motivates their willingness to engage in difficult learning challenges with resilience behavioral responses as tools; what behaviors, disciplines, instructor attitudes and approaches to learning show value in practicing continuous learning and adaptation, is needed.

Research Questions

Primary Question: How do learners in aviation and aerospace education experience and value the practice of resilience as envisioned by industry?

Secondary Question: Could learners' perspectives on resilience and resilience practices be compared and more definitively linked with those deemed critical by the industry in order to close an identified professional resilience competency gap in aviation and aerospace graduates?

Goal: Bridge student resilience perspectives with industry workforce requirements to provide more definitive resilience behaviors to practice. This will enable more precise and effective teaching and learning strategies for educators, while equipping learners with key resilience skills required by the aviation and aerospace industries.

Method

Joyner, Rouse & Glatthorn (2013, p. 149) list a six-element roadmap for developing dissertation methodology which was used to guide methodology framework for this study:

1. Type of research
2. Context and access
3. Participants and how selected
4. Instrumentation
5. Data Collection
6. Data Analysis.

These items, and development of the proposed survey instrument are discussed in additional detail in Chapter 3. Type of research will be an assessment of participants attitudes and opinions on resilience as it relates to learning and skill transfer within the aviation education process. Participants will represent a sample of convenience for the researcher who has access to existing aviation and aerospace undergraduate students within an aviation program approved by the Federal Aviation Administration. A survey instrument will be used. After Institutional Review Board approval, volunteer participants will be selected using informed consent. Surveys are one research tool enabling quantitative data assessment of trends and attitudes within a given population by studying a sample of it. Likert surveys are ordinal scales used to measure those views and attitudes and reflect levels of agreement or disagreement with a particular statement (Jamieson, 2004; McLeod, 2019). A five-point Likert scale survey instrument will be used to sample collegiate aviation student participants, assessing their attitudes and opinions on resilience. This data will be assessed for alignment with five key industry resilience categories identified in a literature review conducted for this dissertation (Ropp & Belt, 2020):

1. Adversity Persistence/Perseverance
2. Contextual Awareness (picture making; visualizing and assessing problems and synthesizing decision strategies)
3. Self-Directed/Autonomy
4. Change Management/Innovation during failure or difficulty
5. Social/Peer Relational Connectivity (peer relationships).

Survey data will be used to confirm these crucial performance-based resilience categories as a framework and ultimately help educators identify more precise resilience competency integration strategies into active learning experiences.

A draft survey evaluating opinions on resilience practices in collegiate aviation undergraduates has been developed. A sample of convenience consisting of senior level aviation students in courses within an FAA approved aviation certificate program is proposed. The research method proposed includes:

1. Obtain committee proposal approval to proceed.
2. Obtain Institutional Review Board approval.
3. Pilot the survey instrument.
4. Recruit participants.
5. Launch and monitor survey returns and results.
6. Evaluate and synthesize survey data.

Assumptions and Delimitations

An assumption made for this proposed study is that attributes of resilience are and will remain important to the industry. An assumption is also made that resilience behaviors can be practiced, developed and then transferred into the workplace similar to other learner skill sets.

Limitations include: survey participant time availability and willingness to complete a survey, the possibility of incomplete surveys (unanswered questions) and differences in participant interpretation of questions (misunderstood meaning). Bias (from the researcher and response bias) and time constraints for the survey must also be considered. These are addressed in Chapter 3.

CHAPTER 2: REVIEW OF THE LITERATURE

A goal of literature reviews is to provide a framework relating new findings to previous research, showing advances or new lines of inquiry and methodological insight and helping advance theory into application (Randolph, 2009). Confirming key thematic resilience categories and related behavioral traits identified in the literature was therefore an essential first step toward developing an aviation and aerospace learner resilience model. Joyner, Rouse & Glatthorn (2013) recommend a three-phase review process of systematic and continuous refinement, going from broad scan to focused review, and a comprehensive assessment/critique (pp. 53-54). A systematic approach following Fink's similar model (2014) for literature review was therefore used. The goal was to identify refreshed, common resilience competency category and behavioral trait descriptors which could be used to refine resilience competency practices within existing aviation student learning.

Fink's literature review process model consisted of seven steps:

1. Select research question
2. Select database
3. Choose search terms
4. Apply practical screening criteria
5. Apply methodological screening

6. Conduct the review

7. Synthesize results

Theoretical orientation

Research of the literature showed resilience as a highly valued personal worker attribute across professional occupations, and especially articulated in aviation and aerospace. The most prominent search returns were from aviation, aerospace and related engineering fields, university aviation and engineering education along with educational theorists, military, psychology and medical industry. These were evaluated with the goal of refining and clustering commonly used descriptions.

Truncation and Phrase Searching methods were used to perform a broad search around the notion of individual resilience and related competency traits. Initial returns yielded 185 sources on resilience which were skimmed for relevance and keyword matches. This included physical/ physiological responses and psychological/mental attitude and behaviors. Keyword searches were made using "mental resilience", "worker resilience", "learner resilience" and "psychological resilience" with additional keyword modifiers including "engineering", "aviation", and "aerospace". Because the focus of this dissertation was on that of resilience competencies in learners within the educational environment, seminal works by researchers and theorists in transformational education (Bloom, 1956; Brookfield, 1995; Cranton, 2016; Dewey, 1916; Knowles, 1975) were continuously consulted and compared for concepts and terminology synonymous with resilience. Five databases were used:

1. Academic Search Complete
2. ScienceDirect
3. Engineering Village

4. Science Citation Index
5. PsycInfo Database

Source returns were then evaluated for keyword descriptors. The results were assessed for:

1. General thematic area clusters. For example: Adversity Persistence or Contextual Awareness.
2. Sub-topics within each thematic area where the literature gave additional behavioral examples.

For example: The theme of Adversity Persistence was delineated by some literature using associated observable behaviors like *purposefully enduring uncertainty*, and *leveraging the struggle into positive action.* Or, the theme of Contextual Awareness was further delineated using actions like ability to *verbalize the issue, draw out/visualize the situation, self-assess one's role*.

A modification of Jackson & Trochim's (2002) five-step concept mapping process was used to perform unit clustering of consistent themes, associated sub-topics and behavioral traits. Five resilience trait categories were identified. They include:

1. Adversity Persistence/Perseverance
2. Contextual Awareness (picture making; visualizing and assessing problems and synthesizing decision strategies)
3. Self-Directed/Autonomy
4. Change Management/Innovation during failure or difficulty
5. Social/Peer Relational Connectivity (peer relationships).

A table listing the complete categories and related behavioral characteristics identified are shown in Appendix A – Table 1. Resilience Traits Table (Ropp & Belt, 2020).

Defining Resilience Competency

At a conceptual level resilience was often found defined using generic terminology around the notion of demonstrating emotional flexibility and adaptability in the context of a hardship. By example, a qualitative dictionary description from Oxford defined resilience as: "the quality of being able to recover, or resist being affected by, a misfortune, shock or illness, implying robust adaptability" (Oxford English Dictionary, 2020). This captures the contextual nature of resilience, but leaves additional questions as to the precise behavioral characteristics associated with recovering or resisting. Teaching rubrics reviewed assessing key undergraduate learning competencies consistently emphasized traits like learner inquiry and analysis, critical and creative thinking, teamwork, and problem solving (Southeastern Louisiana University, 2018; Texas A&M university, 2017; University of Texas, 2012). These competencies further delineate a mosaic of contextually-driven behaviors. Contextual appropriateness therefore would seem an important factor from definitions found.

An analogy of the contextual nature of resilience and why it is equally essential to understand for this dissertation, is the concept of safety in an aviation front line operation such as preparing and performing a large aircraft pushback from an airport passenger gate. Safety of personnel, passengers, and aircraft in addition to executing the task itself is an obvious concern. However, one does not go out and "do" safety as a discrete action. The Federal Aviation Administration (FAA) emphasizes the dynamic nature of aviation in its philosophy of a risk-based approach to high-risk operations, "no single oversight system can assure the effectiveness of risk controls for all the diverse operational environments" (Federal Aviation Administration, 2017, p. 2). Therefore, similar to the notion of resilience behaviors, safely moving an aircraft from an airport gate presumes requisite technical training coupled with the individual's acceptance of potential for threats to the plan. Further, the assumption is that an individual has capacity to detect and effectively engage a variety of event-driven mitigation responses to threats that arise, in order to ensure the ultimate task, aircraft pushback, is completed. As emphasized by the FAA's risk-based approach rationale, the assumption is the technician has the capacity to follow, or return to, the existing protocol while simultaneously identifying emerging, hazardous situations and take additional corrective steps, all within an environment that is by its nature hazardous, dynamic and unpredictable (FAA, 2017). The important role and dynamic nature of individual resilience competency influence on adaptive technical skills was reemphasized in more recent broad-spanning literature review (Ropp & Belt, 2020) and a focused study on technology integration in active learning specifically in aeronautical engineering technology learners (Borgen, Ropp & Weldon, 2021).

Likewise, the term *competency* was found closely associated with resilience, using similar terminology: "capacity to self-sufficiently meet unforeseen challenges or sustain" in a variety of contexts in order to perform a task to a defined standard (Oxford English Dictionary, 2020). McNeill's abbreviated description pertaining directly to student and workforce attributes encapsulates competency as "*how* one performs a task" while coping with a mix of routine and unexpected perturbing external influences (McNeill, 2019). Academia similarly defines competency as "using a blend of interpersonal emotional capacities and vocational skills, with emphasis on *how* one works to solve problems within the context of established social or team culture (University of Texas, 2012).

As a reference point for this study resilience competency is defined as: a person's capacity to apply appropriate response behaviors enabling adaptation, problem-solving and recovery when experiencing challenge, change or uncertainty, in the context of an established social learning or team culture.

Shared Perspectives on Resilience: Cross-domain Similarities

Literature often referred to resilience in terms of mustering one's emotional resources and using contextual cues to adapt to change (Anderson, 2020), persisting toward a goal during uncertainty (Friborg et al., 2003; Gomes et al., 2009; Hjemdal et al., 2011), "bouncing back" (Smith et al., 2008) and recovering to a desired state after a setback (Friborg et al., 2003). More elaborate descriptions like "cognitive upskilling" (gaining new knowledge) and maintaining emotional and functional control (Adkere, 2020; Anderson, 2020) were found in more recent literature. They contained nearly identical behavioral actions. Common recurring findings across the literature related to work teams were these cognitive and emotional abilities were the most limiting factors for new workforce entrant success, described as skill deficits which stifle growth of a modernized global workforce (International Labour Organization, p. 46).

Literature was found to denote resilience in mostly positive, non-technical, interpersonal perspectives, and resilience traits amplifying effectiveness of one's trained job-specific roles, knowledge and skills. Munir & Azam (2019) in their longitudinal study on worker emotional intelligence reported "significant increase" in employee performance where training interventions on resilience competency categories occurred, especially with attributes of emotional intelligence as self-awareness, self-management, social awareness, and relationship management.

Additional resilience descriptions exemplified mental agility and maturity, emphasizing the interpersonal nature of resilience (Friborg et al., 2005; Hernandez et al., 2018; Hoge, 2007). Colfax et al., (2010, p. 90) writing on worker improvement by developing Emotional Intelligence competencies, used equally similar resilience trait descriptor language: “understanding oneself and others, relating to people, and adapting to and coping with immediate surroundings”. Research on high reliability organizations framed resilience as “cognitive readiness” (Hamlet et al., 2020), a mindset enabling one to proactively manage nuances or complete disruption to plans in dynamic environments.

It was also evident that resilience competencies are considered fluid, not static, and can be practiced and developed (Colfax, et al., 2010), using a variety of interpersonal and social resources (Ryan et al., 2018; Smith et al. 2008).

Examples from Specific Domains

There is a continuous theme of similar resilience terminology used in each of the following domain categories. This was taken as an indication of the shared, cross-cutting nature and greater societal value of addressing resilience competencies, not just within a learner’s particular degree field.

Resilience in Aviation and Aerospace

An individual’s ability to adapt and persist toward outcome targets routinely associated with risk, dynamic and adverse work environments demonstrated learning, innovation and self-direction competencies which remain hallmarks of resilience skills for aviation and aerospace work teams (International Civil Aviation Organization, 2016 p. 23; Jones, 2013; Lasky, 2017; Lercel, et al., 2015; Saxena, 2016; U.S. Dept. of Labor, 2018).

However, contextual awareness and problem assessment competencies specific to shared leadership and team decision making were found in safety and aviation human factors research going back decades (Endsley,1995; 1988; Patankar & Sabin, 2010; Reason, 1997). It was similarly described in military studies on individual “hardiness” (Bartone, 1999). Customizable skills, emotional maturity, and analytical capabilities were referred to as “key business differentiators” for the future of aerospace (Jones, 2013; Saxena, 2016), as well as being innovative, versed in participative teaming (Alliger, 2015), and “able to adapt to changing technology and data sets in order to do things differently” (Collins, 2019).

More recent literature used recurring descriptors of resilience, using terminology like mentally agility, persistence, self-direction, continuous learning (Hedden, 2020; Ropp & Belt, 2020; U.S. Dept. of Labor, 2018) all within the context of open-ended, problem-solving scenarios (Garret, 2017; Gohardani, 2018; Hedden, 2020; Ropp & Belt, 2020; U.S. Dept. of Labor Aerospace Industry Competency Model, 2018).

Resilience in Educational Theory

Educational theorists have long emphasized resilience-like mentality and behaviors as essential components of the learning cycle, especially in adult learners (andragogy) (Knowles, 1975) where both teacher and learner are active participants. While these theorists did not explicitly use the term “resilience”, identical attitudinal and behavioral descriptors were articulated repeatedly throughout their published pedagogical and andragogical principles. Examples include hierarchical cognitive skills progression, including innovative creativity (Bloom, 1956), experiential, problem-based learning through struggle (Knowles, 1975; Kolb, 1975), undergoing and enduring challenges (Dewey, 1916) and emphasis on active self-reflection and transformative assessment especially through disruptive or disorienting learning situations (Brookfield, 1995; Mezirow, 2003;1991).

Renewed emphasis on the importance of interpersonal competencies like resilience was noted within well-established educational programs. Sum (2015) emphasized problem-based capstone experiences as “serving valuable roles for faculty and students, promoting student transition in to the professional world" (p. 23). Writing on lean engineering education, principles of which are integrated into aviation and aerospace education, Flumerfelt et al., (2015) list problems for which learners must prepare to encounter as "multi-disciplinary", requiring competencies like systems-thinking, innovation, and adaptation. Others emphasized the need for "the engineering education academy to evolve to include competency mastery" targeted toward skills like persistence, ethical decision making, and problem-solving (O'Brien et al., 2012). Problem solving, learning from error, and engaging with team members with mature levels of emotional intelligence were all noted to require persistence (Flumerfelt et al., 2015; Hernandez et al., 2018). Hernandez et al., (2018) additionally ranked resilience among top mental attitude and contextual responses necessary for student retention in collegiate programs. At the same time, designing such programs presents educators with significant open-ended problems and challenges designing such programs. In his work on capstone education and problem-based learning pedagogy, Thanmbyah (2011) reported capstone-type projects tend to be open-ended in format, more pragmatic in approach, and often may contain learning outcomes not well defined, citing this as a concern among engineering and technical education (like aviation) where learner focus is often toward more clear-cut capabilities.

In the educational context, higher level interpersonal competencies were deemed critical for graduates to succeed, evidenced by the use of competency rubrics with competency areas listed closely associated with resilience, such as being lifelong learners or performance behaviors associated with self-direction and leadership (Association of American Colleges and Universities, 2009; Florida A&M University, 2018; Juiliani, 2013; Southeastern Louisiana University 2018; Texas A&M University, 2018). However, of those performance rubrics evaluated, most remained at conceptual levels and were not well standardized. This is problematic in that it could leave curriculum developers and teachers with too broad interpretation as to what competencies are important to encourage and facilitate student practice of more precise resilience competencies that are important to the aviation and aerospace industries.

Resilience in Medical Science and Healthcare

As a researcher in health care team resilience, Hollnagel (2012) asserted resilience as a critical trait for both individual and institutional well-being. He specifically identified resilience as a key component for measuring and achieving positive organizational cultural traits like safety learning, agility, innovation and other positive qualities influencing success outcomes when reacting to unforeseen emergencies and preventing burnout (Hollnagel, 2012, p.5; Hollnagel, et al., 2015) substantiating similar findings (Chassin & Loeb, 2013; Marx, 2001; Simcox, 2019; Windel et al., 2011). Successful workers must work in teams as “interdisciplinary, internal squads that fix problems instead of sending problems out to a consulting firm” (Durvasula, 2019).

Resilience in Behavioral Psychology

Ijnterna’s differentiation between physiological resilience and psychological resilience traits was used to filter the search to relevant psychological attitudes and behavioral responses (Ijnterna, 2019), as these were more relevant to the focus of the study as it applies to teaching and learning in aviation and aerospace technical education. A focus on negative contextual descriptors was noted in earlier works like enduring hardship, persevering through a health challenge or overcoming disability (Arlin, 1975). In the 1990s focus tended to shift from protective factors to more positive outcomes-oriented and positive reactions through which individuals overcome adversity (Bartone, 1999; Fletcher & Sarkar, 2013; Luthar, 2006; Luthar et al., 2000).

In childhood psychology literature, resilience was cited as an individual's ability to "bounce back" from conflict or unforeseen circumstances while drawing from a variety of resources (Ryan et al., 2018; Smith et al. 2008). Resilience capacity describing one thriving and actually advancing during conflict through self-awareness, positive visualization and affirming contact with others was also prominently cited (Fletcher & Sarkar, 2013; Kegelaers & Wylleman,2018; Luthar, 2006; Luthar et al., 2000; Smith et al., 2008).

Work by Duckworth established the notion of individual "grit": a persevering attitude and persistent goal-oriented focus amidst challenge or failure (Duckworth, 2007). Duckworth's definition has strong resemblance (synonymous to?) that of adversity persistence for resilience. Duckworth established the term "grit" as an array of attitudinal attributes including relentless "perseverance and passion for long-term goals" (Duckworth et al., 2011; Duckworth & Quinn, 2009). She also noted some traits are more crucial than others at different times for particular vocations (Duckworth et al., 2007, p. 1087).

Duckworth's initial two-factor 12-item Grit assessment model (Grit-O) (Duckworth et al., 2007) and refined 8-item Short Grit Scale (Grit-S) both incorporate psychometric user self-assessment on levels of persistence, where participants rank themselves in terms of grittiness in order to measure success predictors (Duckworth & Quinn, 2009). Duckworth similarly noted that grit is a compound concept comprised of multiple key individual traits (Duckworth & Quinn, 2009, p. 172).

More recent research evolved the grit framework to include optimal mindset and well-being as requisite success factors in educational, professional and even personal settings. Calo et al., (2019) looked at traits in senior healthcare (physiotherapy) university students, evaluating relationships between grit, resilience and mindset and their links to academic success. Citing university student experiences of high psychological distress, findings indicated educators' need to improve student sense of well-being as a necessary component for effective learning to take place (pp. 317-318). They asserted this is especially important in learning environments that are dynamic, unpredictable and involve real world scenarios that can have high consequence outcomes like healthcare. This is very similar to the aviation learning and operational environment described in aviation regulatory and advisory literature on safety risk management (Federal Aviation Administration, 2017).

Grit is broadly defined using similar terms of persistence, perseverance and a long view of undergoing challenge or failure toward a desired goal. However, some literature questioned the efficacy of promoting just these ideals, mentioning weaknesses on the Grit assessment scales' rigor due to relatively low number of empirical studies to date (Fernandez-Martin, et al., 2020) although they do refer to Grit assessment scales as "promising".

Counter-Arguments on Resilience

Some research contends that while being persistent and resilient to overcome obstacles is noteworthy and noble, blind determination and passion at all cost in the name of resilience can result in the opposite desired effect. Dugan et al. (2019, p. 48) describe the pitfall of becoming so persistent and goal focused as to not recognize when alternatives should be selected; team dynamics get ignored and the overall culture is negatively impacted because of one's inability to recognize when alternative solutions should be considered. Bastian (2019) similarly argues practitioners of resilience emphasize successful resilience as one's capacity to maintain positive thoughts and emotions with strategies for 'Zen-like' peaceful and mindful responses in order to minimize, shed or avoid stress altogether. But this overlooks key aspects of resilience including experiencing failure or the discomfort of that threat potential. Bastian asserts it is through this discomfort where the sought attributes of resilience are actually developed through discomfort and challenges. He warns that too much emphasis on resilience as a mindset of just peaceful thoughts can result in the opposite effect, where one does not learn to apply positive actions.

Labeling a person as being either "resilient" or "non-resilient" can lead to bias and misleading or inaccurate conclusions (Hoge et al., 2007), especially if one is undergoing challenges, faults or failures and yet maintaining acceptable levels of performance (White, 2015). Hoge et al. (2007) cite an example that being symptomatic of Post-Traumatic Stress Disorder (PTSD) does not mean one is non-resilient. Treglown et al. (2016) observed that excessive (un-tempered), overly persistent mindset - where persistence was cited as a positive behavioral trait of resilience - could actually result in paradoxical aggressive coping behaviors that harm team and organizational effectiveness and inhibiting the very resilient responses desired. Kaiser & Kaplan (2013) emphasized this same point in that even positive attributes and strengths, such as rigid persistence without realizing when to alter the plan, can become weak points when overplayed (Kaiser & Kaplan, 2013). This was further exemplified in aviation literature, where safety-oriented practices are heavily based on adhering to procedures, and failure to persist in following them due to conflicting organizational social customs and norms (Drury, 2017) were reported as one of the violations issued the most by the Federal Aviation Administration (Gould, 2017). Research from medicine on pre-hospital patient emergency assessment and treatment likewise shows the life-saving necessity of systematic and repetitive core procedures especially in dynamic situations. Thim et al., (2012) report on the procedural practice of continually returning to reassess scripted basics: Airway, Breathing, Circulation, Disability and Exposure (ABCDE approach) in acute and dynamic patient care settings especially when one is uncertain of changing patient status or deciding next steps. They list the aims of the ABCDE approach as:

1. Provide life-saving treatment

2. Break down complex clinical situations into more manageable parts

3. Serve as an assessment and treatment algorithm

4. Establish common situational awareness among all treatment providers

5. Buy time to establish a final diagnosis and treatment (Thim et al., 2012, p. 117).

However, a resilience paradox tendency was noted in a study on over-reliance on procedures, labeled 'proceduralization', in complex, event-driven, high-consequence scenarios among maritime workers. Bergstrom et al. (2009) looked at procedural adherence across three groups of maritime workers with low, intermediate and high experience levels. They highlight a paradox often found in high-consequence, rule-based situations where only adhering to rigidly defined response formulas may not provide a suitable outcome. They found ability to deal with dynamic, unexpected situations required a mix of procedural fluidity and procedural adherence. They used aviation as an example of a dynamic environment where following procedures are by nature essential. However, they cited an accident case study of Swissair flight 111 (Transportation Safety Board of Canada, 2003) where strictly following published procedures for an onboard fire added layers of complexity and delay in actions, which was found to be a contributing cause of the resulting fatal crash. It was determined that alternative actions (extinguishing the fire and early preparation for landing) were needed instead of rigidly following the published fire procedure (p. 255). Bergstrom et al. (2009) further note from their study:

> In the aviation industry in particular, proceduralization has been regarded as the most important system component to achieve operational safety. Over time, proceduralization has become more than an answer of how to increase safety in modern socio-technical systems, it may have become *the* answer. (p.42)

The opposing and cautionary perspectives from the literature on presumptive use of resilience and possible unforeseen problems are well noted. On one hand rigidly following pre-defined procedural templates and rules can be essential and provide life-saving steps to regain control and situational awareness. On the other hand, emphasis on overly-prescriptive behavioral reactions to threats and challenges can severely limit innovation or even be the wrong thing to do entirely. In some cases, there are no rules and the human being must have the ability to assess and innovate accordingly in order to survive, as with an in-flight emergency where all hydraulic control of essential flight controls is lost, no published emergency procedure can help, and a crew must rapidly assess and "make up" recovery plans on the spot as occurred in 1989 (National Transportation Safety Board, 1990).

Cautions on over-reliance on prescriptive behaviors and narrow categories of resilience are well noted. These cautions will help steer the philosophical use and development of resilience success metrics for an adaptive resilience training model.

Resilience Measurement Models Evaluated

As discussed in the following section, numerous validated resilience measurement tools exist. It should be emphasized, the purpose of this study is not to create another resilience measurement tool, but to identify student perspectives on resilience competencies in order to provide clarity and alignment for educators to better integrate and mentor specific resilience competencies in active learning experiences and inform future resilience teaching and learning models. As such, it would be up to the educator to select the appropriate resilience measurement tool. However, review of the most prevalent resilience measurement tools was considered essential to gain additional context and vision on established foundational resilience criteria most measured areas across the literature.

Several resilience measurement models were evaluated most of which involved the use of psychometric scales. Connor & Davidson (2003) reported that while several measures of resiliency had been used and reported on, they were not universally distributed or adopted. As a result, choices on preferred scales were rather broad and relied on the researcher's due diligence for a given study context to determine an appropriate resilience measure. Similar to Duckworth's notion of grit (2009, 2007) most resiliency scale assessments present respondents with attitudinal statements constructed according to characteristics commonly associated with resilience (Hoge, et. al., 2007). Hoge points out the factorial structure of these scales yields insight into the composite elements that make up the concept of resilience.

Windle et al., (2011, pp. 4-7) reported on an extensive review of over 200 scholarly papers using resiliency measurements. They identified fifteen scales initially which were evaluated for highest stability and ability to detect clinical changes in subject studies. From this review they provided a summary of the five most prominent resiliency scales (Windle et al., p. 16): CD-RISC, RSA, BRS, ER-89 and the Dispositional Resilience Scale. They reported these to be the highest scoring of test-retest data and overall stability.

An overview of those five most prominently recurring resiliency measures identified is provided here. The psychometric categories were assessed and used to further refine the themed resilience trait categories and behavioral listings for this proposal.

Connor-Davidson Resilience Scale (CD-RISC) (Connor-Davidson, 2003).

This is a self-reporting measurement commonly reported used in patients with Post Traumatic Stress Disorder. It measures resilience component categories of:

- Personal competence
- Acceptance of change and Secure Relationships
- Trust/Tolerance/Strengthening Effects of Stress
- Control
- Spiritual influences

Resilience Scale for Adults (RSA) (Friborg, et al., 2003)

The Resilience Scale for Adults (RSA) assesses resilience levels based on a six-factor scale:

- Perception of self
- Perception of future
- Structured style
- Social Competence
- Family cohesion
- Social resources

Windle et al., (2011) also report its high-ranking usefulness assessing resistance or protection from stress causing factors.

Brief Resilience Scale (BRS) (Smith et al., 2008).

The BRS presents a measure of ability to 'bounce back' from adversity rather than resist it some other models do. The measures are from a self-reporting survey and include the following questions rated on a five-point scale (1: Strongly disagree through 6: Strongly agree):

- I tend to bounce back quickly after hard times

- I have a hard time making it through stressful events
- It does not take me long to recover from a stressful event
- It is hard for me to snap back when something bad happens
- I usually come through difficult times with little trouble
- I tend to take a long time to get over set-backs in my life

Ego Resiliency (ER-89) (Block & Kremen, 1996)

The ego resiliency characteristic is described by Block & Kremen (1996) as a competency of being comfortable with a "fuzzy" interpersonal world and overall adaptive behavior to manage emotional responses to ambiguous or initial experiences that could stimulate angry or more emotional responses (p. 352). Their initial list is a 14 item 4-point measurement scale:

- I am generous with my friends
- I quickly get over and recover from being startled
- I enjoy dealing with new and unusual situations
- I usually succeed in making a favorable impression on people
- I enjoy trying new foods I have never tasted before
- I am regarded as a very energetic person
- I like to take different paths to familiar places
- I am more curious than most people
- Most of the people I meet are likeable
- I usually think carefully about something before acting
- I like to do new and different things
- My daily life is full of things that keep me interested

- I would be willing to describe myself as a pretty “strong” personality
- I get over my anger at someone reasonably quickly

Dispositional Resiliency Scale (DRS) (Bartone, 2007)

Alexander & Klein (2001) describe an early version of Bartone’s DRS in their study on hardiness of emergency personnel. This scale was originally designed to measure psychological hardiness of military combat soldiers. Bartone describes hardiness as “a personality style associated with resilience, good health, and performance under stressful conditions” (Bartone, 2007, p. 943) and a characteristic of people who are open to change and challenges in life (Bartone,1999). It evolved from a 30-item version to a shortened 15-item assessment of the constructs of hardiness including measures in three categories of primary key characteristics:

- Commitment
- Control
- Challenge

Bartone’s work in particular cites evidence that hardiness can be improved through workplace and associated leadership influences, as well as programs to train hardiness components (Bartone & Homish, 2020, p. 516), corroborating the emphasis of this proposal for pursuing a resilience teaching and learning model.

Within psychology literature, traits equating to the resilient individual were believed forged from early childhood and life experiences (Karairmak & Figley, 2017; Luthar, 2006; 2000). At the same time, the contextual, temporal nature of individual resilience was described as capable of being continually practiced and refined from “dynamic person–environment interactions” (Fletcher & Sarkar, 2013). Kelly et al., (2011) cite empirical evidence that “individuals, rather than an organization-wide commitment to innovation, are responsible for the majority of radical innovations [getting to commercialization]" while Howell et al., (2005) similarly cite the importance of resilience characteristics for modern industries like electronics, automotive and aerospace for market sustainability. Additionally, research from high consequence work environments like emergency medical teams emphasized the continuous practice of proactive and reactive resilience behavioral responses (proactive and reactive) as keys to strengthening a necessary state of resilience-readiness (Hollnagel, et al. 2006; Kegelaers & Wylleman, 2018). Hollnagel's work in particular on resilience in engineering design discusses organizational resilience, using what he describes as four human-organizational 'potentials': respond, monitor, learn and anticipate (Hollnagel, 2006; 2015). These categories were refined and used to assess resilience-readiness in hospital emergency departments where daily operations are notably unpredictable as a matter of routine (Chuang et al., 2020). Resilience was found to be "something multifaceted rather than something that can be described by a single quality or dimension" (Hollnagel, 2011).

Workforce research from aviation further emphasized the need for worker learning agility and mixing transferrable skill sets with higher order thinking and reasoning capabilities to meet expectations of the field (Lercel, et al., 2015, pp. 4,9; International Civil Aviation Organization, 2016, p. 23). Lercel et al. (2015, p. 56) emphasize self-responsibility and proactive problem-solving expectations now modeled by the FAA as well, in its relationship with industry in safety and quality management of daily processes. In the same study for the FAA, Lercel, et al. (2015) cite customer service, learning orientation, interpersonal communication, team focus and principles of safety, quality and business management acumen as top competency skill areas called for by the aviation maintenance industry in particular (p. 43).

Key Resilience Traits Identified in the Literature

Five prominent resilience trait categories with subsequent behavioral descriptions were identified in a broad literature review (Ropp & Belt, 2020) shown fully in Appendix A – Table 1. Resilience Traits Table. The five main categories identified and brief supporting examples are described below. The five categories identified were:

1. Adversity persistence (adaptability and perseverance)
2. Contextual awareness (picture making; visualizing and assessing problems and synthesizing decision strategies)
3. Self-directed action/learning autonomy
4. Change Management and Innovation during initial failure or difficulty
5. Social connectivity (peer relationships)

Adversity Persistence

Resilience incorporates multiple combinations of response tactics depending on dynamic contexts both proactive and reactive (Kegelaers & Wylleman, 2018). Alliger et al., (2015) describe the nature of team resiliency in workplace adversity situations as:

> the capacity of a team to withstand and overcome stressors in a manner that enables sustained performance where the overall contributions and experience of the group enduring a situation together generates more resiliency than an individual alone might have… managing variation and rising stressors through huddles, regrouping discussion and "mending". (p. 177)

At a personal level the ability to cultivate perspective and personal calm and the concept of "sense-making" while undergoing adverse situations was emphasized (Bruneau, 2016). Other long held anagogical principles viewed adversity positively when leveraged correctly as a deep learning transfer opportunity (Dewey, 1916/2008; Knowles, 1975). Cognitive learning development models emphasized 'transcendability' as a positive byproduct of persistence in achieving transformative learning outcomes (Steinberg, 2015). Adversity persistence has long been recognized as essential for spurring positive attitudes and action (Steinberg, 2007) and igniting deep personal growth and self-actualization (Arlin, 1975; Inhelder & Piaget, 1958; Kubler-Ross, 1969).

Contextual Awareness (Picture Making)

The ability to form a mental model of a current situation and contextualize its contribution to possible new situations was a heavily emphasized behavior observed across the resilience literature. Writing about cognitive processes and situational awareness related to aviation human factors, Endsley's definition of situational awareness in aviation operating environments provided a foundation to context-driven awareness, "The perception of the information in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley, 1995, 1988). This definition is used in aviation human factors literature (Durso, 2010; Endsley, 1999) and cognitive engineering literature on human mental workload for automated air vehicle flight deck environments (Parasuraman et al., 2008). Safe operation in commercial aviation depends on front-line operators' continuous awareness of their operational environment which is inherently risky (Rochlin, 1993). The importance of picture making or mental models for situational awareness was emphasized in FAA Industry Training Standards (FITS) scenario-based and problem-based training and in routine Practical Test Standards (PTS) for pilots (Glista, 2003; Robertson et al., 2005).

Amann (2003) reported self-awareness, sensory and affective learning experiences as essential for deep learning and generating new knowledge. Contextual awareness was also found in seminal theorists in pedagogical and andragogic methods of learning, as in Bloom's original and revised learning taxonomies (Anderson & Krathwohl, 2001; Bloom, 1956).

In his work on human factors, Sheridan (2010) discusses resilience engineering and emphasizes visualizing a variety of possible scenarios in aviation human factors as "an essential modern proactive approach preparing for future and unforeseen incidents and recovery scenarios in which no explicit table or algorithm exists". Medical surgical training using Virtual Reality applications and smart devices to enhance awareness further substantiated the value of the ability of the individual to rapidly envision "what if?" scenarios (Nehme, Bahsoun & Chow, 2015).

Accompanying these advances is the nuance of the Big Data environment, where blended automation changes human contextual decision making and coordination demands (Parasuraman et al., 2000). This has impact on approaches to Rasmussen's foundational Skill-Rule-Knowledge mode commonly incorporated into teaching and learning methodologies to describe human performance during routine and unfamiliar task conditions and where the individual's analysis of the environment and key goal formulations are believed to occur (Rasmussen, 1983).

Self-directed/Autonomous

A recurring positive behavioral theme that quickly followed resilience terminology was the notion of one who continually took it upon themselves to be inquisitive and deliberately open to learning new things. Bloom (1956) emphasized the challenging experiential learning process itself as an important learning outcome that works to empower the learner to become self-directed and autonomous in applying problem-solving competencies. The positive impact of a mentor's guidance on a learner's self-directed learning autonomy was directly emphasized as a component of learner resiliency (Bowers, 1984). Technical learners and workforce members must develop the mindset of lifelong learners who continuously engage problems-and-learning as a continuous act (Cranton, 2016; Taylor, 1998).

The aerospace industry additionally articulated the value of empowered employees who were self-directed particularly in risk-sensitive operations for risk mitigation, contribution to the learning organization (Lasky, 2017; Saxena, 2016; U.S. Dept. of Labor, 2018) and critical as a high performing, visionary leadership trait (Texas A&M University, 2017). The International Civil Aviation Organization (ICAO) emphasized the critical nature of empowered, autonomous individuals and work teams as success factors in global aviation safety and process standardization (International Civil Aviation Organization, 2019, 2016) applicable to all of the aviation industry.

Self-responsibility and proactive problem-solving expectations are likewise modeled by the Federal Aviation Administration (FAA) in its relationship with industry in safety and quality management of daily processes. An important feature of FAA's enforcement philosophy concerning safety risk management within organizations was found in Order 8002.72: FAA Integrated Oversight Philosophy (Federal Aviation Administration, 2017). This order outlines proactive self-disclosure, correction and prevention of future non-compliance over enforcement actions, and cites FAA's own shifting culture of trying to "identify underlying causes and ensure future compliance" (p.2, 1-4, Items c, d). In this approach responsibility is placed on aviation organizations to create proactive processes and procedures, using frameworks of Safety Management Systems and Risk-based decision-making.

Problem-based learning in engineering and technical education was also consistently emphasized in preparing engineering graduates, and development of collaborative teamwork, self-directed, independent learning and problem solving based upon critical self-reflection were considered “crucial competencies” in addition to technical degree knowledge (Flumerfelt et al., 2015, p. 41).

Change Management

Calo et al., (2019) looked at traits in university undergraduate seniors in health sciences (physiotherapy) evaluating relationship between grit, resilience and positive mindset and academic success. Citing university student experiences of high psychological distress, the authors emphasize the necessity for educators to seek to improve student sense of well-being (meaning a positive perspective and view of a positive outcome) for effective learning (pp. 317-318), especially in challenging learning environments that are dynamic, unpredictable and scenarios that can have high consequence outcomes.

The importance of managing change, adapting attitudes and behaviors in education and the influence on larger interactions with society was noted by the transformative learning theorist Mezirow:

> Contradictions generated by rapid, dramatic change and diversity of beliefs, values, and social practices are a hallmark of modern society. Adults in society face an urgent need to keep from being overwhelmed by change…Rather than merely adapting to changing circumstances by more diligently applying old ways of knowing, they discover a need to acquire new perspectives in order to gain a more complete understanding of changing events and a higher degree of control over their lives. (Mezirow, 1991)

Change management was likewise commonly used to describe a person’s ability to manage both small alterations in direction to plans, to completely disruptive and unforeseen events. In either sense the ability to adapt, find innovative ways to remain in relationships and regain a path to a goal were associated with Change management and Innovation themes. In terms of dynamic organizational or community-wide situations, three levels of resilience were described by Ryan et al., (2018) in a community/cultural study on positive responses to negative extremism and how it equated to community violence and terrorism. These levels were described as 1) National, 2) Community and 3) Individual adaptive change. Ryan reports embracing the necessity of change as healthy "positive adaptation" to dynamic environments enabled community members to resist negative stresses or succumb to radicalized thinking in unhealthy ways. Steinberg (2015) discussed a necessary web of personal characteristic responses to adversity, using the term "resiliency to failure" as a culmination of adaptive internal emotional coping characteristics enabling a person to change during various life challenges. He later coined the term *change resiliency* as a "new science" in response to change (Steinberg, 2015).

Reporting on building risk resilience directly in the aerospace manufacturing sector, change was identified as an expectation of being "ready to go to Plan B if Plan A is not available, and then move on to consider Plans C and D, and perhaps Plan E if circumstances dictate" (Schmarrow & Kruse, 2002). In terms of Big Data and automation technologies in aircraft, the need for the humans to adapt more fluidly are significant in the sense of changing and working through times of sudden disorder and uncertainty (Stanley et al., 2009). Traditionally structured views of the way the world should work have changed:

> the round peg goes into the round hole…that there is only one answer to a question, these structures are more malleable in modern operations than we may want to admit. Ultimately the big data messiness concept requires the human being to change in order to tap into and harness part of its usefulness. (Mayer-Schonberger & Cukier, 2013, p. 35).

Change responsiveness and willingness to face and learn from errors and listen to feedback were highlighted by Flumerfelt et al. (2015, pp. 36,41) in research on engineering students and success rates. They emphasize an understanding of one's strengths and limitations and the ability to remain calm under pressure or when things go wrong being highly ranked and emphasized as competencies desired in final year engineering students.

Safety culture research on high reliability operations (oil rig, aviation, medical) found the most important characteristic was the ability to adapt to new situations or hazards (Marx, 2001; Patankar & Sabin, 2010; Reason, 1997). The ability of individuals to embrace bold, more radical change as the norm in the aerospace workforce was emphasized as a modern challenge for the industry where the learning curve remains constant and intense (Boyle, 2017; Garret, 2017; Gohardani, 2018; Kellner, 2017). This continuous learning dynamic likewise challenges how technologies are adapted used in training and educational approaches. The use of 3D graphics-based work instructions and augmented and virtual reality for example have evolved to become common learning platforms for modern learners who consistently indicate a desire to learn using new technologies (Hartman & Ropp, 2013; Wang et al., 2016) and who are now more used to rapid information access and applied learning and feedback within an online gaming-like environment (Borgen, Ropp & Weldon, 2021).

Social/Peer Relational Connectivity (peer relationships)

Social or peer-group connectivity and support with focus on participative teaming skills were consistently identified as critical competencies specifically within the aviation environment (International civil Aviation Organization, 2019, 2016; Jones, 2013; Ropp et al., 2020; Saxena, 2016). This includes all organizational levels including upper management (Bowers, 1984). A study of community resilience stressed the role of social bonding and a noted both a proactive reduction in perpetuation of violence as well as “ability to maintain a stable level of functioning after traumatic events” (Ellis & Abdi, 2017). They additionally reported relational constructs were attributed to ability of individuals and groups to resist negative influence and temptation to fall into unhealthy, dangerous, radical or other extremist and untoward thinking.

In industrial settings, peer group resilience studies found teams actively briefing and debriefing together had operational performance rates up to 25% higher, tending to defer to within-group expertise rather than individual rank/status for problem-solving (Alliger et al., 2019). Knowledge-based participatory innovation for complex problem-solving and more rapid solution implementation was also found when teams connected verbally and shared experiences and concerns (Ferrarri et al., 2018; Nathanael et al., 2014). Educational theorists also acknowledged the impact of peer-to-peer relationships, social dynamics and the trust, community and support for personal risk-taking as well as the positive influence this had on learning outcomes (Bowers, 1984; Gallagher, 1997; Mezirow, 1991). The same dynamic was found in leadership roles and effectiveness of teams in operations (Mathieu, et al., 2008).

Research on attachment and resiliency among university students pointed to the important role of positive mentoring attachments which directly impacted overall resiliency of individuals. In their work studying attachment and resiliency among university students, Tepeli-Temiz. & Tari-Comert (2018) describe attachment as "an emotional bond developed to a special person" showing the importance of a bonding and social structure for individuals to connect and obtain support. Friborg's Resiliency Scale for Adults (RSA) (2005, 2003) and other collaborative research on resilience validity (Hjemdal et al., 2011) directly measured social competence within his 6-point measurement scales comprised of 1) perception of self, 2) perception of future, 3) structured style, 4) social competence, 5) family cohesion, and 6) social resources. Organizational and team "connectedness" were found essential for identifying, acting on and containing errors (Chassin & Loeb, 2013) and obtaining vital minority voice inputs for solutions who might otherwise not be heard (Hollnagel et al., 2006; Dekker & Woods, 2010; Fuchs et al., 2007; Loder, 1981).

The role of social networking and emotional attachment (to a mentor, parent or other guardian role) consistently comes up in the literature as well. In their work studying attachment and resiliency among university students, Tepeli-Temiz. & Tari-Comert (2018) describe attachment as "an emotional bond developed to a special person". Looking at high attachment relationships to higher resiliency, they incorporated Friborg's work on resilience scales (Friborg et al., 2003, 2005) using a Resilience Scale for Adults (RSA) to assess resilience levels based on a six-factor scale. This scale is comprised of 1) perception of self, 2) perception of future, 3) structured style, 4) social competence, 5) family cohesion, and 6) social resources. Of interest in this study was reference to Friborg's findings that "attachment or social aspects and an ability of resilient people to utilize social or external supports systems to better cope" (Friborg et al., 2003, p.66) and citing social competence as a factor in resiliency as well. Friborg further noted that while resilience "does not protect the individual from negative life events…resilient individuals seem to cope more functionally and flexible with stress." (p. 66). Tepeli-Temiz. & Tari-Comert (2018) go on to cite that attachment theory assumes secure attachment has a direct impact on psychological resilience later in university learning settings and ultimately in life outlook. Hjemdal et al., (2011) evaluated the RSA developed to measure resiliency in adults and found empirical evidence suggesting three overarching resilience characteristics: 1) individual positive dispositional attributes, 2) family support and coherence, and 3) external support systems outside the family.

Synthesis and Discussion

Resilience competency development in teaching and learning models

Literature reviewed here found continuous themes of challenge and deficits in resilience as it relates to the professional workforce. Aviation and aerospace companies were no exception and are the focus of this study. Key takeaways from aviation and aerospace in particular indicate a growing resilience deficit and higher expectations of focused resilience competency capabilities in graduates entering this particular workforce, if they are to be successful as these companies evolve into more flexible learning organizations (Bjerregaard, 2020).

Revisiting Smith's perspective on the important role of problem and competency-based learning (Smith, 2011) emphasizes its importance and substantiates the direction of this proposal:

> The laying of capstones often indicates the ceremonial completion of a building. Thus, the capstone shows that a significant body of work is reaching completion. Metaphorically, a capstone is a crowning achievement. A capstone course is most often intended to be the final course in a major, building on previous coursework in a cumulative and integrative fashion and covering the breadth of the discipline. (p. 3)

At the same time, very recent literature on collegiate and university level education points to the struggle to keep up with evolving competency needs of learners to suit industry demands (Bok, 2020; Crow & Dabars, 2020; Garett, 2017; Hedden, 2020). A gap in effective resilience competency preparation by teachers translates to decreased or could even threaten complete lack of application and transfer by student graduates into their professions. This is a self-sustaining problem which will continue to exacerbate resilience competency workforce deficits identified within the industry. Addressing this gap in aviation and aerospace education, where the workforce is shaped and prepared, is needed.

Finally, it is apparent from the literature that individual resilience is dynamic and fluid. A person's current context such as career path, educational process, learner age group, health, career or family dynamics, continuously influence and challenge one's resilience responses. The challenge for educators is to facilitate more deliberate resilience competency exercise as part of the modern active learning experience. This is especially important in engineering and technology education where professional competency skills in adaptive learning, problem-solving and managing continuous change are an expected part of the everyday experience in the industry (Gohardani, 2018).

CHAPTER 3: METHODOLOGY

The purpose of the proposed study is to assess learner experiences and perceptions of resilience within the context of applied learning, problem-solving coursework in an aviation curriculum, and their motivation to practice resilience competencies salient to identified aviation and aerospace industry requirements identified in the literature.

Research Plan

Surveys are one research tool enabling quantitative data assessment of trends and attitudes within a given population by studying a sample of it. Likert surveys are ordinal scales often used to measure views and attitudes and reflect levels of agreement or disagreement with a particular statement (Jamieson, 2004; McLeod, 2019). McLeod notes that surveys can induce social desirability bias, where participants want to appear in a good light to what their peers may believe and thus alter their responses accordingly. However, this can be mitigated by ensuring confidentiality of participant personal information.

Benefits of survey data include being economical to develop and distribute, especially in the current online environment, and generally offer the benefit of relatively timely turnaround and initial data assessment (Creswell & Creswell, 2018).

The goal of this survey is to obtain student perspectives of resilience in order to inform future development of a new resilience competency teaching and learning construct that is aligned more specifically to the needs of the aviation and aerospace workforce found in the literature, and close an identified resilience competency skill gap in aviation graduates.

Survey Instrument Development

To achieve high accuracy and validity assurance, surveys must be developed using structured methodology and design (Creswell & Creswell, 2018). Survey design methods specific to educational research were adapted from Artino et al., (2014) and Harlacher (2016) to develop a resilience survey instrument.

Artino et al (2014, pp. 463-464) indicate a seven-step survey design process:

1. Conduct a literature review
2. Carry out interviews and/or focus groups
3. Synthesize the literature review and interviews/focus groups
4. Develop items
5. Collect feedback on the items through an expert validation
6. Employ cognitive interviews to ensure that respondents understand the items as intended
7. Conduct pilot testing

Similarly, Harlacher (2016) describes a five-step design process using research-based principles:

1. Determine the goal or goals of the questionnaire
2. Define the information needed to address each goal
3. Write the questions
4. Review the questionnaire for alignment with goals and adherence to research-based guidelines for writing questions
5. Organize and format the questionnaire

For surveys looking at psychological or interpersonal construct traits as metrics (which are less visible), the literature indicates scaled assessment instruments are preferred (Artino, 2014; DeVellis, 2003; McIver & Carmines, 1981). Survey scales are groups of similar items on a questionnaire designed to assess the same underlying construct (DeVellis 2003). In particular, scales more completely, precisely and consistently assess the underlying construct (McIver & Carmines 1981). Thus, scales are commonly used in many fields including educational research.

The goal of the survey instrument is to obtain student perspectives of resilience in order to inform future development of a new resilience competency teaching and learning construct that is aligned more specifically to the needs of the aviation and aerospace workforce found in the literature

Control for Bias

The researcher has professional relationship within the aviation and aerospace fields, having worked in aviation operations, and also teaching and researching as a faculty member directly in an FAA certificated university curriculum in aeronautical engineering technology as well. The researcher teaches and interacts with learners in undergraduate and graduate coursework, and engages in teaching problem-based learning that often includes resilience competency areas described here. Therefore, a level of professional bias must be accounted for. Acknowledging this professional bias clearly in this report is one step in itself to account for it and the impact on the survey questions developed and its administration.

The survey distribution and returns must be accomplished in a manner such that individual participant identities are not revealed. Moreover, it is possible that analysis could reveal results that are not expected, in which case the researcher must be willing to allow the data to drive the research and be willing to acknowledge and change assumptions.

Participant-driven response bias resulting from non-responses that can also skew results. This can be overcome by weekly methodical wave analysis technique described by Creswell &

Creswell (2018) to assess for dramatic changes in overall average responses, especially in the final weeks of a survey study. A weekly assessment of response patterns will be incorporated as part of the planned 30-day survey run time.

Research Timeline

1. After proposal approval by the committee, finalize survey instrument and obtain IRB approval by May, 2021
2. Run survey pilot and make feedback adjustments May, 2021
3. Launch survey in identified summer session courses June, 2021
4. Run survey through June, 2021
    a. Data will be continuously assessed and participant reminders sent weekly during the 30-day period
5. Evaluate survey data July-August, 2021
6. Finish survey data evaluation, write up and defend dissertation: August – November 2021

A 29-question five-point Likert scale survey (Appendix B) assessing learners' opinions and perspectives on resilience traits identified in the literature (Ropp & Belt, 2020) will be piloted and deployed to volunteer student participants. Table 2 in Appendix B shows the survey category, item breakdown and assessment criteria.

Institutional Review Board Approval and Human Subjects Research Training

Human subjects and Institutional Review Board (IRB) approval will be obtained through Saint Louis University. The Primary Investigator author (Timothy D. Ropp) and any associated research assistants will be certified in Collaborative Institutional Training Initiative (CITI) Human Subjects research training for investigators and Responsible Conduct of Research (RCR) training for faculty and graduate students. The author is current in both CITI Human Research Group 2 for Saint Louis University and CITI RCR training.

Survey Pilot Testing

A survey pretest to help establish content validity of the developed survey will be accomplished with a goal of testing N=15-20 participants. This number range falls within that which has been established by survey experts for several years as sufficient even for large surveys to identify major flaws or weaknesses and is generally shared across survey research (Presser, et al., 2004; Sheatsley, 1983). Participants will be obtained and the survey data and feedback obtained using the same IRB informed consent.

Participant Recruitment and Distribution

The distribution method will be an online questionnaire using Qualtrics online survey platform. Student participation using informed consent will be solicited via direct emails. Participants will be undergraduate aviation students in a university aviation program.

Data Analysis

A 30-day data gathering period will be initiated in June, 2021. Results will be checked weekly and participant reminders sent.

CHAPTER 4: RESULTS

A return rate goal of 100 responses will be targeted. McCleod (2019) describes median or mode assessments and distribution display using bar visualization as suitable statistical methods for evaluating survey data. Once an established *N* of survey returns are achieved, a comparative analysis of survey item responses will be accomplished and assessed against the survey question areas of resilience shown in Table 2 (Appendix B). Areas of strongest participant agreement will be used to help prioritize resilience competency area focus and as a basis for further development of teaching and learning methodologies to mentor and engage students more directly in deepening key resilience practices during active learning experiences.

CHAPTER 5: DISCUSSION

Conclusions

While resilience competencies are generally emphasized as a positive and necessary component for graduates, a resilience teaching and learning competency model leveraging specific behavioral traits identified for these industries and tailored to the aviation and aerospace teaching and learning domain does not exist. An accepted model used by academia and industry as a resilience competency transfer tool, enabling key targeted resilience behavior performance in both learning and salient workforce environments is the long-term vision. Results from the proposed survey of aviation learners can be used to address gaps identified in resilience competency preparation in current problem-based / active learning aviation education practices. This in turn will enable identification, practice, and measurement of key resilience competency behaviors salient to modern aviation and aerospace workforce needs.

Limitations of the Study

The study proposed will be limited by the scope of the timeframe available for the researcher to meet established goals. In addition, surveys typically have low return rates. Other pitfalls include incomplete surveys in which only partial data is available. It is also possible that participants will not complete the survey at all.

Direction for Future Research

A long-term development plan for a proposed research path post-dissertation and beyond includes future development of the identified resilience trait categories and learners' own personal perspectives from the survey data, into a resilience teaching and learning model.

Longitudinal field testing and model validation within the actual teaching/learning environment could then be undertaken.

Proposal to Explore Student Pilot Perceptions about Their Experiences with Using Mental Imagery Training Strategies During Their Flight Training Program

[redacted]

This Dissertation Research Proposal is Presented to the Graduate Faculty of
Saint Louis University in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

2021

Page Reserved for Additional Information

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Proposal to Explore Student Pilot Perceptions about Their Experiences with Using Mental Imagery Training Strategies During Their Flight Training Program

Chapter 1: Introduction

The following is a proposal to commence a study to explore student pilot perceptions about their experiences with using mental imagery training strategies during their collegiate private pilot flight training program. Mental imagery training involves the application of imagery enhancement techniques and scripted exercises to create vivid, realistic experiences in the mind while mentally rehearsing psychomotor skills and cognitive tasks (Holms & Collins, 2001; Williams et al., 2013; Saab et al., 2017.) Researchers have studied the use of mental imagery extensively in the field of sport psychology for many decades and their findings indicate that it has enhanced the performance of athletes at all levels of skill and experience (Feltz & Landers, 1983; Jones & Stuth, 1997; Weinberg, 2008). Furthermore, the findings of numerous studies in the fields of medicine and music reveal that the use of mental imagery training has improved the learning and skills proficiency of surgeons and nurses, and has helped musicians improve their music memorization, control their emotions, and prepare for live performances (Johnson, 2003; Haddon, 2007; Sanders et al., 2008; Cocks, Moulton, Luu, & Cil, 2014). However, research to explore the use of mental imagery training within an aviation context to train aircraft pilots is scarce (Jentsch, Bowers, and Salas, 1997; Roth & Andre, 2004).

This is surprising because pilots at many levels of experience use a form of mental imagery training known as *chair flying* to practice their checklists and rehearse their flight procedures (Jentsch, Salas, & Bowers, 1997; Hohmann & Orlick, 2014; Carroll, 2015). However, it is likely that few pilot trainees receive any formal training in the use of chair flying and thus, its use is largely unstructured (Jentsch, Salas, & Bowers, 1997; Orlick & Hohmann, 2015; Roth & Andre, 2004). Therefore, in this study, the researcher will provide a group of novice student pilots with a set of mental imagery training guidance materials for them to use during their private pilot flight training program and then he will explore their experiences with using this supplemental training method. The researcher believes that because the findings of many studies have shown mental imagery training to be an effective method to improve the performance of athletes, surgeons, and musicians, then there is merit in exploring the experiences of pilot trainees using it to improve their flight training performance.

In this chapter, the researcher provides the background for the proposed study and an overview of the current problem facing the commercial aviation industry that this study will address. Then, the researcher presents the purpose of the study along with the central research and supporting research questions that will guide the focus of the study. Also included is a brief description of the Experiential Learning Theory, which will serve as the theoretical framework supporting the study. Finally, the researcher explains the importance of this study and its implications to the commercial aviation industry and the pilot training community at large.

Chapter 2 includes a review of the research literature related to the use of mental imagery across the disciplines of sport psychology, medicine, music, and aviation. In addition, the researcher provides a formal definition of mental imagery in the context of aviation as derived from the literature. Then, the researcher discusses the findings of several studies that have revealed some of the neurological factors that contribute to the effectiveness of mental imagery training. Following this is a description of several mental imagery training methods that researchers and mental imagery coaches have used in the field to improve human performance, many of which the researcher will apply to the proposed study. In Chapter 3, the researcher provides a detailed explanation of the phenomenological qualitative research method he will use to conduct the study and the steps he will take to add validity and reliability to the study.

Background for the Study

From the outset of powered human flight, the aviation training community has continually sought new ways to teach pilots how to fly. Prior to their historic first flights in 1903, the Wright brothers needed a means to practice flying their newly invented aircraft without actually flying it, so they built kite replicas of their gliders and used them as rudimentary flight simulators to learn and practice their flight skills (Smithsonian, n.d.). Over the ensuing century, pilot trainees at all levels of experience have made use of numerous inventions in flight simulation and other training technologies to learn, practice, and improve their flight skills. These include computer-based learning systems with interactive audio-visual components, static flight training devices (FTD), and high-fidelity full motion flight simulators (FFS). In recent years, the application of virtual reality (VR) technology for flight training has been gaining momentum (FAA, 2020; Weirauch, 2020). In addition, many personal computer-based flight simulators are available for pilot trainees to use in a self-directed manner to gain experience, acquire knowledge, and practice their flights skills at home on their own and at their own pace (Alessandro, 2008). Today, it would be uncommon for a pilot trainee to complete a qualification training program without having spent a portion of their training time using some type of supplemental electronic learning and training technology (FAA, 2020).

In addition to advancing the use of modern training technologies to supplement pilot training, the aviation training community has continued to develop and apply unconventional training methods to enhance their pilot training programs. For example, in an effort to address the increasingly complex human factors problems associated with air carrier operations, the Federal Aviation Administration (FAA) (n.d.) began authorizing U.S air carriers to develop and implement Advanced Qualification Programs (AQPs). This authorization allowed airlines "to develop innovative training and qualification programs that incorporate the most recent advances in training methods and techniques" (FAA, 2017, p. ii). This gave airline training departments the opportunity to move beyond the strict confines of traditional and regulated training requirements and tailor their pilot qualification and recurrent training methods to address the specific needs of their pilots (FAA, 2017). Some of the key features of AQPs are their emphasis on the application of innovative training strategies, their inclusion of crew resource management training, their reliance on pilot performance data to drive the content of the program, and the incorporation of scenario-based flight simulations that give air crews multiple opportunities to practice normal and abnormal operations in real time (FAA, n.d.; FAA, 2017; Kearns, Mavin, & Hodge, 2017).

The impetus behind the development and implementation of many such innovative training technologies and methodologies has been to:

- Improve aviation safety,
- Enable pilots to gain knowledge and skills proficiency across a wide spectrum of aircraft performance regimes during maneuvers and exercises on the ground in a safer and more practical manner than in the air,
- Reduce the cost of flight training by replacing a portion of actual aircraft flight training with training in less expensive training devices and,
- Improve the efficiency and effectiveness of pilot training (FAA, n.d.; FAA, 2020; McLean, Lambeth, & Mavin, 2016; Huddlestone & Harris, 2017; ICAO, 2013; IATA, 2014).

Furthermore, the International Air Transportation Association (IATA) (n.d.) asserted that, "improved pilot training methodologies is the key to further accident reduction" (p. 1).

Moving forward, the pilot training community must continue to develop new training strategies to improve the rate of success for new pilot trainees in order to keep up with the global demand for new pilots (Boeing, 2020). According to Boeing's 2020 market forecast report, the aviation industry will need an estimated 763,00 new commercial pilots over the next two decades to operate the world's projected fleet of commercial aircraft, business jets, and civil helicopters. North America alone will need 208,000 of these new pilots. These totals are down from Boeing's previous forecast due to the recent worldwide downturn in air travel demand caused by the 2020 COVID-19 pandemic, which resulted in high numbers of pilot layoffs. This has caused a temporary over supply of qualified pilots, but the market fundamentals that drive air traffic demand remain strong and the long-term need for qualified pilots remains high (Boeing, 2020; Murray, 2021).

Prior to the recent downturn, the commercial aviation industry had been experiencing a shortage of qualified pilots and the trend of new pilot certifications indicated that the number of new pilots entering the industry was lagging expected demand (Boeing, 2020). In addition to the reduction of pilot input, tens of thousands of the industry's current pilots will reach retirement age over the next decade (Boeing, 2020; Murray, 2021). This has prompted the aviation training community to begin adopting increasingly innovative solutions to increase pilot production rates to meet the ongoing demand for new pilots (Boeing, 2020). This includes the use of online and virtual training formats and the exploration of various immersive technologies and flexible distance learning methods in an effort to enable optimum learning and knowledge retention (Boeing, 2020). According to Boeing (2020), "effective training and an adequate supply of personnel remain critical to maintaining the health, safety and prosperity of the aviation ecosystem" (p. 1).

As the aviation industry recovers from the effects of the worldwide COVID-19 pandemic, it must ensure that there will be an adequate number of qualified pilots to support long-term fleet growth trends (Boeing, 2020; Murray, 2021). However, one of the obstacles to new pilot starts is the high cost of qualification training (Murray, 2021). Prospective pilots must make a substantial financial investment to earn the credentials to gain employment as a commercial pilot. For those who pursue a four-year bachelor's degree with an aviation major, the tuition alone can exceed $75,000 and the additional costs of flight training can top well over $50,000 (Liberty University, 2021). For example, residential students enrolled in one of the largest four-year collegiate aviation programs in the United States can expect to pay an estimated $53,360 per academic year (two semesters) for tuition, fees, room, board, and books (ERAU, n.d.a; ERAU, n.d.b). In addition, these students will pay an additional $45,000 to $75,000 for flight training leading to a multi-engine commercial pilot certificate, depending on their track of study (ERAU, n.d.b). This equates to a cost of $258,440 to $288,440 for an aviation bachelor's degree with a multi-engine commercial pilot certificate.

However, not all airlines require a college degree as a prerequisite for employment as a pilot. Therefore, some aviation students opt to forego the expense of a four-year degree and earn their flight qualifications through a non-university affiliated flight school. These students can still expect to pay a minimum of $40,000 to $50,000 for their initial training leading to the multi-engine commercial pilot certificate (AMS Flight School, 2020; Pavco Flight Center, 2020; Epic Flight Academy, 2021).

Nevertheless, even after earning these requisite credentials, newly certificated commercial pilots are ineligible for hire at U.S air carriers because they do not meet the minimum flight experience requirements established by 14 CFR Part 121.436. This is due to a pilot qualification rule change that took effect in August 2013, requiring all pilots of civil aircraft operated under 14 CFR Part 121 air carrier operations to hold an airline transport pilot (ATP) certificate (FAA, 2013a). This normally requires a minimum of 1500 hours of flight experience reduceable to 1000 hours of flight experience for pilots who have earned a four-year aviation degree from an FAA-approved institution (FAA, 2013b). Furthermore, many other commercial pilot employers prefer to higher pilots with at least 500 hours of flight experience (Martin, 2018). However, after earning their commercial pilot qualifications within the minimum flight time required by 14 CFR Part 141 or Part 61 regulations, newly certificated pilots may have fewer than 300 hours of total flight experience – well short of the minimum hours required for employment. Therefore, the typical path for newly certificated commercial pilots is to continue their training to become certified flight instructors (CFIs) because flight schools will hire them to teach with only entry-level experience and because instructing gives them an opportunity to earn the requisite flight experience to gain employment with the airlines or elsewhere (Chaika-Cadin & Taylor, 2020; Lutte & Lovelace, 2016). The cost of obtaining additional flight instructor certifications can exceed an additional $10,000 to $15,000 (Epic Flight Academy, n.d.; Liberty University, 2021).

Accordingly, it is critically important for entry level pilot trainees interested in a career in aviation to successfully earn their certifications at or below the expected training cost. Otherwise, they may incur financial setbacks that preclude them from continuing. Beckman and Barber (2007) found that of the 51% of students who dropped out of the professional pilot degree program at Middle Tennessee State University, 90% of them cited financial constraints as the reason. This is consistent with the findings of other studies addressing aviation student retention rates (AOPA, 2010; Dillingham, 2014; Leonard & Bjerke, 2019; Kearns, 2018).

When student pilots discontinue their training due to financial concerns, it may be due in part to incurring additional costs over and above the estimated minimum costs to earn each certificate. For example, federal regulations require student pilots to acquire a minimum of 35 to 40 hours of flight experience to earn a private pilot certificate, but according to the Federal Aviation Administration (2006), the U.S. national average indicates that "most pilots require 60 to 75 hours of training" to earn the certificate (p. 2). Each additional hour of flight training could cost the student an average of $150 to $250 (Lessons.com, n.d.). Exceeding the regulated minimum training requirements to earn a pilot certificate could occur due to a number of factors, including student learning ability and flying aptitude; student knowledge and skills retention from one lesson to the next; inadequate student study habits; poor instruction, unstructured training, student illness, and training disruptions caused by poor weather and aircraft availability issues (AOPA, 2010; Bryan, 1996; Martin, 2016; Wetmore, Jackman, & Savard (2010). Encountering training challenges such as these could contribute to the need for additional flight lessons for pilot trainees at all levels of experience.

However, it is the private pilot qualification course that establishes the foundation of pilot flying skills and it is "often one of the most difficult courses for an aspiring aviator" (Leonard & Bjerke, 234). The experiences and success of student pilots undergoing their private pilot training program may determine whether they progress to advanced flight training courses and remain on track to enter the commercial aviation industry or drop out of training and take a different path. Leonard and Bjerke (2019) asserted that "collegiate flight programs need to ensure that students can complete their flight training in the shortest number of flight hours and days possible" (p. 233) as this will lead to increases in successful graduations. Furthermore, they stated that "Due to the fact that the aviation industry is facing a critical pilot shortage, it is imperative that institutions training the next generation of aviation professionals are well-versed in ensuring the success of its students" (Leonard & Bjerke, 2019, p. 228).

Problem Statement

As the aviation industry recovers from the decline in air travel caused by the COVID-19 pandemic, the pre-existing challenges of finding and hiring qualified pilots will re-emerge. The number of new pilot certifications indicates that new pilot starts will not meet the demand and thus, the health of the commercial aviation industry is in jeopardy (Boeing, 2020; Murray, 2021). Therefore, the aviation research and pilot training communities must continue exploring new strategies to make pilot training more effective, more efficient, and less expensive, especially for student pilots at the entry level. There is an urgent need to find new training methods that could potentially help student pilots hasten their pace of learning, maintain their knowledge and skills proficiency, remain effectively engaged in their training during training interruptions, and reduce the number of repeated flight training lessons. A growing body of research in other disciplines indicates that the use of mental imagery training has been effective for developing and improving the cognitive and psycho-motor skills, overall performance, and confidence of athletes, surgeons, and musicians (Weinberg, 2008; Haddon, 2007; Johnson, 2003; Sanders et al., 2008; Cocks et al., 2014). However, there are no examples of research to explore the potential benefits of using mental imagery training to supplement the training of novice student pilots. Therefore, the researcher proposes the current study as described below.

Purpose of the Study

The purpose of this study is to explore student pilot perceptions about their experiences with using mental imagery training strategies to supplement their private pilot flight training program. The researcher will provide a group of novice collegiate student pilots with a set of mental imagery training materials he developed for them to use throughout their flight training program. Then, the researcher will collect and analyze the student pilots' descriptions of their lived experiences with using this training method. The student pilot participants will provide descriptions of their experiences by posting written comments via an online data collection form throughout the study sample period and by participating in one-on-one interviews with the researcher at the end of the study sample period.

Research Questions

This study will attempt to answer the central research question: *What are student pilot perceptions about their experiences with using mental imagery training during their private pilot fight training program*? The researcher will apply a phenomenological qualitative research methodology involving an analysis of data collected directly from the student pilot participants via their written feedback throughout their training course and via their verbal responses during one-on-one online interviews conducted at the conclusion of the study sample period. Chapter 3 includes a detailed description of the phenomenological research methodology the researcher will use to conduct this study.

To uncover student pilot perceptions about their lived experiences of using mental imagery training, the researcher will seek answers to the following supporting research questions:

1. What do student pilots perceive as the outcomes from using mental imagery training strategies?
2. How did the use of mental imagery affect student pilot motivation, confidence, and self-efficacy?
3. What mental imagery training techniques do student pilots perceive as effective or ineffective?
4. In what ways did student pilots adapt their use of mental imagery to suit their own individual learning styles and preferences?

As the study progresses, the researcher expects to revise these supporting research questions and develop additional questions based on a progressive analysis of the collected data. The researcher will seek answers to these and other questions via the instruments described in the data collection and analysis section in Chapter 3.

Theoretical Framework of The Study

To answer the central and supporting research questions of this study, the researcher will apply an appropriate theoretical framework to guide the study. As discussed in more detail in Chapter 2, Chase & Galvin (2013) described mental imagery as a process of mentally rehearsing the performance of physical tasks by using all the senses to create or recreate the experience in the mind. Based in part on this definition, the researcher of the proposed study views the use of mental imagery training as a unique form of experiential education and will use Kolb's (2014) Experiential Learning Theory as the theoretical framework supporting this study. David Kolb (2014) formulated the Experiential Learning Theory by integrating the common themes of numerous prominent twentieth-century scholars of human learning and development into a systematic framework that can address modern problems in learning and education. In particular, Kolb (2014) used the similarities in the experiential learning models of John Dewey, Kurt Lewin, and Jean Piaget to create "a model for explaining how individuals learn and to empower learners to trust their own experience and gain mastery over their own learning" (p. 53).

Kolb's (2014) experiential learning theory is "soundly based in intellectual traditions of social psychology, philosophy, and cognitive psychology" (p. 3) and it has been widely accepted as "a useful framework for learning-centered educational innovation, including instructional design, curriculum development, and life-long learning" (p. xxv). According to Kolb (2014), experiential learning has become the method of choice for learning and personal development for mature adults and its use has become widely accepted as a method of instruction in colleges and universities throughout the United States. Numerous educational institutions now provide various types of experiential learning opportunities to their students, such as internships, apprenticeships, laboratory studies, field projects, and in-classroom experiential learning exercises (Kolb, 2014). These are experiential opportunities because learners have direct encounters with what they are learning about rather than merely thinking about the encounters (Kolb, 2014).

With this theory in mind, the researcher of the proposed study created a set of mental imagery training materials to guide the experiential learning opportunities for the student pilot participants of this study. The participants will use these materials to complete experiential learning exercises using mental imagery training techniques and strategies. The researcher discusses the concepts of Kolb's Experiential Learning Theory in more detail in Chapter 2.

Importance of the Study

The findings of this study to explore student pilot perceptions about their experiences with using mental imagery training may be valuable to many organizations within the pilot training community, including airline training departments, military flight schools, civilian Part 61 and Part 141 flight schools, and collegiate aviation institutions. If student pilots perceive their use of mental imagery training favorably, this may support its formal use in entry-level flight training programs, and it might support further inquiry into the use of mental imagery training as a supplemental training method at all levels of flight training. Furthermore, there is a potential for the use of mental imagery training to improve student pilot success rates, increase student pilot retention, reduce the number of repeated flight lessons, and thus decrease the cost of flight training. Any one of these potential outcomes could contribute to a higher number of pilots successfully entering the commercial aviation industry and thus help to meet its staffing needs for the future. In Chapter 2, the researcher will highlight relevant evidence from the body of literature supporting the exploration of the use of mental imagery training in the discipline of aviation pilot training.

Chapter 2: Review of the Related Literature

This chapter includes a detailed summary of the researcher's comprehensive review of the literature related to the use of mental imagery to enhance human performance in four disciplines – namely sports, medicine, music and aviation. According to Vagle (2018), conducting a review of the related literature is a necessary step in phenomenological research because it serves to orient the researcher to the phenomenon of interest, and it helps the researcher gain clarity about the topic under investigation. Furthermore, the literature review provides a framework for establishing the importance of the study (Creswell & Creswell, 2018) and it is useful for developing the rationale for the study (Creswell & Poth, 2016). Accordingly, the literature highlighted in this chapter informed the researcher about the practice of mental imagery and how mental imagery training strategies might influence the performance of student pilot trainees. Furthermore, the highlighted literature serves as the foundation of the rationale for conducting this study to explore the use of mental imagery in an aviation pilot training context.

The literature review begins with an examination of several definitions of mental imagery applicable to different contexts. The researcher then presents a suitable definition of mental imagery applicable to pilot training as derived from the literature. Based on this definition, the researcher explains how the use of mental imagery exercises fits within the framework of Kolb's (2014) Experiential Learning Theory. Following this, the researcher discusses some of the neurological factors that contribute to the effectiveness of mental imagery and then presents a description of several mental imagery training methods that other researchers have found to be effective. The literature review concludes with a summary of several studies from the four disciplines that highlight different types of mental imagery training strategies along with their findings that add support for exploring the use of mental imagery training in the field of aviation pilot training.

From the outset of the researcher's review of the literature related to the uses of mental imagery to improve human performance, it became evident that there are numerous existing definitions of mental imagery as applied to different disciplines. Therefore, the researcher began the literature review by examining the many definitions of mental imagery and then deriving a suitable definition of mental imagery applicable to the aviation discipline and to this study.

Defining Mental Imagery in Aviation

Defining mental imagery is challenging because of its many different applications. For example, due to a growing understanding of the neurological basis that contributes to the effectiveness of mental imagery, health practitioners are increasingly using it as a tool for the treatment of various psychological disorders, including anxiety, depression, schizophrenia, and Parkinson disease (Pearson, 2019). Furthermore, they are using guided mental imagery extensively as a coping strategy to treat patients suffering from chronic pain (Berna, Tracey, & Holmes, 2012). However, others have used mental imagery successfully as a training methodology in various disciplines, including sports (Post, Muncie, & Simpson, 2012; Morris, Spittle, & Watt, 2005), music (Du Toit, 2015), and medicine (Mick et al., 2016; Bathalon, Martin, & Dorion, 2004) to boost human performance; to hasten the rate of learning cognitive and psychomotor skills; to improve and maintain those skills; and to overcome performance anxiety. For example, Post and Wrisberg (2012) found that elite gymnasts used imagery to decrease their fear of injury, increase their confidence, rehearse their performance routines, maintain their focus, and manage their pain. Furthermore, the results of many empirical studies examining the effects of mental imagery have shown that combining physical practice with mental practice using a variety of mental imagery techniques leads to an equivalent or higher level of skill proficiency than when using a commensurate amount of physical practice alone (Feltz & Landers, 1983; Feltz, Landers, & Becker, 1988; Weinberg 2008). This implies that people can use mental imagery as a suitable supplement or partial replacement for physical practice in various types of training regimens.

During the past fifty years, psychology researchers have developed numerous formal definitions of mental imagery (Richardson, 1969; Finke, 1989; Kosslyn, Ganis & Thompson, 2001), but the literature related to this topic is replete with the descriptions of several other terms closely associated with mental imagery that may cause confusion about it. These include mental rehearsal, mental preparation, self-talk, visualization, and mental practice, each having their own formal definitions. For example, Driskell, Cooper, and Moran (1994) defined mental practice as "the cognitive rehearsal of a task in the absence of overt physical movement" (p.481). However, this definition neglects the important role that explicit physical movements may play in developing a more vivid mental image of rehearsed tasks. For instance, it is common for athletes to mentally practice their sport while mimicking many of the physical motions involved, such as standing, bending, and swinging their arms. U.S. Olympic Freestyle Skier, Emily Cook did this in preparation for every aerial ski jump she performed in practice and in competition (Clarey, 2014). Additionally, elite athletes have used the term visualization since the 1960s in reference to mentally simulating competition but Cook asserted that this term does not go far enough in describing what she does to mentally prepare for each ski jump because it does not include all of the senses, such as smelling, hearing, feeling, and "everything" (Clarey, 2014, p. 1). Therefore, perhaps a more encompassing definition that captures a greater range of mental imagery methods is that of Chase and Galvin (2013), who defined mental imagery as "the process of rehearsing a performance of a physical task while using all the senses to create or recreate the experience in the mind" (p. 429).

Chase and Galvin developed this definition in the context of sports psychology, but it relates well across multiple disciplines that involve the completion of physical tasks, including piloting an aircraft. For example, to demonstrate their mastery of aircraft control, every commercial pilot student must perform numerous sophisticated three-dimensional maneuvers in flight, including chandelles, lazy eights, and steep spirals. Just as Olympic divers, gymnasts, and freestyle aerial skiers must execute a combination of discrete, serial, and continuous physical movements, applying both perceptual and motor skills with precise timing and agility to complete their intended exercises (Weigelt & Stockel, 2013), aircraft pilots must physically control the speed and movements of their aircraft using their hands, feet, legs, and arms while making fine-tuned adjustments based on kinesthetic sensations and visual references to complete each maneuver. Therefore, Chase and Galvin's (2013) definition of mental imagery is applicable to the aviation pilot training context. However, in addition to the physical tasks involved with flying, operating an aircraft also requires the completion of numerous cognitive tasks. Among these are performing bearing, distance, time, and fuel calculations; programming flight management systems; interpreting the aircraft's flight instruments and navigation systems; recognizing and responding to abnormal situations; maintaining situational awareness of the aircraft's trajectory; and completing complex checklist procedures (Casner, Geven, Recker, & Schooler, 2014). Therefore, to develop a comprehensive definition of mental imagery applicable to aviation, it is necessary to consider how the use of mental imagery influences the performance of cognitive tasks.

In a study of first year medical students, Bathalon, Martin, and Dorion (2004), found that the combination of using kinesiology-guided teaching with daily mental imagery during surgical training resulted in better acquisition and retention of cognitive surgical skills than the training protocols that excluded the use of mental imagery. Thus, these researchers asserted that such alternative educational approaches will potentially play a prominent role in the future of surgical training (Bathalon, Martin, & Dorion, 2004).

Furthermore, in a study to explore the effects of using mental imagery to improve the cognitive task performance of maneuvering an animated vehicle around a video game track using the arrow keys of a computer keyboard, Wright and Smith (2007) found that the use of a particular form of mental imagery when practiced alone, without any additional physical practice, resulted in cognitive task performance that was on par with the performance of those who had completed the additional physical practice of the skill. This implies that mental imagery users could, to some extent, effectively replace repetitive physical practice with mental imagery practice and still achieve at least the same level of performance for some types of cognitive tasks.

Still further, in a qualitative study to explore the perceptions of musicians about the efficacy of using mental imagery to learn and improve their musical skills, Haddon (2007) surveyed music students and professors at the University of York. The results revealed that mental imagery was a widely used practice among both groups and that the participants viewed it as a means of quickening memorization, aiding interpretation, and producing a better understanding of musical aspects (Haddon, 2007).

Thus, from these few examples, it is evident that the definition of mental imagery should address cognitive skills when applied to the aviation discipline. Therefore, for the purposes of this study to explore student pilot perceptions about their experiences with using mental imagery training during their flight training program, the researcher has defined the term mental imagery as *the process of rehearsing the performance of physical and cognitive tasks while using one or more of the senses to create or recreate the experience in the mind*. This is a slightly modified version of the Chase and Galvin (2013) definition, and it aligns with the principles of Kolb's experiential learning theory.

It is important to note that within the aerospace pilot community, mental imagery is most closely associated with the term *chair flying*, which refers to the practice of rehearsing flight procedures while seated in a chair on the ground without actually going flying. Pilots often chair fly in front of a cockpit poster to learn how to complete and then practice the execution of normal, abnormal, and emergency checklist procedures, using the poster as a reference for identifying the various cockpit switches and controls referenced in each checklist (Hohmann, 2011). Kern (1997) described chair flying as a "combination of visualization techniques, procedural practice, mental modeling, and cognitive conditioning" and he asserted that it is "one of the easiest and most effective methods of self-improvement" (p. 57). Roth and Andre (2004) described chair flying as a technique pilots often use to prepare for missions by mentally rehearsing the information they will need later and to go through every sequence of their flights. This may include simulating the movements they must make while flying, such as moving their arms, hands, and feet to interact with the various controls and flight instruments (Roth & Andre, 2004). It also involves practicing the rhythmic flow of procedures they must accomplish by memory; verbally rehearsing the numerous types of radio communications during different phases of flight; and reviewing specific profiles used to execute flight maneuvers and instrument approaches. Pilots at all levels of experience use chair flying, from novice student pilots practicing their basic flight skills to the U.S. Navy's Blue Angels flight demonstration team preparing for their air show routines (Jentsch, Bowers, and Salas, 1997; Carroll, 2015).

Chair flying is considered to be one of the most reliable methods of improving pilot skills and a valuable component of primary flight training (Stoller, 2004). However, because of a lack of published guidance and the absence of any formal training about how to chair fly effectively, it is likely that many aviation students practice chair flying rather haphazardly using a wide variety of unstructured methods and techniques (Jentsch, Bowers, & Salas, 1997; Hohmann & Orlick, 2014). In a study to examine the psychological skills of Canadian military pilots, Hohmann & Orlick (2014) interviewed 16 experienced pilots and found that all of them were familiar with chair flying and had practiced it, but their uses of it varied considerably. While some described chair flying as sitting in a chair in front of a cockpit diagram to review the applicable aircraft checklist procedures, others referred to it as a way of mentally putting themselves in the cockpit by imagining their surroundings and the hundreds of buttons and switches in front of them and then visualizing every aspect of the flight, including the actions they would take during emergency situations (Hohmann & Orlick, 2014).

In an earlier study to assess the degree to which pilots used mental practice, Jentsch, Bowers, and Salas (1997) surveyed a cross section of 60 pilots ranging from initial student pilots to certified flight instructors and found that nearly all of them used mental imagery frequently. Before completing the survey, the researchers told the participants that the use of mental imagery could take the form of “chair flying” or “hangar flying” (Jentsch, Bowers, & Salas, 1997, p. 73). The survey results indicated a large variability among the participants with respect to the manner in which they used mental practice, leading the researchers to suggest that pilots could benefit from learning improved mental practice techniques (Jentsch, Bowers, & Salas, 1997).

Such variability in the practice of chair flying within the discipline of aviation may be due in part to vague notions of what chair flying is and how to use it effectively. Hohmann (2011) discovered that even though Canadian military pilots regarded chair flying as a recommended training exercise, “formal instruction in the method of chair flying is not provided” (p. 69). Furthermore, aviation students and flight instructors may not be fully aware of the potential benefits of chair flying and mental imagery training due to a scarcity of information about these practices in aviation training publications.

Haddon (2007) found this to be the case in her study of university musicians whereby 91 percent of the music students and 89 percent of their professors indicated that they use mental imagery as a deliberate practice strategy but none of the students and only 23 percent of the professors could recall any references to the use of mental imagery described in their music training books. Similar results might emerge from a survey of aviation students and their instructors because there is little to no mention of mental rehearsal, visualization, or chair flying in any of the most commonly used publications used in aviation training, including the *Pilot's Handbook of Aeronautical Knowledge* (FAA, 2016a), the *Airplane Flying Handbook* (FAA, 2016b), the *Instrument Flying Handbook* (FAA, 2012), and most surprising, the *Aviation Instructor's Handbook* (FAA, 2020). Furthermore, unlike the prevalent descriptions and detailed guidance about the use of mental imagery found in sports psychology texts (Eklund & Tenenbaum, 2014; Shinke, McGannon & Smith, 2016), there is no mention of its use to improve pilot performance in several of the most recently published aviation psychology books (Vidulich, Tsang, & Flach, 2014; Martinussen & Hunter, 2018).

Nevertheless, it is likely that a high percentage of flight instructors and academic professors encourage their students to chair fly often without providing them with a clear definition of what chair flying or mental imagery is or how to use these training strategies effectively (Jentsch, Salas, & Bowers, 1997; Hohmann & Orlick, 2014). Therefore, at the start of the proposed study, the researcher will provide participants with the following definition of chair flying as it relates to this study and to align it with the term mental imagery: *Chair flying is the act of practicing flight procedures on the ground or using any one or a combination of mental imagery techniques to practice and experience the performance of aircraft flight procedures,* *maneuvers, cognitive tasks, and missions in the mind.* While the researcher will use the term mental imagery more prevalently than chair flying in the mental imagery guidance materials provided to the study participants, it is likely that the participants will favor the term chair flying and use the two terms synonymously. Based on these derived definitions, the researcher views the use of mental imagery training and chair flying exercises as experiential learning opportunities that fit well within the framework of Kolb's Experiential Learning Theory.

Experiential Learning Theory

As introduced in Chapter 1, Kolb's Experiential Learning Theory will serve as the theoretical framework supporting this study and it guided the development of the mental imagery training materials that the student pilot participants will use to supplement their private pilot flight training. Kolb's (2014) intention for developing his theory was to describe "a theoretical perspective on the individual learning process that applied in all situations and arenas of life" (p. xvii). McCarthy (2010) described experiential learning as active learning, interactive learning, and "learning by doing" (p. 91), which is in contrast to indirect or passive learning through hearing about or reading about the realities under study. Kolb (2014) defined learning as "the process whereby knowledge is created through the transformation of experience" (p. 49), and he explained that the distinguishing difference between experiential learning and traditional education is its focus on process rather than behavioral outcomes (Kolb, 2014). The idea behind this is that people form and continuously modify their understanding of concepts and new ideas through experience.

According to Kolb (2014), the learning process occurs during a four-stage cycle involving four adaptive learning modes, namely – concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) as illustrated in Figure 1.

During this cycle, learning occurs from the resolution of creative tension among the four learning modes, and for learners to be effective, they need to:

- involve themselves fully, openly, and without bias in new concrete experiences (CE),
- reflect on and observe their experiences from many perspectives (R0),
- create concepts that integrate their observations into logically sound theories (AC), and
- use these theories to make decisions and solve problems (AE). (Kolb 2014, p. 42)

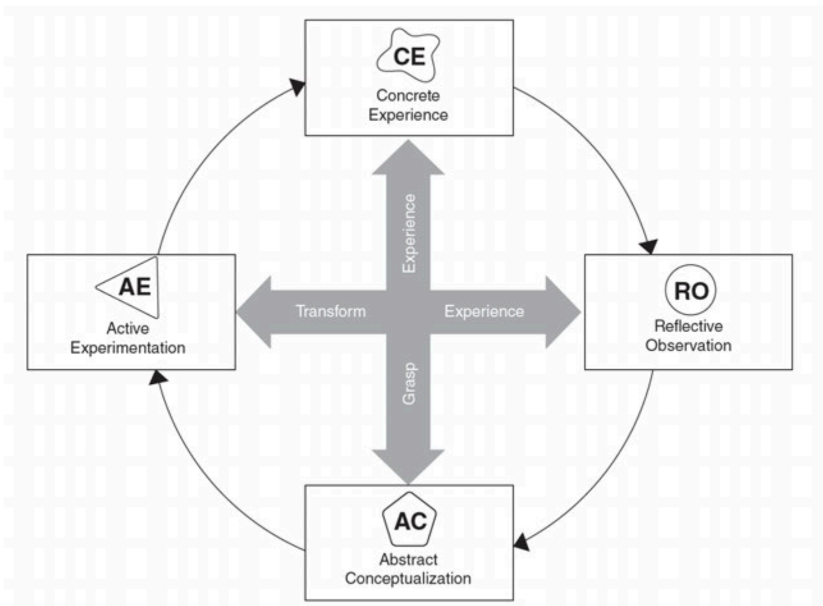

Figure 1. Kolb's Experiential Learning Cycle (Kolb, 2014, p. 51)

Kolb (2014) explained that the process of learning involves moving in varying degrees from actor to observer and from specific involvement to general analytic detachment. As illustrated in Kolb's learning cycle, concrete experience contrasts abstract conceptualization while active experimentation is the opposite of reflective observation. Based on their learning style preferences, learners must choose which of their abilities to apply in specific learning situations, but all four modes of the learning cycle are experiential, and learners must encounter all four for learning to occur (Kolb, 2014).

Mental imagery training fits within the experiential learning cycle as a form of active engagement with the phenomenon, or as Weinberg and Gould (2018) asserted, a simulation similar to a real sensory experience, such as seeing, feeling, or hearing, but the entire experience occurs in the mind. Furthermore, mental imagery experiences can also involve bodily movements (Chase & Galvin, 2013). Consequently, mental imagery training exercises are concrete experiences similar to actual perceived experiences and structured conceptualization. Moreover, mental imagery exercises fit into what Kolb (2014) described as an immense variety of applied methods developed for experiential learning, including simulations, structured exercises, games, observation tools, role playing, and skill-practice routines. The common core of all such methods is to “simulate situations designed to create personal experiences for learners that serve to initiate their own process of inquiry and understanding” (Kolb, 2015, p. 11).

The following is a simplified example of how the experiential learning cycle applies to the acquisition and development of a flight skill by student pilots – in this case the skill of performing a normal takeoff. After receiving introductory ground training about how to perform a normal takeoff, student pilots will gain concrete experience (CE) in performing that task during actual flight training lessons in the aircraft. After each lesson, they will actively and subconsciously reflect on what they practiced (RO), taking notice of how they felt physically and emotionally while performing the task. Then, the students will further conceptualize their understanding of how to perform the takeoff by completing structured mental imagery exercises and thinking through the task as vividly as they can (AC). Then, upon returning to the aircraft, students will actively experiment with performing the normal takeoff with their new knowledge that became transformed by their experiences during the learning process. After this, the cycle restarts with new concrete experiences in performing the normal takeoff.

The Association of Experiential Education (AEE, n.d.a) is a nonprofit professional membership association based in St. Petersburg, Florida that "is dedicated to experiential education and the students, educators, and practitioners who utilize its philosophy" (p.1). The AEE strives to raise the quality and performance of experiential programs through its accreditation and certification programs. The AEE (n.d.b) provides the following list of experiential education principles of practice that will guide the current study:

- Experiential learning occurs when carefully chosen experiences are supported by reflection, critical analysis and synthesis.
- Experiences are structured to require the learner to take initiative, make decisions and be accountable for results.
- Throughout the experiential learning process, the learner is actively engaged in posing questions, investigating, experimenting, being curious, solving problems, assuming responsibility, being creative, and constructing meaning.
- Learners are engaged intellectually, emotionally, socially, soulfully and/or physically. This involvement produces a perception that the learning task is authentic.
- The results of the learning are personal and form the basis for future experience and learning.
- The educator and learner may experience success, failure, adventure, risk-taking and uncertainty, because the outcomes of experience cannot totally be predicted.
- The educator's primary roles include setting suitable experiences, posing problems, setting boundaries, supporting learners, insuring physical and emotional safety, and facilitating the learning process.
- The educator recognizes and encourages spontaneous opportunities for learning.
- Educators strive to be aware of their biases, judgments and pre-conceptions, and how these influence the learner.
- The design of the learning experience includes the possibility to learn from natural consequences, mistakes and successes. (AAE, n.d.b, The Principles of Practice)

According to the AEE (n.d.b), experiential education is a teaching philosophy that informs many methodologies in which educators purposefully engage with learners in direct experience and focused reflection in order to increase knowledge and develop skills. The researcher of the proposed study views mental imagery training and chair flying exercises as forms of experiential learning intended to enhance the learning of new flight skills, to increase proficiency of previously learned flight skills, and to help students prepare ahead of time for flight training lessons. Therefore, the Experiential Learning Theory will serve as an appropriate theoretical framework for this study. Furthermore, to add support for the use of mental imagery exercises to supplement flight training, it is appropriate to discuss the neurological factors that may contribute to their effectiveness as experiential learning opportunities. The researcher describes this topic next.

The Neurological Basis for the Efficacy of Mental Imagery

Before addressing the results of various research studies found in the growing body of literature regarding the use of mental imagery training techniques to enhance human performance, a discussion regarding the cognitive processes involved in mental imagery is appropriate. Kosslyn, Ganis, and Thompson (2006) described mental imagery as a means of accessing perceptual information from memory as a way of 'seeing with the mind's eye' and 'hearing with the mind's ear' etc. It is a cognitive process fundamental to motor learning and performance and its use is of particular interest to researchers working in the fields of cognitive psychology, neuropsychology, neurophysiology, and neurorehabilitation among others (Cumming & Williams, 2012). Weinberg (2008) reported that the body of evidence regarding the effectiveness of using mental imagery to enhance human performance is growing and that much of this evidence stems from studies to explore the cognitive processes that make such gains possible. Therefore, the aim of this section is to discuss the findings of several such studies that highlight the neurological aspects of mental imagery usage that contribute to its effectiveness to learn and improve cognitive and psychomotor skills.

While there is extensive and growing evidence supporting the use of mental imagery as an effective means of improving cognitive and psychomotor skills, the underlying factors for why it is effective appear to be the close associations and overlaps of brain activities that occur during both physical practice and mental practice (Cumming and Williams, 2012). Mulder et al. (2003) proposed that:

> When a subject is mentally practicing the execution of a movement, impulses are sent to target muscles. Furthermore, it is suggested that the same neuromotor pathways that are involved in the execution of a specific action are also activated during mental practice. This activation aids skill learning by improving the appropriate coordination patterns as a result of the strengthening of motor programs in the motor cortex, and by priming the corresponding motor neurons of the muscles necessary to execute a motor task. (p. 212)

Researchers are able to examine and compare such brain activities during physical activity and mental imagery through the use of brain scanning technologies, including functional magnetic resonance imagery (fMRI), (Datta & Bandyopadhyay, 2013). One of the primary advantages of using fMRI scans is that it is non-intrusive and it provides a clear, high resolution image of the brain with indications of where the strongest brain activities are occurring at the time of scanning (Datta & Bandyopadhyay, 2013). Functional MRI scans measure brain activity by detecting changes in blood flow to different regions of the brain. This is possible because oxygen rich blood from the lungs has a different magnetic resonance than blood that has already released its oxygen content to other cells in the body (Datta & Bandyopadhyay, 2013). Increases in brain activity demand higher levels of oxygen rich blood and thus, fMRI scanners can detect the specific areas in the brain demanding these increases in oxygen-rich blood. The measurement of these blood flow increases is the blood-oxygen-level-dependent (BOLD) signal and being able to record these signals gives researchers a clear indication of which areas of the brain are in most demand of oxygen during the time of the brain scan (Datta & Bandyopadhyay, 2013).

Ganis, Thompson, and Kosslyn Study

Ganis, Thompson, and Kosslyn (2004) used fMRI brain scans to investigate the shared neural processing that occurs during visual mental imagery and actual visual perception. Participants in this study completed six fMRI scanning sessions alternating between imagery and perception conditions. Each scanning session consisted of 16 trials for a total of 48 trials per condition (Ganis et al., 2004). Several days prior to the scanning sessions, the participants studied a booklet of faint line drawings of common objects with a light foreground and black background. Each scanning session began with an audible cue describing the image that the participants were to either view directly on a computer screen within their field of vision or to imagine the image with their eyes closed. The results of the fMRI BOLD signals indicated remarkably similar activations of brain regions during the visual perception and the visual imagery conditions, with an overall proportion of overlap of about 92% (Ganis et al., 2004). The areas with the greatest similarity in activation were the frontal and parietal cortex while the smallest similarity was in the occipital cortex. Other variations of overlap occurred across multiple regions of the brain. Ganis et al. (2004) asserted that “regions engaged by visual imagery across the brain were a subset of those engaged during visual perception” (p. 236) and that “visual imagery and visual perception draw on most of the same neural machinery” (p. 239).

Olsson, Jonsson, Larsson, and Nyberg Study

In a different study using fMRI technology, Olsson et al. (2008) used statistical analysis of BOLD signals to examine the brain activity involved during the mental imagery of a complex motor task between two groups of participants. The complex task involved a high jump over a horizontal bar. One group was comprised of elite experienced high jumpers and the other group was comprised of novice high jumpers with no experience. Olsson et al. (2008) predicted that experienced high jumpers would use mental imagery from an internal perspective (first person view from within), which would engage movement-related regions of the brain, while novice high jumpers would use mental imagery from an external perspective (third person outside observer), which would engage visuo-perceptual regions of the brain. Olsson et al. (2008) theorized that in order to successfully employ an internal imagery perspective and feel as if the action is actually occurring, it is necessary to have well-developed motor representations of the action. In other words, imagers must have experience with the action in order to activate the motor regions of the brain while performing imagery of the action.

During the imagery training sessions, the participants read and listened to verbal instructions to visualize the entire high jump from the start of the runway until the landing and to do so using an internal perspective according to the script (Olsson et al, 2008). Then, all participants completed an fMRI scanning session during which they visualized the high jumping task according to written and oral internal imagery instructions for 20 cycles lasting eight seconds each separated by an eight second rest period. They performed each imagery cycle with their eyes open so that they could see a prompt on a screen, which served as a signal for starting and stopping each imagery cycle. Olsson et al. (2008) analyzed the fMRI data using a combination of MANOVA and sample t-tests to compare the brain region activity of the experienced high jumpers to that of the novice jumpers.

The results were as Olsson et al. (2008) predicted. Brain activity of experienced high jumpers during imagery showed increased activity in several motor areas, mainly left-lateralized, including the supplemental motor area (SMA), the left superior frontal gyrus, the left cerebellum, and the bilateral pre-motor cortex. Conversely, the brain activation pattern for the novice high jumpers showed activation in visuo-perceptual regions of the brain, including the left inferior parietal cortex, superior occipital cortex, left superior temporal cortex, left precentral gyrus, and the right lingual gyrus (Olsson, 2008). Although the supplemental motor area of the brain was active among the novice high jumpers, it was to a lower extent threshold than the experienced high jumpers.

Olsson et al. (2008) found a significant difference in the BOLD values in three brain regions. In two areas, namely the left pre-motor cortex and the right pre-motor cortex, the BOLD signals of experienced high jumpers were significantly stronger than for novice jumpers. Furthermore, the BOLD signal change in the left superior temporal gyrus was significantly stronger for the novice high jumpers than the experienced high jumpers. This region is associated with auditory processing and thus, the higher signal change for novice high jumpers may have been an indication that novice jumpers had difficulty using the first-person internal perspective to imagine the high jump, so they used a third person external perspective instead (Olsson et al., 2008). Olsson et al. (2008) asserted that their findings revealed "pronounced differences between skilled jumpers and novices during motor imagery" (p. 9) and that mental imagery appears to be able to activate and perhaps strengthen motor regions of the brain provided that the person engaging in imagery has developed adequate motor representations of the task.

Debarnot, Clerget, and Olivier Study

Debarnot, Clerget, and Olivier (2011) conducted a study to investigate whether motor mental imagery can elicit an early boost in the performance of a physical task similar to the boost that occurs from physical motor practice. The basis for this study is the theory that people acquire motor skills during at least two distinct phases. The first is a fast phase, which occurs while physical training is occurring and as an immediate result of practice. However, there is also a transient post-training phase of skill acquisition that occurs after a short delay of five to thirty minutes following the completion of a physical practice period (Debarnot et al., 2011). This phase is a motor memory consolidation period that produces an ‘early boost’ in skill performance as the skill transforms into a stable and long-lasting skill (Debarnot et al., 2011).

Debarnot et al. (2011) theorized that during this delay period, the same brain networks that activate during physical practice, specifically those in the primary motor cortex, reactivate while at rest and then replay the neuronal activity involved in the skill, thus modifying the synaptic connections activated during physical practice in order to refine the motor memory process (Debarnot et al., 2011). Debarnot et al. (2011) emphasized the well-examined theory that mental practice and motor imagery are an effective means of enhancing cognitive and motor performance due in part to comparable autonomic nervous system activity that occurs during both imagined and actual movements.

Debarnot et al. (2011) conducted an experiment involving three groups of participants who completed a finger tapping task on a computer keyboard. Each group completed a pre-training practice session to establish the baseline data for each participant. Then, participants in the physical practice group completed a training session in which they performed the finger tapping task during 10 blocks of 30 seconds each, separated by a rest period of 20 seconds. Participants in the motor imagery (MIM) group mentally imagined performing the finger tapping task for the same duration as the physical practice group after reading scripted instructions about how to imagine the task using visual and kinesthetic imagery and how to prevent finger movements during the motor imagery training. Control group participants read from a magazine for the same duration as the training session and did not complete any finger sequence training.

After the training session, all participants completed a post-training practice session of two blocks of trials in the same manner as the pre-training practice session. Then, a 30-minute delay period ensued in which all participants refrained from performing any motor imagery or physical practice of the finger-tapping task. After the delay period, all participants completed a re-test session where they performed the same finger tapping practice routine for the third time.

Debarnot et al. (2011) analyzed the two dependent variables for each practice session, namely, the number of correct tapping sequences and the mean duration of each sequence. The results led Debarnot et al. (2011) to assert that motor imagery training can lead to an early boost in performance similarly to the boost that occurs following physical practice and that both motor imagery and physical training can lead to a similar increase in the amplitude of early boost performance.

Bohan, Pharmer, and Stokes Study

While the body of literature in mental imagery research indicates a high level of concurrence regarding the commonalities of brain activities that occur during mental imagery and physical practice, Bohan, Pharmer, and Stokes (1999) discovered a lack of consensus among researchers about when during the process of learning a new skill that the use of mental imagery rehearsal yields the greatest benefits. Some researchers argue that mental imagery is most effective only after people develop their skills well, such as the imagery used by elite athletes, while others contend that imagery is effective early in the skills acquisition process and that imagery practice may be most beneficial in the early stages of learning (Bohan, Pharmer & Stokes, 1999). Nevertheless, Bohan, Pharmer, and Stokes (1999) found consensus in the literature that motor imagery practice has a positive effect on motor task performance and that it is most effective when used in conjunction with physical practice. This is because “the high-level mental nodes represent the underlying concepts of a skill and are activated during both physical and imaged movement, whereas the subordinate low-level muscle nodes are only activated during actual physical movement” (Bohan, Pharmer, & Stokes, 1999, p. 652). Because of this, “the positive effect of imagery practice on movement performance is attributed to increased activation rates of higher-level mental nodes, which in turn increase the overall speed of response” (p. 652).

Based on their findings in the literature, Bohan, Pharmer, and Stokes (1999) conducted an experiment involving 30 participants to determine the most beneficial point in a training program to start using mental imagery. During this experiment, each participant sat by themselves in a darkened room in front of a computer monitor. Using a joystick, they controlled the movement of a white cursor toward a white target box on the black screen as instructed. The initial movement of the joystick started the movement of the cursor on one side of the screen toward the target on the other side and the speed depended on the displacement of the joystick. Moving the stick a second time in the opposite direction controlled the velocity of the cursor movement down to zero, thus terminating the cursor movement. To land the cursor on the target, the participants had to coordinate the amount of force applied to the joystick with the timing of the return movement.

Bohan, Pharmer, and Stokes (1999) divided the participants into three groups based on their planned learning levels. The early learning group completed 10 practice trials, the intermediate learning group completed 20 practice trials, and the late learning group completed 40 practice trials. All participants then completed 20 practice trials using only mental imagery with the control stick disabled. For each imagery trial, the participants first viewed the position of the target and the cursor before imagining the action of moving the stick as necessary to guide the cursor to the target. Then, after a rest interval of two minutes, each participant completed a posttest of 10 trials of the task. The researchers recorded the movements and response times required to acquire the target.

The results of the posttest showed that movement times did not differ among all three groups and that the mean movement times decreased significantly following imagery rehearsal. In addition, participants in the early and intermediate learning groups exhibited significant gains in movement speed after imagery rehearsal, but movement times for those in the late learning group did not change significantly from pretest to posttest (Bohan, Pharmer, & Stokes, 1999).

There were two primary findings in this study. The first was that mental imagery practice appeared to be more beneficial during early stages of learning. Participants in the late learning group – those with more experience with the task – did not show improvement as a function of imagery, and this was likely due to what is known as the ‘ceiling’ effect, whereby they became so proficient during practice that further improvement by imagery became negligible ((Bohan, Pharmer, & Stokes, 1999). However, this could have also been due to these experienced learners becoming so fatigued or bored with the mental imagery trials because they knew the task so well that they may not have put much effort into them (Bohan, Pharmer, & Stokes, 1999).

The second major finding of the Bohan et al. (1999) study is that the early learning group was able to reach the same level of proficiency as the intermediate and late learning groups with fewer physical practice attempts. This finding is consistent with the notion that mental imagery and physical practice activate shared neural mechanisms. Both findings led Bohan, Pharmer, and Stokes (1999) to conclude that when learning a novel task, imagery practice may be sufficient to enhance motor performance with little or no additional physical practice and that the use of mental practice may be appropriate early in the learning process without the need for much actual physical practice of the task before using it. The researchers also concluded that the optimal stage in the learning process for implementing imagery practice depends on the individual’s mental representation of the component motor skills underlying the task. Therefore, if the performer possesses the requisite components, imagery practice should be beneficial early in the process of transferring them to the novel skill (Bohan, Pharmer, & Stokes, 1999).

Summary

This section highlighted several neurological factors that contribute to the effectiveness of mental imagery uses. The development of brain scanning equipment has enabled researchers to examine the brain activities involved during mental imagery and to compare these activities to those used during actual perception. In particular, the use of fMRI technology has proven to be particularly helpful in this area. Ganis, Thompson, and Kosslyn (2004) used fMRI scans of the brain and found that similar cognitive control processes occur when viewing images directly (perception) as when imagining those images. Olsson et al. (2008) used fMRI technology to analyze BOLD signal differences in the brain during the mental imagery of a complex task and found that mental imagery of a motor task is most effective in activating the motor areas of the brain when the subject has enough experience with the task to form an adequate mental representation of the task. Debarnot, Clerget, and Olivier (2011) found that mental imagery was successful in producing an early boost in performance of a physical skill similar to the boost produced after physically practicing the skill and that the primary motor cortex region of the brain is causally involved in implementing this early boost in performance. Lastly, Bohan, Pharmer, and Stokes (1999) found that the positive effect of mental imagery practice on movement performance due to an increase in the activation rates of higher-level mental nodes can occur early in the learning process.

The results of these brain scan studies revealed that similar brain functions are involved in mental imagery, perception, and physical activity. Such findings add support for exploring the use of mental imagery to supplement other training methods. However, before initiating such inquiry, it is important for researchers to consider and account for the fact that people have varying degrees of mental imagery aptitude as described in the next section.

Mental Imagery Aptitude

Mental imagery aptitude varies among people (Marks, 1973) and this could affect the outcomes of mental imagery research efforts. Consequently, many research studies to evaluate the effectiveness of mental imagery interventions begin with a measurement of each participant's imagery vividness. David Marks (1973), a seminal researcher in the field of mental imagery, successfully tested the reliability of a questionnaire he developed to determine people's mental imagery aptitude. His *Vividness of Visual Imagery Questionnaire* (VVIQ), which remains a standard in imagery research studies today is comprised of four sets of four questions, with each set corresponding to a visual image description. Participants rate their own ability to visualize the described object using a five-point scale, ranging from 'Perfectly clear - as vivid as normal vision" to 'No image at all' (Marks, 1973). For example, the questionnaire asks participants to visualize a rising sun and then rate their imagery of four different image prompts, such as how well they can picture the sun rising above the horizon into a hazy sky. Through this process, participants self-assess whether they are 'good visualizers' or 'poor visualizers' based on their VVIQ score (Marks, 1973). Interestingly, the VVIQ questionnaire might also reveal students and research participants who completely lack the ability to see images in their mind's eye. This condition, called *congenital aphantasia,* is a phenomenon recently discovered by Zeman, Dewar, and Della Sala (2015) and may affect about two to three percent of the population. Researchers should consider screening for this condition and for those with low VVIQ scores when conducting research that requires participants to complete mental imagery training exercises. Furthermore, VVIQ scores may be useful to mental imagery coaches and instructors for making adjustments to their mental imagery exercises according to the imagery aptitude of their trainees.

While the VVIQ questionnaire is a reliable means to assess visual imagery vividness (Marks, 1977), it only addresses the one modality of being able to see images with the mind's eye. However, people also have the ability to imagine multiple senses, such as sounds, smells, the feeling of motion, and the emotions involved when performing the task. Therefore, Andrade, Deeprose, Baugh, & Ganis (2014) developed the Plymouth Sensory Imagery Questionnaire (psi-Q) to measure the "vividness of imagery across a range of sensory modalities – visual, auditory, olfactory, taste, touch, bodily sensation, and emotional feeling" (p. 550). Similar to the VVIQ, information obtained from the psi-Q could be helpful in designing and facilitating mental imagery training sessions. For instance, if an aviation student completed the questionnaire and the results indicated that the student was weak in the ability to imagine smells, then it would be appropriate to remove references to the smells of the cockpit from imagery training scripts used for that student. Conversely, it would be appropriate to include references to various sounds in the imagery guidance scripts for those who score strongly in the imagery modality of sound, such as imagining the change in wind and engine noise as the aircraft accelerates and decelerates during specific maneuvers. According to Andrade et al. (2014), it is not uncommon for individuals to rate one or more modalities as strong and the others as weak.

Participants in the proposed study will complete the psi-Q questionnaire at the start of the study as described in Chapter 3 – Methodology. The imagery guidance materials provided to the participants encourages them to adjust their imagery scripts based on their self-assessed imagery aptitude. This is one of several techniques and methods of customizing mental imagery training exercises to meet the needs of trainees. In the next section, the researcher discusses several other methods and strategies for enhancing the vividness of mental imagery and using it to supplement physical training.

Mental Imagery Training Methods

The research literature regarding the use of mental imagery to improve human performance includes many examples of different methods and strategies used to implement mental imagery training, including the use of mental imagery scripts, audio podcasts, and relaxation exercises – all intended to guide and enhance the vividness and effectiveness of the mental imagery experience. The purpose of this section is to briefly describe some of these mental imagery methods because each is applicable to the proposed study to explore student pilot perceptions about their use of mental imagery training. The researcher incorporated these methods into the mental imagery training materials that the participants will use during this study. To begin, the researcher discusses the Holmes and Collins (2001) PETTLEP model as it will serve as the foundational mental imagery implementation strategy for this study.

The PETTLEP Model

Holmes and Collins (2001) developed the PETTLEP model of mental imagery, which they based on fundamental cognitive neuropsychology and the findings of research studies showing that the same neurophysiological processes involved in actual or physical movement are also involved in mental imagery (Smith, Wright, Allsopp, & Westhead, 2007). Researchers view these shared neurophysiological overlaps as "a possible explanation for the performance-enhancing effects of imagery" (Smith et al., 2007, p. 80). According to Holmes and Collins (2001), "if physical and mental practice are equivalent, then many of the procedures shown to be efficacious in physical practice should also be applied in mental practice as well" (p. 62). Therefore, the Holmes and Collins (2001) PETTLEP model of imagery includes seven elements that imagery researchers, coaches, and users should consider when designing and implementing mental imagery interventions in order to replicate the actual physical practice experience more closely. These elements are the (P) Physical nature of the imagery experience; the (E)

Environment where the imagery exercise occurs; the similarity of the imagined (T) Task to the actual task; the (T) Timing or pace of the exercise; adjustments to the exercise based on (L) Learning the task; the (E) Emotions involved in performing the task, and finally the (P) Perspective in which the participant views their imaging, as in first person (internal) or as a spectator (external) (Holmes & Collins, 2001). While it is not necessary to include all elements of the PETTLEP model with each imagery intervention, Smith et al. (2007) proposed that such interventions would be more effective by including more of them.

To further explore the effects of the PETTLEP model on athletic performance, Smith et al. (2007) conducted two studies involving specific elements of the model. The first study, which involved three different test groups and a control group of field hockey players, focused primarily on the physical nature of the task of performing penalty flicks and the environment in which the players performed their flicks. During the six-week intervention, all players in the test groups performed their assigned imagery intervention every day for about ten minutes while the control group players read field hockey literature. All participants completed their normal practice and game schedule. The Group 1 players were the sport-specific group, and they performed their imagery while wearing their hockey uniforms and standing on their team's hockey field. Group 2 players were the clothing group, and they performed their imagery in the standing position at home while wearing their uniforms. Group 3 players were the traditional group, and they performed their imagery in the seated position at home while wearing everyday clothes. At the end of the six weeks, all players completed a video recorded assessment of penalty flicks at an unguarded goal. While all groups showed improvement from pre-test scores, "the sport-specific group scored significantly higher than the clothing group, which scored significantly higher than the traditional imagery group" (Smith et al., 2007, p.86). All three of the imagery groups scored significantly better than the control group. These results highlight the potential additional benefits of including multiple elements of the PETTLEP model to imagery interventions. Furthermore, all imagery participants reported positive perceptions about the effects of imagery on their performance (Smith et al., 2007).

In their second study, Smith et al. (2007) randomly assigned female gymnasts to one of four groups – namely, a physical practice group, a PETTLEP group, a stimulus group, and a control group to assess their improvement in performing a full turning straight jump on a balance beam. In this study, the PETTLEP group participants used all seven of the PETTLEP model elements during their imagery intervention sessions. This involved the participants reading a descriptive imagery script immediately prior to each imagery exercise in an effort to help them imagine the physical sensations of the task and the emotions felt prior to performing the task. To address the environmental and physical components involved with the task, the gymnasts performed their imagery while dressed in their normal gymnastics clothing and standing on the beam in the same gym where they would complete their assessment. Furthermore, the script instructed them to imagine each jump in real time from an internal perspective and to alter their imagery tactics as they became more experienced and proficient (Smith et al., 2007). This last element addressed the learning (L) component of the model. The stimulus group participants read the same script as the PETTLEP group participants, but their imagery occurred at home while dressed in everyday clothing. Both of these imagery groups performed the imagery intervention sessions three times per week for about three to five minutes in which they imagined the jump twice. These participants and the gymnasts in the control group refrained from physically practicing the jump during the six weeks of the study. The physical practice group did not complete any imagery interventions and instead, they performed two practice jumps on the beam three times per week.

The results of the second Smith et al. (2007) study revealed significant improvement of both the physical practice group and the PETTLEP group in performing the balance beam jumping turn. Although the stimulus group scores also improved, the improvement was not statistically significant from the control group, which actually showed a decline in skill. However, the remarkable finding of this study was that the PETTLEP group's improvement and performance scores were such that "PETTLEP imagery appeared to be as effective as physically performing the task" (Smith et al., 2007).

In a different study, Wright and Smith (2007) compared the effects of using the PETTLEP model of imagery practice to the use of traditional imagery practice methods and physical practice alone to improve cognitive task performance. This study involved eighty college students randomly assigned to one of four groups based on the intervention they would receive after completing a pre-test involving a timed video game exercise in which they maneuvered a race car around a track by use of the arrow keys on a computer keyboard. To address the physical element, participants in the PETTLEP group completed their imagery intervention training while seated at the same computer where they could touch the keys of the keyboard. The traditional imagery group completed imagery training in a different room with their eyes closed. The physical practice group completed additional practice races using the same computer. The post-test results showed that the PETTLEP group's performance increase was similar to the physical practice group's performance and that both of these groups' performance increase was significantly higher than the imagery only and control groups (Wright & Smith, 2007).

The results of these and similar studies to explore the effects of incorporating the elements of the PETTLEP model into mental imagery training interventions support the use of this model as a guide for developing the imagery training interventions used in the proposed study. As such, the mental imagery training materials provided to each participant include suggested techniques they can use to incorporate as many of the PETTLEP elements as they desire. For example, the imagery guide advises the student pilots to try practicing their flight skills while seated in a static aircraft parked on the ramp of their training airport while wearing the same clothes and flight gear they normally wear when they physically practice, such as their kneeboard and aircraft headset. This strategy addresses the physical (P) and environmental (E) elements of the PETTLEP model and provides students an opportunity to experience multiple aspects of actual flight training as they perform their imagery exercises. This includes seeing the components of the instrument panel; moving the control yoke and throttle; sensing their weight and body position in the pilot seat; operating the rudder pedals; and taking in the smells of the cockpit.

Furthermore, to address other elements of the PETLEP model, the guidance materials used in the proposed study include several mental imagery scripts, similar to those used in the Smith et al. (2007) study, to guide the participants' imagery as they mentally practice performing their flight tasks. For example, some of the scripts include prompts to cause the participants to think about how they are feeling emotionally as they perform specific maneuvers. This addresses the emotional (E) element of the PETTLEP model. In addition, the scripts encourage participants to alter their imagery perspective at times, which addresses the second (P) of the PETTLEP model. The student pilots can either read these scripts to themselves, listen to them as someone else reads them aloud, or listen to them via an audio recording. While listening to the scripts in the natural environment, students can close their eyes and follow along as they manipulate the flight controls and mimic the physical inputs required during each procedure and maneuver. However, for mental imagery scripts to be most effective, script developers should consider adhering to certain design elements found in the literature.

Imagery Scripts and Audio Recordings

One of the key benefits of using imagery scripts is that they add structure and organization to the practice of mental imagery, leading to greater effectiveness and avoiding harmful outcomes (Williams, Cooley, Newell, Weibull, & Cumming, 2013). Nordin and Cumming (2005) found that imagining poor performance could lead to a reduction in the actual performance of the imagined task. Therefore, the use of carefully structured and well-worded imagery scripts can serve as an effective means of keeping imagers focused on the most appropriate elements of each imagery intervention.

To develop structured imagery exercises, it is important to consider the manner in which imagers will use the script (Williams et al., 2013). In some cases, the imagery script serves as a tool in self-paced exercises in which imagers read the scripts to themselves either silently or aloud (Williams et al., 2013). In other exercises, imagers may listen to a recording of the script, which allows them to close their eyes and listen as they imagine the elements described in the script (Williams et al., 2013). However, during some imagery training sessions, imagery coaches might prefer to read their scripts aloud to their trainees so they can moderate the pace of the script based on the reactions and feedback from each imager.

According to Williams et al. (2013), imagery script writers should consider several important elements in each script, including the purpose of the script, who will use it, where and when the imager will use it, and specifically what the imager will imagine. To help imagery coaches and script developers address all of these elements in their customized scripts, Williams et al. (2013) developed an imagery script checklist that includes notation boxes for inserting specific and relevant information. For example, in the “Why” box, the script writer can describe the purpose of the script, such as *to help Bob cope with pre-competition nerves and enhance his feelings of self-confidence*. This helps focus the script writer’s attention on keeping the script aimed on its purpose. Munroe, Giacobbi, Hall, & Weinberg (2000) highlighted the importance of focusing on the purpose of each imagery script during the script writing process because of the many ways in which people use imagery.

For example, the following are two mental imagery scripts intended for different purposes. The first is a script produced by Saab et al. (2017) for their research in exploring the use of imagery in surgical training. Its focus was on technical training and its purpose was to guide resident surgeons through the intricate procedures associated with performing a total abdominal hysterectomy. These researchers made an audio recording of the script and referred to this instrument as the mental practice tool (MPT). The participants listened to the MPT using headphones as they mentally engaged with the narrative (Saab et al., 2017). The following is an excerpt of the Saab et al. (2017) script:

> *You have safely entered the retroperitoneal space and now will identify the ureters. You always tend to see the right side with a little more ease, so you start there. You imagine the clear laparoscopic view as you follow the ureter, crossing over the common iliac at the pelvic brim, diving down along the sidewall under the ovary, then turning medially and disappearing anteriorly under the uterine medially and disappearing anteriorly under the uterine artery, coming within a centimeter lateral to the top of the uterosacral ligament. The ureter courses retroperitoneally along the medial side of the broad ligament. Gently, using the Yankauer suction in the left hand, you medially retract the ovary and its blood supply. Using a second suction or the back of a pickup, you stroke gently back and forth parallel to the vessels. You see the iliacs pulsating and you transfer your gaze just medial and deep, to find the ureter peristalsing. You feel satisfaction. You palpate the ureter by placing your finger and thumb on either side of the peritoneal reflection. You sweep upward towards the cut edge and you confirm the presence of that non-pulsating cord along the medial aspect of the peritoneum…* (p. 218)

Alternatively, rather than focusing on the technical aspects of a task, Morris, Spittle, and Watt (2005) developed scripts to explore water polo player's perceptions about the quality and effectiveness of their mental imagery by guiding them to mentally experience different sense modalities and the emotions experienced during the course of play. The following excerpt pertains to mentally practicing a goal shooting maneuver:

> *You are situated at the opposition 4-meter line to the left of goal and in line with the post. You tread water vigorously directly in front of your opponent, who is marking you closely. You lift up out of the water to receive a clean pass from a player to your right who was calling out to you. You swim back slightly and raise the ball out of the water above your head. The goalie looks toward you and moves into a defensive position to the left of goal. You shoot the ball powerfully over the top of your opponent to the top right corner of the goal and it smashes into the back of the net. Your teammates are pleased that your shot for goal is successful.* (Morris, Spittle, & Watt, 2005, p. 105)

These short excerpts illustrate just two of the many ways mental imagery researchers have used scripts in different disciplines to enhance the imagery experience of participants and to explore the effectiveness of mental imagery training.

In perhaps the earliest study to explore the use of imagery in the field of aviation, Prather (1973) explored the use of mental imagery scripts to improve the landing performance of T-37 Air Force pilot trainees. In that study, the imagery test group of trainees completed four imagery sessions on different days immediately following actual flights. The pilot trainees sat in a cockpit mockup of the T-37 aircraft and listened to different pre-recorded scripts applicable to the landing pattern. Similar to the strategies employed in the PETTLEP model, the researcher instructed the participants to imagine the scripted scenarios as vividly as possible and "to perform the same motor actions and eye movements that they would use if they were in the actual landing pattern" (Prather, 1973, p. 354).

The four recorded scripts used for the study ranged from about 11 to 15 minutes in length and varied in detail. The first script included complete, detailed instructions regarding airspeeds, thrust settings, pitch attitudes, bank, etc. while the last script simply included essential situational cues, such as 'you are on base' or 'you are on final' (Prather, 1973, p. 345). The scripts also included variations in the landing sequences such as go-arounds, touch-and-go landings, and full-stop landings. Prather (1973) explained that the use of tape recordings allowed for exact timing and a more precise control of the mental imagery sessions. The results of the study showed that the trainees who had participated in the guided, scripted imagery sessions improved significantly more than the control group of pilots who did not complete the mental practice exercises. This finding supports the use of scripts to add structure to imagery training exercises and it highlights the merit of incorporating scripted imagery audio recordings into flight training regimens.

For the proposed study involving student pilot participants, the general goal of the mental imagery and chair flying scripts will be to improve the overall performance of the participants and to help them successfully complete their flight training program. However, achieving this goal might occur by focusing parts of the imagery scripts on elements other than flight skills, maneuvers, and cognitive tasks. Munroe et al., (2000) reported that the use of mental imagery can help people manage their emotional state, such as anxiety, stress, self-confidence, and motivation, which may play a large role in their performance. Post and Wrisberg (2012) found that gymnasts used imagery to decrease anxiety, reduce the fear of injury, increase confidence, rehearse performance routines, maintain focus, and manage pain. Script writers can also design imagery exercises to help trainees "psych up" for training and competition (Cumming & Williams, 2013) or to become relaxed in order to better focus on their imagery experience and to feel more in control of their emotions and thought processes (Ekeocha, 2015).

Mind and Body Relaxation Strategy

Researchers have suggested that being in a relaxed state of mind and body may enhance the imagery experience, helping participants to avoid distraction, vividly imagine the skill or movement, overcome anxiety, maintain focus, and become fully immersed in mentally performing their imagined tasks (see Amasiatu, 2013; Goldschmidt, 2002; Holmes & Collins, 2001; Smith et al., 2007). According to Amasiatu (2013), knowing how to relax is a necessary precursor to the effective use of imagery.

Mick et al. (2016) found that mental imagery sessions typically involve a period of scripted relaxation exercises followed by an expert educator reciting a mental imagery script, outlining the specific steps of a task while emphasizing visual, haptic, and cognitive cues. Then, once students have gained a sufficient level of competency in mental practice skills, they can perform them independently. Such relaxation exercises often involve having the imagers sit in a relaxed posture with eyes closed and then guiding them through a series of controlled breathing exercises with soothing words to induce relaxation, such as "With each breath that you take, your body is beginning to grow heavy, warm, and relaxed" (Morisi, n.d.). Relaxation exercises may also include verbal guidance through a progressive muscle relaxation (PMR) exercise involving a sequence of tensing and relaxing different muscle groups of the body with the aim of releasing tension in the mind and body (Epelbaum, 2012). Several researchers across multiple disciplines have described the practice of having participants complete a relaxation exercise prior to completing mental imagery training interventions (see Bachman, 1990; Mick et al., 2016; Bernier & Fournier, 2010; Sanders et al., 2008; Eldred-Evans et al., 2013; Du Toit, 2015).

Scenario-Based Imagery Training

Another method to enhance the effectiveness of mental imagery training is the inclusion of embedded scenarios into guided imagery scripts. According to Merriam, Caffarella, and Baumgartner (2007), guiding students to think through the question, "*What would you do if…*" and then having them verbalize and discuss their actions with one or more other people is one of the many forms of narrative learning in adult education (Merriam, Caffarella, & Baumgartner, 2007). Furthermore, the FAA(2020) recommends the inclusion of scenario-based training (SBT) and posing “What if” scenarios to pilot trainees during visualization exercises in which students mentally rehearse and verbally describe what they would do and how they would perform during normal and abnormal situations. The Federal Aviation Administration describes SBT as “a training method that uses a highly structured script of real-world experiences to address aviation training objectives in an operational environment” and a technique that helps learners gain a deeper understanding of the information and improve their ability to recall the information (FAA, 2020, p. 7-11).

Furthermore, telling stories is one of the ways in which people make sense of what they are trying to learn, serving as a means of confirming an understanding of the new information, even if only in their heads (Merriam, et al., 2007). The forming and vocalizing of stories about past experiences and future responses can support learning by helping the hearers of those stories gain experience vicariously, substituting for direct experience (Jonassen & Hernandez-Serrano, 2002, as cited in Merriam, et al., 2007). Learning with others is often beneficial due to the effects of pooled knowledge, error-correction, observational learning, and increased motivation (Nokes-Malach, Richey, & Gadgil, 2015). Therefore, learners might benefit from working in pairs or small groups to discuss how they would handle various normal and abnormal situations while imagining each scenario. Furthermore, they might find it helpful to complete verbal mental imagery exercises with other learners. During these paired or group mental imagery training exercise sessions, learners can take turns verbalizing and mimicking their actions as they imagine handling different situations. For student pilots, this could include the completion of emergency memory items and checklist procedures; rehearsing the radio communications with air traffic controllers; and stating the decisions they would make to bring the scenario to a successful conclusion. Through this process, the observers might gain additional knowledge and experience vicariously while also noting and discussing errors and alternate strategies.

Martin, Murray, and Bates (2011) explored this concept during a ten-week study to examine airline pilot perceptions about the efficacy of conducting scenario-based discussions in the cockpit during the quiet periods of long flights. During the study, Martin, Murray, and Bates (2011) encouraged 128 airline captains and first officers to spend some of their free time enroute each day to think through and discuss how they would handle different novel emergency and abnormal scenarios. At the end of the ten weeks, 57 of the pilots responded to a seven-question survey regarding their opinions about the efficacy of the inflight scenario-based discussions, a form of chair flying while flying. The results of the survey were “overwhelmingly positive” with nearly all pilots reporting gains in new knowledge, ranging from a “small amount” to “a lot”, and all but one pilot considered themselves better prepared to handle at least one of the discussed events if it happened unexpectedly (Martin, Murray, & Bates, 2011). However, 56 percent of the pilots did not respond to the survey, which could be an indication that they did not partake in the inflight discussions. This may have been due to low opinions about the value of such an exercise or that they did not know what to discuss. The researchers had left the fabrication of the novel events up to the imagination of the pilots. In other words, it was an unstructured chair flying exercise, and some flight crews might not have been interested or skilled in developing their own scenarios. Therefore, the Martin, Murray, and Bates (2011) study highlights the need for adding structure and guidance to scenario-based mental imagery exercises.

Interestingly, researchers have discovered through qualitative tactics that the use of imagery may be more complex than earlier studies had reported (Post & Wrisberg, 2012). For example, athletes use imagery rather creatively to prepare for “what-if” situations by imagining ways to correct problems and respond to mistakes (Post & Wrisberg, 2012). In other words, they use scenario-based imagery to think through how they will recover from various types of errors in their performance. Likewise, student pilots could use scenario-based mental imagery scenarios to imagine the emotions they might feel when making an error, such as losing altitude during a steep turn maneuver during an evaluation flight, and then imagining making the timely adjustments to correct the error. The mental imagery training guide provided to the student pilot participants in this study includes scripting to prompt them to think about how they will recover from making performance and procedural errors.

Summary

In this section, the researcher described several methods that trainees and imagery coaches can use to enhance the vividness of mental imagery to make imagery exercises more effective. This includes Holms and Collins' (2001) PETTLEP model, which encourages the inclusion of multiple elements to mimic actual physical practice while also addressing other key aspects of mental imagery. In addition, the researcher discussed the benefits of using mental imagery scripts to add structure and order to imagery training exercises, including scenario-based exercises. Furthermore, the researcher briefly described practice and advantages of completing a mind and body relaxation exercise prior to beginning a mental imagery training session.

In the following sections, the researcher will highlight how other researchers have used these and other methodologies to explore the effects of mental imagery on human performance. The researcher will present the findings of these studies as support for conducting the proposed study to explore the use of mental imagery training in a collegiate flight training program. Because of the scarcity of research studies pertaining to the effects of mental imagery related to aviation training and pilot performance in general, the researcher examined the body of literature related to the use of imagery in other relevant disciplines – namely, sport psychology, music, and medicine. The researcher's presupposition is that if mental imagery use has been effective for improving human performance in those disciplines, pilot trainees might find it useful as well.

Cross-Disciplinary Mental Imagery Training Strategies

The results of numerous studies in the disciplines of sport psychology, music, and medicine have demonstrated positive effects on human performance through the application of mental imagery and mental rehearsal techniques (Feltz & Landers, 1983; Jones & Stuth, 1997; Weinberg, 2008; Haddon, 2007; Johnson, 2003; Sanders et al., 2008; Cocks, Moulton, Luu, & Cil, 2014). The results of cross-disciplinary studies should be of keen interest to the aviation training community because of their implications regarding the potential benefits of using mental imagery training interventions to improve pilot trainee performance. Comparatively, the physical and cognitive skills necessary to pilot aircraft share similar characteristics to those required in sports, music, and medicine. All four disciplines require sophisticated hand-eye coordination and the acquisition, practice, and implementation of numerous cognitive and psychomotor skills.

For example, similar to the actions required in many sports, pilots must use their eyes, hands, and feet in a coordinated effort to maneuver their aircraft using the control yoke, the rudder pedals and the throttle to control the aircraft's flight path through a three-dimensional environment under rapidly changing conditions, such as during takeoffs and landings. Furthermore, just as surgeons must apply a high degree of manual dexterity, good hand-eye coordination, high intellectual skills, effective decision-making skills, and excellent visuo-spatial awareness (NHS, n.d.; Galasko, 1999), pilots must acquire and apply advanced cognitive and fine motor skills such as interpreting flight instruments; mentally calculating the aircraft's trajectory based on time, speed, and distance; and making delicate adjustments to pitch, bank, and power during each flight maneuver. Moreover, while musicians must learn and often memorize complex musical compositions and then perform them on stage in front of a live audience, pilots must learn and memorize numerous normal, abnormal, and emergency procedures and then perform them in a well-choreographed manner to evaluators during qualification tests and at other times with passengers onboard who expect a safe, flawless performance.

Consequently, it is appropriate for pilot training researchers to explore how specific types of mental imagery training strategies have improved human performance in other relevant disciplines because similar strategies might also be effective in improving the performance of pilot trainees. Therefore, in the following sections, the researcher provides a review of several mental imagery training strategies as described in research studies in the disciplines of sport psychology, music, and medicine followed by a review of the few related studies conducted in the aviation discipline. The findings of all of these studies add merit to exploring the practice of mental imagery in collegiate aviation.

Mental Imagery Training Strategies in the Sport Psychology Discipline

Researchers in the field of sport psychology have studied the effects of mental imagery to enhance human performance for many decades and their findings indicate that the use of mental imagery training has been an effective means to improve athletic performance (Felts & Landers, 1983; Jones & Stuth, 1997; Weinberg 2008). Jones and Stuth (1997) surveyed a large body of literature involving the use of mental imagery training in athletics and found that its use among coaches was as high as 94 percent. Furthermore, the summation of studies, both anecdotal and empirical, indicate that "mental imagery has been used successfully with a wide variety of sports and has been found to be effective when used for such tasks as skill acquisition, anxiety management, and self-confidence enhancement" (Jones & Stuth, 1997, p. 110). Moreover, the literature indicates that mental imagery has served as an effective replacement for physical practice when physical practice had become impossible or impractical (Jones & Stuth, 1997). Still further, Robert Weinberg (2008) conducted a meta-analysis of a large volume of anecdotal reports, case studies, and laboratory results to examine the relationship between imagery and sports performance. He found that while overall the use of imagery has a positive effect on athletic performance, its use among most athletes is rather sporadic and not systematic (Weinberg, 2008).

Nevertheless, mental imagery use is prevalent among athletes, especially at higher levels of competition (Hall, Rodgers, & Barr, 1990). In fact, nearly 100 percent of the Canadian athletes in the 1984 Olympics used mental imagery to prepare for these games (Orlick & Partington, 1998). At the 2000 Olympic games in Sydney, Australia, the use of imagery was one of the strongest predictors of successful Olympic performance among U.S. athletes (Taylor, Gould, & Rolo, 2008). Numerous coaches of elite athletes have endorsed the use of mental imagery strategies to reach the highest levels of performance . Bob Bowman, the swim coach of Michael Phelps – the greatest swimmer and most decorated Olympian of all time (Fortt, 2017) – believes that mental rehearsal is "a proven, well-established technique to achieve peak performance in nearly every endeavor" and that this is because, "the brain cannot distinguish between something that's vividly imagined and something that's real" (Gallo, 2016, p. 1). Bowman claimed that Phelps used mental rehearsal extensively for months before a race, for up to two hours a day (Gallo, 2016) and Phelps himself attributes much of his success to his use of various types of imagery, including kinesthetic imagery (Moran et al., 2012). Duhigg (2012) reported the following about Phelps' use of imagery:

> Each night before falling asleep and each morning after waking up, Phelps would imagine himself jumping off the blocks and, in slow motion, swimming flawlessly. He would visualize his strokes, the walls of the pool, his turns, and the finish. He would imagine the wake behind his body, the water dripping off his lips as his mouth cleared the surface, what it would feel like to rip off his cap at the end. He would lie in bed with his eyes shut and watch the entire competition, the smallest details, again and again, until he knew each second by heart. (p. 51)

In 2008, Phelps revealed that he visualizes how he wants the perfect race to go, seeing "the start, the strokes, the walls, the turns, the finish, the strategy, all of it" (Phelps, 2008 as citied in Moran, Holmes, and MacIntyre, 2012, p. 94). He also highlighted his reliance on kinesthetic imagery, in that he imagines how the water feels and how he moves in it (Moran et al., 2012).

Another example of elite athletes who use imagery to improve their performance is that of four-time Olympian diver Troy Dumais who used visualization to mentally practice his dive performances. Dumais said, "If you can see yourself hitting a dive, the chances of you hitting a dive increase greatly" (Cohn, n.d.). According to Amasiatu's (2013) research, "the world's best athletes have extremely well-developed imagery skills" (p. 72) and they use it daily to prepare themselves to get what they want out of training, to perfect their skills within training sessions, and to make technical corrections. They also use it to strengthen their self-confidence by imagining themselves succeeding in competition whereby they draw upon all of their senses to feel themselves executing their skills perfectly (Amasiatu, 2013).

The literature in the field of sport psychology abounds with results from numerous empirical studies that strengthen the claims of elite athletes like Phelps and Dumais about the power of mental imagery to enhance their physical and cognitive performance (Weinberg, 2008). However, while researchers have found that the use of mental imagery alone is better than not physically practicing when it is not possible to do so, such as during an injury recovery period, many have concluded that is not an appropriate total substitute for physical practice (Feltz & Landers, 1983). Instead, studies have shown that "the combination of physical and mental practice results in superior sports performance" (Cocks, Moulton, Luu, & Cil, 2014, p. 236). As such, many researchers have used quantitative methods to explore the specific effects of combining physical practice with mental practice on sport performance. Examples include Caliari's (2008) study to assess whether mental practice is an effective strategy for learning the forehand task in table tennis and Straub's (1989) study to examine the effects of different mental imagery techniques on dart throwing accuracy. These and other similar studies often occur in controlled, laboratory settings over short durations and seldom include the collection and analysis of rich, descriptive data regarding participants' perceptions about their experiences of using mental imagery to learn, practice, and prepare for athletic performances.

However, the body of literature also includes many examples of qualitative studies to explore and analyze the behaviors and perceptions of mental imagery users, especially those of elite, well-accomplished athletes. Such studies serve to help researchers better understand the power, influence, and effects of mental imagery training on human performance. According to Post and Wrisberg (2012), quantitative laboratory studies fail to provide much information about the athlete's lived experience with mental imagery. However, through qualitative existential phenomenological interviewing using a limited number of open-ended questions and related follow-up questions, researchers have been able to obtain in-depth, rich descriptions from study participants about their experiences with the phenomenon of mental imagery usage (Post & Wrisberg, 2012). One example of such a study is that of Berneir and Fournier (2010) who interviewed 21 expert golfers and found that they used imagery in a variety of ways to help them focus their attention on relevant information, perfect their golf swing, evaluate their shots, and manage their psychological state as described below.

Bernier and Fournier Study. Bernier and Fournier (2010) conducted a study to examine the functional aspects of mental imagery and to describe the relationship among function, content, and the characteristics of mental images used by expert golfers in different situations. The *content* refers to what the athletes imagine, which could include specific movements, the environment, or the outcome. However, it could also be the imagined emotions, images of a particular strategy, images of the context, or body-related images. Furthermore, the perspective used to view the image (internal vs. external) defines the content of the image (Bernier & Fournier, 2010). The *characteristics* of imagery refer to the manner in which people imagine mental images, including the amount, duration, direction, deliberation, and modality of what they imagine (Bernier & Fournier, 2010). It also includes the speed, the vividness, and the color of the image. Lastly, the *function* of imagery addresses its purpose or why the imagery is taking place, such as to learn a task, improve performance, or to get motivated. This may be the most important part of the model because the reason for using mental imagery will highly influence the nature and process of the ensuing cognitive activities (Murphy, Nordin, & Cumming, 2008). All three of these functional aspects of imagery vary with the demands of the situation (Bernier & Fournier, 2010). Therefore, Bernier and Fournier (2010) conducted their qualitative descriptive study to explore the three concepts from the perspectives of elite golfers and to examine how the situation influenced these golfers' imagery.

Bernier and Fournier (2010) collected qualitative data from 21 expert golfers via field interviews, self-confirmation interviews, and focus group forums. They conducted the field interviews while seven players played a nine-hole golf course whereby the golfers answered a series of questions after each shot about their use of mental imagery and how they used it before and after each shot. In addition, six players completed a self-confirmation interview after playing a nine-hole round of golf that the researchers video recorded. During playback of the video, these players answered questions about their use of imagery for each golf shot. The remaining eight players participated in a video recorded focus group forum in which they shared their experiences with general and everyday imagery use.

The three forms of interviews yielded rich and interesting descriptions of golfer's use of imagery. Bernier and Fournier (2010) found that these golfers mostly used an internal perspective with only occasional use of an external perspective. One participant described seeing himself play as he walks the course, but when he is behind the ball, he uses an internal view. The researchers also found that golfers use the function of imagery to focus attention on relevant information, to perfect their swing by finding the right rhythm, to evaluate the shot, and to manage their psychological state, including enhancing confidence and managing arousal.

Bernier and Fournier (2010) found a link between the situation and the function of imagery as each use of imagery corresponded to the situation. For example, one golfer stated, “For short shots, I use imagery to be more precise and to enhance my confidence” (Bernier & Fournier, 2010, p. 447). This player used imagery to prepare for training sessions ahead of time, and in the evening to consolidate work done during training. The researchers also found links between the situation and the content of imagery. For example, the type of shot influenced the content of the mental images created before playing the shot. One player stated, “Each hole is different, hence what I imagine is different” (p. 447). Some players reported using more mental imagery for short shots requiring precision.

Bernier and Fournier (2010) also highlighted apparent links between imagery function and imagery content. For example, one player described how she manipulated her mental images to prepare the technical aspects of her shots before playing. Furthermore, the main functions of mental imagery among these elite golfers were to get focused, to achieve optimal concentration for the next shot, and to either relax or to get more exited. Some players used mental imagery to improve their swing by visualizing corrective actions based on what went wrong with the previous shot.

Post and Wrisberg Study. In another inquiry to examine athletes’ use of mental imagery, Post and Wrisberg (2012) conducted a phenomenological study with 10 highly skilled current and former female gymnasts between the ages of 19 and 25 years old to explore their lived experience with sport imagery. Each gymnast had considerable experience in competing at the NCAA Division 1 level or higher and had used imagery throughout their competitive careers.

Post and Wrisberg (2012) collected qualitative data during interviews with the participants using a variety of formats including face to face meetings, telephone calls, and online video conferencing. The structure of each interview remained the same regardless of the format. During the interviews, participants answered open-ended prompts such as: “Think of a time when you used imagery in your sport and describe it to me as fully as possible”.

Five higher-order themes emerged during the analysis of Post and Wrisberg’s (2012) data. The first was that these gymnasts used imagery to *Prepare for the Moment* by rehearsing their body movements, reinforcing proper mechanics, focusing on critical areas, and correcting past mistakes. Some gymnasts reported using imagery before going to sleep and that they fell asleep while visualizing their routines. The participants reported using imagery to rehearse their routines and skills perfectly, which provided them with a better chance of doing them perfectly in ‘real life’ (Post & Wrisberg, 2012). When mistakes occurred while imagining their performance, such as wobbling on a balance beam, they imagined it again and again until it was perfect. Furthermore, by mentally rehearsing past performances involving mistakes, the gymnasts were able to eliminate those mistakes or diminish the prospects of them happening in future performances (Post & Wrisberg, 2012). In addition, the gymnasts used mental imagery to focus on critical areas by devoting extra attention to difficult skills, using imagery as a way of giving them technical reminders they could use when actually performing. Their use of imagery provided them with additional practice time to perfect their skills, fix their mistakes, and continue to train while recovering from an injury (Post & Wrisberg, 2012).

The next theme – *Mentally Preparing for Competition* – addressed the use of imagery as a means to calm nervousness and performance anxiety, to build confidence, and to review all of the elements of an upcoming competition (Post & Wrisberg, 2012). This would include imagining what was going to happen, the sensations of the atmosphere, the presence and sound of the crowd, the arrangement of equipment, how they would recover from mistakes, and the emotions they expected to feel, such as pressure, anxiety, fear, and excitement (Post & Wrisberg, 2012). Mental imagery use helped these gymnasts focus on seeing themselves performing their routines successfully and this helped to calm their nerves and deal with anticipatory anxiety or fears about performing. Some participants used imagery just prior to performing a skill as a way of collecting their thoughts to focus on what they were doing. Imagery reminded them that they could do the skill successfully and this boosted their confidence(Post & Wrisberg, 2012).

The third emergent theme in the Post and Wrisberg (2012) study was the practice of *Feeling the Skill* through imagery. Some participants reported enhancing the feel of imagery by incorporating actual body movements while imaging, such as hand and arm movements, twisting, and tensing specific muscles. This enabled them to experience the kinesthetic components of their skills more vividly. Others, however, only imagined the kinesthetic sensations of their body movements and the feel of equipment without using any overt body movements (Post & Wrisberg, 2012).

The fourth upper-level theme was the variability of the participant's imagery perspective and the speed used when imaging, along with the effort required during their mental imagery (Post & Wrisberg, 2012). All of the gymnasts described using both an internal and an external perspective when mentally imaging and some reported using the external perspective from different angles. The internal perspective involved seeing their actions through their own eyes, while the external or third person perspective involved seeing themselves from the vantage point of a spectator watching their performance (Post & Wrisberg, 2012).

In addition, the participants sometimes used real time imagery as it enabled them to experience the correct timing, tempos, and rhythm of their skills. At other times, they mentally imagined their performance in slow motion or used freeze-frame images because it allowed them to go through their routines incrementally, helping them to focus on important parts that they might miss while imaging in real time. Post and Wrisberg (2012) reported that imagery had become effortless for most of the participants because they had used it so often. However, certain elements of imagery required more effort, such as controlling the imagination of making mistakes, such as falling off a balance beam.

The fifth upper-level theme was the commonality of the *Time and Place* that participants completed their mental rehearsal. Most of the gymnasts reported using imagery in competitions either just before getting onto the mat or apparatus at the beginning of a routine or even in the middle of a routine, such as immediately prior to making a tumbling run on the floor. They claimed it helped them calm down and to get one more practice in before competing. They also used it at practice, in class, while walking to class and at home, but in particular, they used it the night before competitions (Post & Wrisberg, 2012, p. 107).

The results of the Post and Wrisberg (2012) study are consistent with other research showing that elite athletes use imagery in a multisensory fashion for both cognitive and motivational functions, from both internal and external perspectives, at different speeds, and when recovering from an injury. Post and Wrisberg (2012) asserted that "athletes should be encouraged to use as much sensory information as possible when imaging" (p. 118) and that they should supplement it with actual movement to enhance sensory aspects. Furthermore, gymnasts should attempt to use different imagery speeds and they should base their use of imagery on their personal needs, such as to complete extra rehearsals, to build confidence, to decrease anxiety, to improve focus, and to energize the feeling of their skills. Post and Wrisberg (2012) encouraged coaches to include imagery as an instructional tool for influencing athlete's behavior.

Brouziyne and Molinaro Study. Using a quantitative research strategy, Brouziyne and Molinaro (2005) conducted a study to test whether a combination of mental imagery and physical practice was effective in improving golf chip shots. This study involved 23 novice golfers divided into three groups: a physical practice group (PP), a physical and mental imagery group (PP + MI), and a control group. All participants completed a pretest consisting of 13 trial shots of hitting a ball toward a flag to establish the baseline performance for each. They then completed one training session each week for five weeks. The training sessions for the PP and PP + MI groups included verbal instruction and observed physical demonstrations of the chip shot prior to completing 13 physical practice shots. However, prior to making each shot, participants in the PP + MI group held the club at the tee with their eyes closed and mentally pictured a scene described by the experimenter who guided them though a mental representation. They imagined the feeling of muscular tension and the experience of making a successful approach shot, which included the trajectory of the ball and where it would land. The participants in the control group did not complete any additional physical practice after the initial practice session and instead, they played tennis or table tennis during the five training sessions.

The posttest was identical to the pretest whereby all of the participants performed 13 approach chip shots under the same conditions with the goal of placing as many golf balls as possible close to the target flag (Brouziyne and Molinaro, 2005). The results of the posttest trials showed that participants in the PP + MI group were significantly more accurate in landing chip shots closer than six meters from the flag than participants in the PP and control groups (Brouziyne & Molinaro, 2005). According to Brouziyne and Molinaro (2005), these results confirm the results of other similar studies in other sports showing that the combination of both mental and physical practice produces greater improvement than physical practice alone. Furthermore, Brouziyne and Molinaro (2005) asserted that their study showed that "mental imagery can indeed have a positive effect on motor skill acquisition and that their results justify the use of mental imagery with beginners.

Amasiatu Study. The aim of Amasiatu's (2013) research was to describe what mental imagery is all about and to offer suggestions about how to develop a mental imagery rehearsal program that athletes could use to enhance their performance. According to Amasiatu (2013), "mental imagery rehearsal is simply a mental technique that programs the mind and body to respond optimally" (p. 69). Athletes can use this as a mental training tool that enables them to enhance their focus and confidence to perform successfully. However, because many athletes do not receive training about how to use imagery systematically, they are often unable to control their images (Amasiatu, 2013). Conversely, evidence exists indicating that when athletes use mental rehearsal systematically, they can effectively use it to practice specific skills; improve their confidence; create positive thoughts; assist them in problem solving; control their arousal and anxiety; review and analyze past performances; and prepare for future performances (Amasiatu, 2013).

Amasiatu (2013) asserted that the use of mental imagery can "provide repetition, elaboration, intensification, and preservation of important athletic sequences and skills" (p. 70). However, imagery is not synonymous with the term visualization because visualization is only one form of imagery (Amasiatu, 2013). Imagery also includes the imagination of kinesthetic senses whereby the imager experiences the feelings of the movement or skill, using these feelings to perfect his or her performances. Therefore, imagery can and should be a holistic process that includes visual, auditory, tactile, emotional, and kinesthetic cues (Amasiatu, 2013).

Amasiatu (2013) described mental rehearsal as a means to help athletes get the best out their training and competition, using it daily to direct what will happen during their training and experiencing their performance prior to competing. Amasiatu (2013) asserted that, “The developing athlete who makes the fastest progress and those who ultimately become their best make extensive use of mental imagery rehearsal” (p. 71). Furthermore, mental rehearsal improves with practice and can reach a point where the imager can draw on all of the senses to pre-experience the achievement of goals, moves, performance, and coping strategies. Citing Orlick (1990), Amasiatu (2013) reported that using mental imagery soon after a very successful performance while the feeling is still fresh can be very valuable because it allows the imager to re-experience and retain the successful aspects of the performance.

Amasiatu (2013) outlined four phases of a mental imagery training program designed for athletes. In the introduction phase, which should last no more than 30 to 40 minutes, Mental imagery coaches and facilitators should introduce athletes to mental imagery in such a way as to sell the idea of imagery to them, because it only works for athletes if they believe in it (Amasiatu, 2013). They need to understand that research findings have shown the use of imagery to be an effective training technique to enhance sport performance and that it will likely have similar effects on them. During this first phase, athletes should receive basic training about mental imagery with enough relevant evidence that shows it to be an effective means of enhancing performance (Amasiatu, 2013). In addition, coaches should inform their athletes about how imagery works and how they will incorporate it into their training (Amasiatu, 2013).

The second phase of a mental imagery training program should include an evaluation of the athletes’ mental imagery ability so that imagery facilitators and coaches have an understanding of their athletes’ ability to use all of their senses and emotions when practicing imagery (Amasiatu, 2013). The third phase involves providing the athletes with basic imagery skills training, which includes exercises aimed at developing sharper, more vivid images that may help to strengthen the senses important in sport performance. It also includes controllability exercises whereby the athletes learn how to manipulate their images at will (Amasiatu, 2013). In addition, this phase should incorporate self-awareness exercises intended to increase athletes' vividness of emotional imagery to help them learn how to investigate their own feelings and behavior in their sport.

The fourth phase of a mental imagery training program involves the systematic implementation and monitoring of participants (Amasiatu, 2013). It is important for the program to be an integral part of training and practice, rather than something simply added onto the program as an extra element. Amasiatu (2013) emphasized that imagery programs do not need to be long and complex and that it is a good idea to keep them concise and simple. Athletes should start by choosing a skill that is easy to control, such as a basketball free throw, and then, as they gain imagery proficiency, they can add more variety and complexity to the program.

Mental Imagery Training Strategies in the Medical Discipline

While the findings of the previously presented studies in the field of sport psychology illustrate how the use of mental imagery has affected the performance of athletes, many researchers have conducted similar studies in the medical field to examine the effects of mental imagery use on the performance of surgeons and nurses. In this section, the researcher highlights the strategies and their outcomes of several such studies. Each one offers support for further inquiry into the use of mental imagery training as a supplement to pilot training.

Immenroth et al. Study. Immenroth et al., (2007) rationalized that like professional athletes, surgeons must perform many "complicated, fine-motor movements under stressful conditions" (p. 385). Therefore, these researchers conducted an 11-month study involving 98 surgeons to explore the effectiveness of incorporating mental imagery training exercises into a specialized laparoscopic surgery training program. In ten separate four-day courses conducted during the 11-month period, Immenroth et al., (2007) collected baseline surgical performance data of each participant by videotaping their performances of the procedure using a surgical simulator. These baseline recordings occurred after the surgeons had initially learned and practiced the laparoscopic surgical procedure using a surgical training simulator. Then, the researchers randomly divided the participants into three groups. One group received additional practical training in performing the laparoscopic procedure. The second group received a commensurate amount of specialized imagery training from qualified mental trainers on how to repeatedly imagine and vocalize the procedure. Their training included a relaxation exercise followed by a facilitator-guided mental visualization of the procedure. Then, the participants completed a self-guided mental visualization exercise of the procedure. A third group served as the control group and thus received no additional practical or mental imagery training, and they did not complete any additional practice after the initial training and baseline assessment.

At the completion of the training phase, all participants were video recorded again individually while they completed the same surgical procedure using a Pelvi-Trainer simulator (Immenroth et al., 2007). Then, four independent, calibrated evaluators compared and assessed the baseline and post-training performances. The results showed that the surgeons who completed mental imagery training achieved better outcomes than those who had received additional practical training and those who had received no additional practice (Immenroth et al., 2007). The researchers concluded that mental imagery training was effective in optimizing the performance of the surgeons undergoing the specialized surgical training. Furthermore, a survey of the participants revealed that these surgeons regarded their mental imagery training as a valuable tool in their education (Immenroth et al., 2007).

Sanders et al. Study. Sanders et al., (2008) conducted a similar study to examine the effects of using mental imagery rehearsal for the learning of basic surgical skills whereby medical students participated in guided imagery sessions in which they imagined making incisions and completing surgical sutures. In this study, the researchers randomly assigned sixty-four second-year medical students to either a test group or a control group. Both groups completed identical training comprised of lectures, demonstrations, and physical practice of surgical procedures performed on cadaver pigs' feet. However, students in the test group completed two additional guided imagery sessions whereby a clinical psychologist guided them through a relaxation exercise and then a doctor-educator guided them through an imagery exercise in which they imagined performing an incision and a set of surgical sutures. Students in the control group completed two additional concentrated textbook study training sessions of commensurate time to the test group's additional training in lieu of the mental imagery sessions. In between these different types of training sessions, both groups of students completed a scored assessment of their performance of operating on pig feet. Then, after a ten-day gap of no training, the standardized evaluators assessed all students again on their performance of an identical surgical procedure on live rabbits.

Sanders et al. (2008) found that the surgical skills exhibited during the actual surgery on live rabbits of the students who participated in the mental imagery sessions was significantly better than the students in the control group. Furthermore, the skills of the control group students declined following the ten-day period while the skills of the test group students improved (Sanders et al., 2008).

Eldred-Evans et al. Study. Eldred-Evans et al. (2013) conducted an empirical, quantitative study to investigate the efficacy of using the mind as a training simulator to develop basic laparoscopic surgical skills in novice surgeons. Eldred-Evans et al. (2013) asserted that because laparoscopic surgery presents challenges to trainees who have to develop a unique set of psychomotor skills in an impaired spatial and tactile environment, the use of laparoscopic simulators has become an effective and convenient option for developing the necessary skills by allowing repeated self-practice. However, these devices are not always readily available and some simulators, such as virtual reality simulators (VRS) are quite costly. Eldred-Evans et al. (2013) hypothesized that mental imagery training could serve as a more cost-effective supplement to VRS training by facilitating skills development after physically practicing on a box trainer, often referred to as a "pelvi-trainer."

In their study, Eldred-Evans et al. (2013) randomly placed 64 medical students at Kings College in London, England into one of four groups. Participants in Group 1 served as the control group, and they received 30 minutes of training in how to manipulate the laparoscopic instruments to cut out a circle on a box trainer. After 48 hours, these participants completed another 30 minutes of self-practice using the box trainer. Participants in Group 2 completed this same initial training, but after 48 hours, they completed a 30-minute training session using an expensive and sophisticated virtual reality simulator (VRS). Participants in Group 3 followed the same protocol as Group 2, but instead of using the VRS, these participants completed a 30-minute mental imagery training session using the Mackay (1981) nodal model of mental practice in which participants completed a detailed guided mental imagery exercise to create a rich mental representation of each of the 12 individual steps (or nodal points) involved in completing the circle cutting procedure (Eldred-Evans, 2013). This session began with a relaxation exercise followed by the guided visualization of each step of the procedure facilitated by an experienced mental trainer who read a detailed imagery script aloud. For example, a portion of the script to help participants create a vivid mental image of the surgical procedure read as follows:

> *I can see the grasper approach the left side of the circular shape, pushing onto the tissue 1 cm outside of the circular shape; I can feel my arm moving forwards and downwards guiding the grasper toward that particular point close to the circle. I think about grasping quite close to the cut. I can feel the rings of the grasper around my thumb and my fourth finger transmitting the resistance of the tissue. I can feel my finger opening the jaws of the grasper. (Eldred-Evans et al., 2013, p. 547)*

Participants in Group 4 did not complete any physical practice using the box trainer, and instead, they completed an initial training session using only the virtual reality simulator followed 48 hours later by a session of self-practice in the VRS and a mental imagery training session.

One week after all participants of the Eldred-Evans et al. (2013) study completed their training sessions, they completed an assessment of their performance of physically cutting the circle on the box trainer. The assessment parameters included the time taken, precision, accuracy, and overall performance. The results of the box trainer assessment revealed that the participants who completed a combination of physical practice training and mental practice training had the best overall score across all domains except for the speed of completing the task. The researchers suggested that the mental training group may have developed a higher level of cautiousness in their approach to completing the circle cutting task. Furthermore, this group was the only group to complete the surgical cutting task with significantly higher levels of precision and accuracy than the control group. As expected, Group 4, which did not complete any physical practice on the box trainer, performed the worst in all domains.

Based on the results of their study and their research into the uses of mental imagery to learn and improve other surgical procedures and to reduce stress among surgical trainees, Eldred-Evans et al. (2013) suggested that mental imagery is most effective when trainees receive a degree of tutored training to ensure they fix the skill properly in their minds. They cautioned that the use of mental practice without first learning the task via mentored physical training could actually be detrimental to learning. When done properly, however, Eldred-Evans et al. (2013) asserted that “novice surgeons can use mental training as a ‘simulator of the mind’ and develop skills faster and with fewer hours spent in the simulator lab” (p. 549). Furthermore, Eldred-Evans et al. (2013) emphasized that while mental imagery training does not yet have a defined place in surgical training programs, “mental training represents a promising tool which with further research could be a useful addition to the surgical training curriculum” (p. 550). This is partly because mental training is convenient, students can practice it outside of the clinical environment at any time and location, and it is a cost-effective alternative to simulator training (Eldred-Evans et al., 2013).

Mick et al. Study. A few years after the Eldred-Evans et al. (2013) study, Mick et al. (2016) described the use of mental practice as a training methodology used in surgical training. The authors asserted that the use of mental practice is not the same as the use of positive imagery, self-efficacy statements, motivational strategies, or attention focusing. Rather, it is a specific form of mental preparation, and it is “an integral part of the formal training of many individuals who perform complex motor skills at high levels” (Mick et al., 2016, p 443).

Mick et al. (2016) reported that researchers have only recently investigated the use of mental practice as a formal teaching tool and that it is absent from most residency program curricula. These researchers asserted that mental practice offers many potential benefits for surgeons at all levels of training and experience, such as in their performance of motor skills, hand-eye coordination, and surgical instrument use. Surgeons normally practice such skills on human cadavers and surgical simulators, but due to financial constraints and limited access to these resources, the use of mental practice training may help augment physical practice while improving the accuracy and precision of surgical movements (Mick et al., 2007). The researchers suggested that the process of imagining how a movement looks, feels, and affects a patient may strengthen the cortical representations of the task formed by previous physical practice, or it may prime specific neuromuscular pathways.

In their report, Mick et al. (2016) highlighted the results of other studies suggesting that novice surgeons might find it difficult to imagine performing the steps of an operation they have rarely seen or executed. On the contrary, senior surgeons familiar with an operation may benefit the most from using mental practice as a means to prepare for surgery after a leave of absence or for rarely performed surgeries (Mick et al., 2016). Nevertheless, the findings of medical research studies indicates that mental practice has improved the physical practice skills of surgeons at all levels of training (Mick et al., 2016). According to Mick et al., mental practice works similarly to simulations in that it "allows trainees to plan cases, consider choices, make decisions, and ponder outcomes in a safe manner" (p. 444), which may improve their situational awareness in the operating room. Furthermore, mental practice fosters faster memory retrieval with less effort when the imager codes those memories in a format that facilitates the task, as illustrated by how easy it is to imagine the process of tying a shoelace but how difficult it can be to describe that process in words (Mick et al., 2016). This example supports the practice of mentally rehearsing tasks rather than only verbally rehearsing the steps involved in performing those tasks. Mick et al. (2016) suggested that when completing a visual and tactile task, "using stored mental images of an operation would be more efficient and accurate than mentally converting memorized text describing the same procedure into the images, feelings, and movements needed to correctly complete the task" (p. 444).

Mick et al. (2016) developed a set of step-by-step mental practice scripts for use in training a group of otolaryngology residents to perform tympanoplasty surgery. During a process lasting about 30 minutes, an attending surgeon guided the residents through the script prior to them performing each tympanoplasty operation. The authors noted that these scripts were easy to develop and that they were particularly useful because of their low cost of implementation The results of postoperative surveys indicated that the residents liked the scripted mental practice sessions, leading Mick et al. (2016) to believe that mental practice "could be a valuable teaching tool for procedures in a wide variety of clinical settings" (p. 444).

Wright et al. Study. In a different clinical setting, Wright et al., (2008) explored the use of mental imagery training as a tool for improving nursing skills. These researchers applied the Holms and Collins (2001) PETTLEP model of imagery training to their research imagery training program for a blood pressure measurement psycho-motor task. After completing a preliminary clinical nursing examination for pre-test data collection purposes, fifty-six nursing students completed an imagery aptitude self-assessment questionnaire and all of them achieved an acceptable score to participate. The researchers randomly assigned the students to either the control group or the PETTLEP imagery test group. During a four-week skills acquisition period, the students in the control group completed the usual preparation for the clinical examination by reviewing the procedures and performing memory recall drills associated with the task. Students in the PETTLEP imagery group supplemented their training by completing structured imagery training sessions three times each week using customized scripts tailored for each student to help them imagine the blood pressure measurement task (Wright et al., 2008). These participants performed their imagery while dressed in their uniforms, standing in the correct stance and holding onto the applicable medical implements. In addition, they completed their imagery in their clinical setting, imagining each task fully in real time using an internal perspective.

After four weeks, all participants completed the same numerically scored evaluation of the blood pressure measurement task. Calibrated task assessors blind to the participants' group allocation graded the task, and using a one-way between-group analysis of variance, Wright et al. (2008) found that the PETTLEP imagery group participants performed significantly better than participants in the control group. Wright et al. (2008) suggested that PETTLEP-based imagery has the potential to enhance the learning process of the blood pressure measurement skill and suggested further research to assess its generalizability to other nursing skills.

Mental Imagery Training Strategies in the Music Discipline

As within the sport psychology and medical fields, the findings of mental imagery research studies in the field of music indicate that the use of mental imagery can be an effective training strategy to improve the performance of musicians. The researcher reviews several such studies next.

Ross Study. Ross (1985) conducted a study to compare five different methods of trombone practice to assess the effectiveness of mental imagery training. The five methods were: all physical (PP), all mental (MP), mental with simulated slide movements (MPS), combined physical and mental (CP), and no practice (NP). Following a pre-test assessment of a sight-read, 34-measure musical piece, Ross (1985) assigned participants to one of the five different practice method groups, providing each with specific written instructions about how to practice the musical piece three more times from beginning to end. For example, the MP group participants were to try and “see”, “hear”, and “feel” themselves playing the piece as vividly as possible, while the MPS group participants were to hold their trombone in the normal playing position while moving the slide to the correct positions as they imagined playing the piece (Ross, 1985). The combination group participants performed one mental rehearsal in between two physical practice rehearsals and the NP control group participants did not practice the piece at all. Instead, they read an article about sight-reading.

After completing the three practice rehearsals, each participant played the musical piece again for assessment purposes. Evaluators blind to the group association of each participant watched and assessed a video recording of each participant’s post-rehearsal performance. Using statistical analyses, Ross (1985) found significant differences in the scores of improvement between the CP and NP groups, the CP and MP groups, and the PP and NP groups. These comparisons are not surprising as the results of many studies indicate that some form of practice will increase performance versus no practice. However, while analyses of the results showed that the mental practice (MP) group had higher gains in improvement than the no practice group, the combination of mental practice and physical practice had the highest improvement scores of all groups (Ross, 1985). Ross (1985) asserted that "the combination of mental and physical practice was found to be as useful as all-physical practice", which is consistent with the findings of similar studies in other disciplines.

Haddon Study. Haddon (2007) conducted a survey of 25 third-year music students and instructors at the University of York to investigate what mental musical imagery meant to them and whether it was a formal part of their musical development. The results of the survey revealed that approximately 84 percent of staff and 91 percent of the students used mental imagery as a deliberate practice strategy either sometimes or always. When asked to define musical imagery, there was high agreement among participants that it meant rehearsing music in the head, rehearsing interpretative possibilities, rehearsing physical movements in the mind, and visualizing a successful performance. Furthermore, the participants viewed imagery as a means to quicken memorization, aid interpretation, and produce a better understanding of musical aspects while also helping them avoid problems associated with physical practice, possibly compensating for shorter practice hours. Haddon (2007) asserted that "Imagery has considerable benefits for all kinds of musical activities and is significant for the understanding of effective practice and performance" (p. 306).

Bernardi et al. Study. Bernardi et al. (2013) conducted a study to explore the differences associated with various mental practice strategies in the context of music memorization. These researchers asserted that musicians have used mental practice successfully to improve musical performance without physically performing at the instrument and that mental practice techniques include the formal analysis of the musical score, the mental listening of the piece, the auditory imagery of the pitches, movement imagination, and visual imagery of the musical score.

For this study, 16 pianists from the University of Music and Drama in Hannover, Germany, each with more than 15 years of piano instruction experience, memorized two pieces of music of similar difficulty level and unfamiliar to the participants – one by means of mental practice (MP) and one using only physical practice (PP) on two different days. On the first day, half the group used mental practice only while the other half used physical practice only. During the 30-minute mental practice period, participants could use any strategy they wanted to except playing the actual piano. They could sit at a table with the music, listening to a recording of the piece as many times as they wanted, and moving their fingers if they chose to do so. However, they received no mental imagery training guidance. During physical practice, participants played a digital piano and were to focus on physically practicing the piece without stopping to mentally rehearse or formally analyze the music (Bernardi et al., 2013).

At the end of the practice period, each participant played the musical piece two times from memory on a MIDI keyboard that recorded their performances. Then, the participants spent an additional 10 minutes studying and practicing the same piece. Those who had studied only by mental practice were free to combine mental strategies with real piano playing. However, the participants who had studied the piece using only physical practice continued to practice in the same way they had prior to the first assessment. Then, each participant performed the pieces two more times from memory on the MIDI keyboard. The researchers used only the best of the two performances for statistical analysis On the second day, participants memorized the second piece of music using the opposite practice strategy they had used on the first day.

Bernardi et al. (2013) assessed the participant's performances in two ways. The first was objectively via a manually performed note by note count of total notes played and wrong notes played by analyzing the digital playback of each piece. The second was a subjective assessment whereby highly experienced evaluators listened to each performance independently and rated each performance on four predetermined dimensions.

The results of the Bernardi et al. (2013) study revealed that after the first 30 minutes of practice, physical practice alone was superior to mental practice alone in both objective scores of performance and all four subjective scores of performance.   However, after the additional practice time in which the MP participants were able to also incorporate physical practice, there was no significant difference between MP + PP and PP + PP with regards to the two objective scores of performance. This means that the combination of mental and physical practice produced similar results as the same amount of physical practice time for the two objective domains. The differences in performance for the four subjective scores remained significant even after the additional practice time.

Bernardi et al. (2013) asserted that mental practice appears to help musicians reach a determinate level of performance and it serves as an effective tool for any musician facing time constraints, diseases, or injuries resulting from the strain of repetitive physical practice. Moreover, mental practice allows musicians to practice anywhere, at any time, with no burden on the body. While it may not be as effective as physical practice, the combination of mental practice and physical practice may optimize the practice time available (Bernardi et al., 2013).

DuToit Study. Du Toit (2015) conducted a hybrid case study involving highly experienced expert string musicians to explore their experiences with using mental imagery training strategies to overcome possible setbacks involved with musical performances. During the first of three incremental interviews with each participant, Du Toit (2015) found that these setbacks included insufficient practice time, difficulty in memorizing and performing musical compositions from memory, and poor concentration ability during performances. After this initial interview, Du Toit (2015) gave each participant a list of mental imagery training techniques that they were to apply to their daily practice routine. These techniques included ways in which to relax the body before imaging, exercises to develop imagery ability, instructions for how to stay mentally ahead of the music while playing it, methods of enhancing inner hearing in the mind, the mechanics of rehearsing mentally through miming, suggestions to alternate music tempos mentally, and guidance for imagining an ideal performance (Du Toit, 2015). After one month of using these techniques, DuToit (2015) interviewed each participant to discuss their experiences with applying the imagery and rehearsal techniques. Du Toit (2015) conducted a third interview one month later.

Several interesting themes emerged from the two post-intervention interviews. While all of the participants found that they had already been applying a few of the intervention techniques to some degree, two of them experienced difficulty in applying mental imagery to their practice routines because they were already set in their ways from an excess of 25 years of practicing the same way. One participant commented that learning such techniques at a younger age would be better. Nevertheless, all participants found the techniques to be beneficial at varying degrees. In particular, all were very positive about using mental leadership techniques to stay mentally ahead of the music as they were playing and all of them had positive experiences with imagining an ideal performance, as it helped them gain confidence, overcome negative thoughts, and relieve anxiety (Du Toit, 2015). Johnson (2003) asserted that musical performances are rarely ever perfect, so while musicians should not intentionally imagine making mistakes, they should imagine recovering from mistakes by continuing to play fluidly.

All of Du Toit's (2015) participants believed their biggest setback to music performance was insufficient practice time due to busy schedules, muscle fatigue, and injuries and they acknowledged that mental imagery could make up for this. Furthermore, the participants felt their use of imagery made their rehearsals more efficient by saving time and eliminating unnecessary repetition. However, Du Toit's (2015) participants did not regard mental imagery as a satisfactory substitute for physically practicing on the instrument altogether. In addition, Du Toit's (2015) participants found the imagery intervention techniques helpful for memorizing music at a faster pace.

Mental Imagery Training Strategies in the Aviation Discipline

The body of research regarding the use of mental imagery training in the aviation discipline is surprisingly limited, especially in comparison to the extensive research available in other disciplines and when considering how prevalent the practice of chair flying is among pilots at all levels of skill and experience (Jentsch, Bowers, & Salas, 1997; Hohman & Orlick, 2014). Nevertheless, the researcher now presents the mental imagery training strategies used in the few studies applicable in the field of aviation that are available in the literature. Each of these examples add support for further inquiry regarding the use of mental imagery to supplement flight training.

Prather Study. As briefly described in the imagery training methods section above, Prather (1973) conducted what may have been the first study of its kind in the field of aviation to explore the use of mental practice to improve pilot flying performance. In that study, Prather (1973) assessed 23 Air Force T-37 pilot trainees on their landing performance after completing introductory flight training in the landing pattern. Then, he randomly assigned the participants to either the test group or the control group. After completing each of a sequence of specific flight training lessons covering landings, the test group of trainees listened to one of four 12 to 15-minute guided imagery tape recordings about the landing pattern while seated in a cockpit mockup used for flight procedures training. The tape recordings included instructions about the landing pattern and guidance to "imagine the situations as vividly as possible and to perform the same motor actions and eye movements that they would if they were in the actual landing pattern" (Prather, 1973, p. 354). To help them vividly visualize their location in the landing pattern, the recordings guided the trainees' imagery using statements such as, "You are now on base" and giving them detailed instructions about the required airspeeds, throttle settings, pitch attitudes, bank angles, etc. (Prather, 1973). The content of the recordings also included variations in the landing sequence including the performance of a touch and go, a go-around, and full stop landings. The control group of trainees did not complete the guided mental imagery sessions and instead, they viewed media presentations that were part of the normal training program.

After completing the specified training flights, both groups of trainees underwent an assessment of their landings by flight instructors who did not know to which group the trainees belonged. Although the scoring was subjective, Prather (1973) found that mental practice combined with actual practice was more effective than actual practice alone because the landing performance of the test group trainees improved significantly more than the control group of pilots who did not complete the mental practice exercises. This study highlights the potential benefits that may result from incorporating structured mental imagery training sessions into pilot training curricula and that this topic warrants additional inquiry.

Jentsch, Bowers, and Salas Study. Nearly twenty-five years later, Jentsch, Bowers, and Salas (1997) found that mental practice was not yet a formal part of aviation training and that only four relevant structured studies with pilots appeared in the literature. Consequently, these researchers attempted to determine the degree to which pilots were already using mental practice and the extent to which they were accepting of the practice. To make this determination, Jentsch, Bowers, and Salas (1997) completed a survey-based study of a cross section of 60 pilots at an airline-affiliated flight training academy ranging from student pilots to certified flight instructors. Using a Likert scale from 1 (“not at all”) to 7 (“always”), a large majority of 86 percent indicated that they used mental imagery frequently and at an average of about four hours per week for flight training. However, the data indicated that imagery use among these pilots was widely varied in terms of the content of their imagery and the manner in which they used it. For example, some pilots used imagery to practice entire flights in their heads while others focused only on single procedures. In addition, there was variation among the participants regarding their focus of details in imagined scenes, how often they imagined making mistakes, and what imagery perspective they used while imaging. Based on these findings, Jentsch, Bowers, and Salas (1997) suggested that “improved techniques for mental practice may be of benefit to pilots, especially to those who are at the beginning of their flight training” (Jentsch, Bowers, & Salas, 1997, p. 1175).

Roth and Andre Study. Roth and Andre (2004) conducted what may be the first study ever to quantifiably test the effects of chair flying on pilot performance. Their aim was to explore whether the use of the chair flying technique could offer the same advantages to pilots as using a PC-based flight simulator to prepare for a simple flight operation in the simulator. Roth and Andre (2004) described the chair flying technique as sitting in a chair and mentally rehearsing the information needed for the mission and to go through every sequence of the flight. This includes simulating the movements of the arms, hands, and feet needed to fly, such as mimicking the movements of the throttle, the rudder pedals, and the flight control stick (Roth & Andre, 2004). In general practice, some pilots choose to physically enhance these rehearsals kinesthetically by using equipment such as a broomstick to replicate the feel of the control stick and a bottle to mimic the throttle (Roth & Andre, 2004). Roth and Andre (2004) asserted that "despite the fact that it [chair flying] is very common among pilots, there is no evidence, guideline, and scientific knowledge on how to apply this technique correctly" (p. 2). They found that while almost every flight instructor recommends chair flying to their students, there is rarely sufficient explanation about how to use the technique or the potential benefits associated with it (Roth & Andre, 2004).

For this study, Roth and Andre (2004) randomly assigned 60 pilots having no significant flight experience to one of three groups. One group was the memorization group, another was the simulator group, and the third was the chair flying group. Prior to the start of the experiment, all of the participants read an operating handbook on how to handle and fly the PC-based simulator used for the study. The simulator included a fully functional physical control yoke and a flight simulator control console. On the day of the experiment, the participants completed a brief review of the operating handbook and then practiced flying the simulator for five minutes to get familiar with the controls. The investigators provided a handout to each participant that explained the flight mission profile and then verbally explained it. The participants then watched a one-time demonstration of how to fly the mission using the simulator. The mission profile included a series of required tasks that involved advancing the throttle to full power, pushing a timer button to start the clock, pulling back on the control yoke at a target speed to initiate the takeoff, retracting the landing gear, establishing a target climb speed, leveling off at the assigned altitude, accelerating to a target airspeed, reducing the power to a specified setting, and then holding that altitude and airspeed for 30 seconds before pushing a button on the computer keyboard to pause the mission. After the demonstration, each group of participants followed a different set of special instructions.

The memorization group participants studied and memorized the flight mission for 15 minutes. They did not practice the flight profile in the simulator. The simulator group spent 15 minutes practicing the mission using the simulator. The chair flying group participants listened to verbal instructions about the method of chair flying and how to apply it. They then spent 15 minutes studying the profile and practicing it via the chair flying method while seated away from and out of sight of the simulator.

After the 15-minute practice session, participants completed an assessment flight of the practiced or memorized flight mission in the simulator. The simulator software objectively recorded and scored the performance data. Using descriptive statistics and one-way analysis of variance (ANOVA), Roth and Andre (2004) analyzed multiple parameters between groups. Based on the results, Roth and Andre (2004) concluded that "Chair Flying can be an effective preparation technique for a simple aviation related mission" (p. 6). They found that simply memorizing the instructions led to a superficial understanding of what to do, but chair flying appeared to have generated a deeper understanding of the mission similar to the understanding gained by practicing it on the actual simulator. Roth and Andre (2004) asserted that their study showed that chair flying can be effective in preparing for a simulator mission and called for further research to investigate whether chair flying could be as equally effective as PC-based simulators for preparing for a real mission in the aircraft.

Hohmann and Orlick Study. In a more recent study, Hohmann and Orlick (2014) conducted a descriptive qualitative study to explore how elite military pilots use psychological skills to enhance the quality and consistency of their performance. This study involved a series of semi-structured interviews of 15 Royal Canadian Air Force military pilots with various backgrounds and experience levels in multiple high performance aircraft types. Several of these pilots were in the process of becoming instructor pilots, others were high ranking instructors, and two were in top supervisory positions. From these interviews, Hohmann and Orlick (2014) found that all of the participants were familiar with chair flying and that it was an important part of their training. In addition, all of the participants were in agreement that chair flying was an integral component of their pre-flight preparation, especially when they were students, and that they viewed it as an essential and effective means of preparing for real-life missions.

However, while all of the participants had engaged in chair flying during their training – many at the recommendation of their instructors – a common theme emerged indicating that none of them had received any formal instruction about how to chair fly or use mental imagery. Even though chair flying was a recommended training exercise within the Canadian Air Force, pilot trainees received no formal instruction in the method of chair flying (Hohman & Orlick, 2014). One participant stated that "everybody says chair flying, but nobody really teaches anybody how to do it" (p. 8). Hohmann and Orlick (2014) found that most of the learning about how to chair fly and use mental imagery among pilots was either self-directed or arose through dialogue with other students and pilots. Because of this, there were obvious differences in the manner in which pilots engaged in chair flying, but all of them attempted to replicate potential flight events as realistically as they knew how (Hohman & Orlick, 2014).

Overall, the pilots in Hohmann and Orlick's (2014) study used imagery to assist in skills acquisition, skill refinement, and error correction using mainly visual and kinesthetic modalities. Pilots described chair flying as a way of putting themselves in the cockpit and then using a first-person perspective to see the cockpit and horizon through their own eyes. Some of the pilots remarked about their practice of reaching out to operate switches or pulling back on an imagined throttle while chair flying. Others highlighted their use of auditory imagery to mentally hear radio calls such as what the air traffic controller would say or ask (Hohman & Orlick, 2014).

Hohmann and Orlick's participants reported that they performed the majority of their chair flying during their initial training in flight school but as they became more familiar with their aircraft and how to perform their flight maneuvers, their use of chair flying decreased. However, they continued to use chair flying when preparing for important tests and missions, when transferring to a new aircraft, and when returning to flying after a break from flying (Hohmann and Orlick, 2014).

Hohmann and Orlick (2014) remarked that based on the existing support for the extensive use of psychological skills in elite and high-risk sport contexts, "it is surprising that there is an absence of applied research with respect to the use of mental skills and MST [mental skills training] in military flying training and performance." (p. 5). According to Hohmann and Orlick (2014), because mental skills play such an integral role in the optimal performance of pilots, it would be of immense value to include psychological skills training to military pilot trainees.

Summary

In this chapter, the researcher provided a formal definition of mental imagery derived from existing definitions and applications of mental imagery, mental practice, and mental rehearsal developed by numerous researchers in various disciplines over the span of many decades. The researcher expanded this definition to include its close association with the common practice of chair flying among aircraft pilots at all levels of experience.

In addition, the researcher discussed some of the neurological factors that contribute to the positive effects of mental imagery. In simplistic terms, the positive effects of mental imagery use are due to the activation of many of the same brain regions that occur when physically performing psycho-motor skills as when vividly imagining them. However, imagery aptitude and imagery preferences can vary substantially among people. Consequently, researchers and mental imagery coaches should take this into consideration when designing mental imagery training interventions. Furthermore, the researcher described the use of several different mental imagery training strategies, including the use of written imagery scripts, pre-recorded audio imagery guidance, scenario-based imagery, and the application of specific imagery techniques outlined in Holmes and Collins' (2001) PETTLEP model.

The body of literature contains numerous examples of the use of mental imagery training as a method to improve human performance. The findings of numerous qualitative and quantitative research studies in a variety of disciplines indicate many positive effects from the use of combining mental imagery training strategies with physical practice. Some of these demonstrated effects include faster rates of learning and acquiring new psycho-motor skills; improved accuracy and consistency in technical skills; heightened awareness and focus; increased motivation; boosts in confidence; greater control over negative emotions; reduced stress and anxiety; swifter memorization; improved concentration; and longer retention of skills. Furthermore, research findings indicate that the use of mental imagery can serve as an effective supplement to physical practice and a good replacement for it when physical practice is not otherwise possible due to various setbacks. Moreover, the inclusion of mental imagery exercises has helped some people get the most out of their training and people at all skill levels from beginner to elite have found it to be beneficial. Such results provide strong support for exploring the use of mental imagery training strategies in a collegiate aviation training program context.

According to Creswell & Poth (2016), conducting a review of the literature serves as a means for the researcher to find gaps in the body of literature about the topic and to determine whether an investigation of the topic will add something new to the body of research (Creswell & Poth, 2016). In this case, the researcher's review of the literature revealed significant gaps in the body of knowledge related to exploring the use of mental imagery in the aviation discipline. The researcher found no information within the literature regarding the lived experiences of student pilots using mental imagery training strategies to supplement their flight training. Conducting this exploration of student pilots' perceived experiences of using mental imagery may reveal useful new information about the effects of mental imagery training on the performance of novice pilots. Therefore, the researcher proposes to conduct a phenomenological qualitative research study to explore student pilot perceptions about their experiences with using mental imagery training strategies during their private pilot flight training program. Chapter 3 includes a detailed description of the methodology the researcher will use to conduct this study.

Chapter 3: Methodology

The purpose of this chapter is to describe the design of this proposed study to explore collegiate student pilot perceptions about their experiences with using mental imagery training. It begins with a reiteration of the central and supporting research questions that this study will attempt to answer and a description of the qualitative research methodology the researcher will use to answer these questions. The chapter includes a brief background of the researcher and a discussion regarding the ethical considerations involved in this study. Also included is a general description of the mental imagery training materials the researcher will provide to the student pilot participants of this study they will use during their flight training program. After describing the data collection and analysis process of the proposed study, the researcher discusses how he will address the validity and reliability of the research findings.

The Central and Supporting Research Questions

The central research question of this study is, "*What are student pilot perceptions about their experiences with using mental imagery training during their private pilot flight training program*? To help answer this question, the researcher will seek answers to the following supporting research questions:

1. What do student pilots perceive as the outcomes from using mental imagery training strategies?
2. How did the use of mental imagery affect student pilot motivation, confidence, and self-efficacy?
3. What mental imagery training techniques do student pilots perceive as effective or ineffective?

4. In what ways did student pilots adapt their use of mental imagery to suit their own individual learning styles and preferences?

The Guiding Research Methodology

Answering the central and supporting research questions of this study requires the collection and analysis of the participants' perceived experiences. Consequently, a qualitative research approach is appropriate. As Creswell and Poth (2016) asserted, researchers apply qualitative methods when they are seeking a complex and detailed understanding of the issue that may only arise by talking directly with people and allowing them to tell their stories unencumbered by what the researcher expects to find or what the researcher has read in the literature. It is important to note that the researcher's intent for this study is not to prove or validate the effectiveness of mental imagery training as applied to flight training programs. Rather, the goal of this study is to explore the lived experiences of student pilots engaging with the phenomenon of mental imagery training during their private pilot flight training program. Therefore, the researcher will apply a descriptive phenomenological research approach because it is a form of inquiry based on philosophy and psychology in which the researcher describes the essence of the lived experiences of individuals about a phenomenon as described by those who have experienced the phenomenon (Creswell & Creswell, 2018; Neubauer, Witkop, & Varpio, 2019; Moustakas, 1994, Vagle, 2018). By taking this approach, the researcher will rely on participants to provide in-depth responses to open-ended questions about how they have understood their experiences (Jackson, Drummond, & Camara, 2007).

While historians credit Edmund Husserl as the founder of phenomenology and for defining it in the early part of the 20th century, it evolved from philosophical traditions over several centuries (Vagle, 2018; Neubauer, Witkop, & Varpio, 2019). Husserl rejected the idea that objectivity produced better science, better methodology, and better results (Vagle, 2018). In Husserl's era, researchers designed their studies to remove or at least reduce the human's influence on studies of human sciences to ensure objectivity (Vagle, 2018). However, Husserl's philosophy about human research is that humans do not live objectively and that "living and experience take place in the intentional relationship between the subjective and the objective – and this 'between' space is ever expansive" (Vagle, 2018). Husserl's view was that people live their lives phenomenologically in the space between objectivity and subjectivity (Vagle, 2018).

One of Husserl's essential philosophical underpinnings of phenomenological research is that no assumptions, no philosophical or scientific theory, no deductive logic procedures, and no other science or psychological speculations should inform the inquiry (Neubauer, Witkop, & Varpio, 2019). This requires phenomenological researchers to suspend their own attitudes, beliefs, and suppositions about the phenomenon under study so they can focus on the participants' experiences with the phenomenon and to identify the essences of the phenomenon (Neubauer, Witkop, & Varpio, 2019). The phenomenological researcher is to "stand apart, and not allow his/her subjectivity to inform the descriptions offered by the participants" (Neubauer, Witkop, & Varpio, 2019, p. 93). This can occur via a transcendental process of reduction or epoche whereby the researcher brackets off pervious understandings, past knowledge and assumptions about the phenomenon under study (Neubauer, Witkop, & Varpio, 2019). However, as Vagle (2018) noted, "transcending one's consciousness in order to study the consciousness of others is a tall order" (p. 58). Creswell and Poth (2016) summarized Husserl's concepts of epoche or bracketing as the process investigators use to "set aside their experiences, as much as possible, to take a fresh perspective toward the phenomenon under examination" as if they are perceiving it for the first time (p. 78). Creswell and Poth (2016) highlighted that researchers who embrace the idea of bracketing begin their projects by describing their own experiences with the phenomenon and then bracket out their views before proceeding with the experiences of others.

Martin Heidegger was a student of Husserl and may be the most notable phenomenologist to follow Husserl, but his approach to phenomenology was significantly different than his teacher (Vagle, 2018). While Husserl believed that researchers should bracket out their preconceived assumptions about the phenomenon and their experiences with the phenomenon, Heidegger stressed that because people live out phenomena interpretively in the world, researchers should not bracket out the world but instead, fully engage in the phenomenological inquiry (Vagle, 2018).

Many other prominent phenomenologists have followed these seminal researchers, including Maurice Merleau-Ponty and Jen-Paul Sartre of France, each developing their own new ideas about phenomenological research and how to conduct it. Consequently, there are currently multiple phenomenological philosophies and methodologies in practice today and according to Vagle (2018), there is no single, crystal clear and unified way to craft a phenomenological study. Vagle (2018) asserted that the phenomenon itself determines how researchers should study it, and any technique, process, or tool that the researcher thinks will help in the exploration to illuminate the phenomenon is “fair game”, as long as the researcher can justify it (p. 17). Furthermore, Vagle (2018) stated that it is possible to choose aspects of different phenomenological approaches and combine them in unique ways (p. 70). For the proposed study, the researcher will, in general, apply a Husserlian transcendental descriptive phenomenological philosophy by attempting to bracket out his preconceived notions and assumptions about the phenomenon of mental imagery training and seek to find the essences of student pilots’ experiences with using this training method during their flight training program.

Vagle (2018) highlighted that phenomenology is not concerned with finding generalizable, quantifiable results, it produces no hard data, and it does not make use of precise, objective measures that quantifiably prove anything. Instead, the aim of phenomenology is to gain a deeper understanding of the phenomenon under study. This leads some to regard phenomenological research as non-scientific. However, phenomenologist van Manen highlighted that because the root meaning of the word ‘scientific’ means ‘to know’, phenomenological research is most certainly scientific because it is “a systematic, explicit, self-critical, and intersubjective study of its subject matter” (Vagle, 2018, p. 11).

To ascertain the essence of the participant’s lived experiences with mental imagery in the proposed study, the researcher will apply the following Husserlian descriptive transcendental phenomenological research process as summarized by Creswell & Poth (2016, p. 78):

1. Identify the phenomenon of study.
2. Bracket out the researcher’s own experiences with the phenomenon.
3. Collect data from several people who have experienced the phenomenon.
4. Analyze the data by reducing the information into significant statements or quotes.
5. Combine the statements into themes.
6. Develop a textural and structural description of what the participants experienced and how they experienced the phenomenon.

Through this process, the researcher will construct a complete description of the meaning and essences of individual participants and then, through imaginative variation, the researcher will distill all of the participant’s descriptions of their experiences into a unified synthesis of essences (Neubauer, Witkop, & Varpio, 2019). Neubauer, Witkop, and Varpio (2019) further summarized Moustakas’ approach to transcendental phenomenology data analysis as,

> The researcher reads the data, reduces the data to meaning units, re-reads those reductions to then engage in thematic clustering, compares the data, writes descriptions, and so on in an ongoing process of continually engaging with the data and writing reflections and summaries until the researcher can describe the essence of the lived experience. (p. 95)

The researcher of the proposed study will attempt to apply several of Husserl's ideas about phenomenology to this study, beginning with adopting a phenomenological attitude of questioning what he may typically take for granted and entering into a questioning mindset, whereby he will try to become curious about things that he might otherwise treat as obvious (Vagle, 2018). In addition, the researcher will make every effort to apply phenomenological reduction or epoche, which will involve suspending his judgment of the existences and pre-understandings of the phenomenon of mental imagery training (Vagle, 2018). Furthermore, the researcher will bracket out or put aside his own knowledge and experiences while conducting the study and analyzing participants' descriptions of their experiences with mental imagery training. The researcher will address these efforts in the sections that follow.

The Researcher

The researcher of the proposed study has more than 35 years of aviation experience, which includes more than 10,000 hours serving as a flight and simulator instructor, charter pilot, and airline pilot. He has provided more than 2000 hours of primary and advanced flight instruction to pilots at all levels, including student pilots working toward earning a private pilot certificate and experienced airline pilots earning type ratings in complex turbojet aircraft. The researcher has more than 15 years of aviation classroom teaching experience and has served as an associate dean, assistant dean, and professor at one of the largest collegiate aviation programs in the United States. In addition, the researcher has extensive experience in developing pilot training programs, having served for more than 15 years the manager of pilot training programs at two U.S. airlines and two foreign airlines.

The researcher holds a Bachelor of Arts degree in Liberal Arts and Science from Virginia Tech, with a concentration in mathematics and minors in biology and history. He holds a Master of Commercial Aviation (MCA) degree from Delta State University and a Master of Arts Degree in Human Services Counseling with a Cognate in Executive Leadership from Liberty University. While earning his counseling degree, the researcher completed several academic courses that focused on listening and communication skills and how to interpret body language and other unspoken forms of communication. Furthermore, the researcher has served as an online college professor teaching live sections of courses using online meeting applications such as Zoom, Teams, and Webex. In addition, the researcher has extensive experience in conducting interviews during his career and has taught aviation interview courses to college students for several years. This training and experience prepared the researcher to conduct the one-on-one interviews planned for this study.

The researcher first learned about the practice of mental imagery from his high school swim coach in the early 1980s. This coach periodically had all of the members of the swim team lay on their backs on the pool deck with their eyes closed as he guided them through a progressive muscle relaxation exercise followed by a visualization exercise to imagine swimming a perfect race. The researcher found this to be an effective means of improving his own swimming skills and preparing for competition. He used these skills extensively during his high school and collegiate swimming career. During his aviation career, the researcher has used similar mental imagery strategies to learn flight skills and improve his own pilot proficiency. As a flight instructor, the researcher has taught numerous students about the use of chair flying and mental imagery and has encouraged students to apply these strategies to their own flight training.

Because of his own positive experiences with using mental imagery and his direct observations of students using this training method, the researcher has developed a positive bias about the efficacy of applying mental imagery techniques to pilot training. As such, the researcher will remain vigilant of his biases and deliberately bracket them out of the study as advocated by Creswell and Poth (2016). In other words, the researcher will set aside his own experiences as much as possible so that he can approach the phenomenon under examination from a fresh perspective and with an open mind (Creswell & Poth, 2016; Vagle, 2018).

The researcher will bracket out his bias in part by ensuring that all interview questions and feedback prompts include neutral wording and phrases. For example, rather than asking, "What are your impressions about the benefits of the mental imagery techniques you used?", the researcher will ask, "What are your impressions about the mental imagery training techniques you used?". The aim will be to restrict the use of qualitative words, such as "benefits" from the questions asked of participants wherever practical. The goal will be to avoid positively or negatively influencing participant responses by the words and phrasing used in each question. Furthermore, as much as practical, the researcher will attempt to maintain a neutral tone of voice, body language, and facial expression during interviews with participants so as not to influence their responses.

Ethical Considerations

Prior to initiating this study, the researcher will obtain approval from the Saint Louis University (SLU) Institutional Review Board (IRB). This is to confirm that the researcher will conduct the study in accordance with established guidelines and ethical protocols to ensure the safety and well-being of the participants (Creswell & Poth, 2016). Gill, Stewart, Treasure and Chadwick (2008) highlighted the importance of informing research participants about the details of the study and providing assurance about ethical principles, such as anonymity and confidentiality. Accordingly, prior to the start of the data collection process, the researcher will ask all participants to sign an informed consent form that includes a detailed written explanation about the purpose and content of the study and a list of specifics involved in voluntary participation. In particular, all participants must acknowledge their understanding that the research project received approval from the SLU Institutional Review Board for studies involving human subjects. In addition, the consent form will clearly articulate any known risks associated with the use of mental imagery and inform the participants that they are free to withdraw from the study at any time without any consequences (Creswell & Poth, 2016). The consent form will inform participants that their participation or lack of participation in the study will have no effect on their flight course grade and that they may discontinue the use of the mental imagery training resources provided to them at any time without restrictions or penalties.

Moreover, as a matter of good ethical practice, participants will be free to continue using the mental imagery training resources at their discretion even if they opt out of participating in the data collection process. The researcher will ensure that all students in the sample population who are interested in using the mental imagery training materials have access to them even if they choose not to participate in the study. In other words, the researcher will provide all of the students in AVIA 220 and AVIA 225 equal access to the mental imagery guidance materials. A copy of the informed consent form is located in Appendix A.

Another important ethical precaution the researcher will take is to inform the participants that mental imagery aptitude varies among different people and that a small percentage (two to three percent) of the population lacks the ability to imagine any visual images at all using the "mind's eye" – a phenomenon called *congenital aphantasia* recently discovered by Zeman, Dewar, and Della Sala (2015). Consequently, the imagery guide will inform participants in the introduction section that because people's imagery aptitude varies, some of the mental imagery techniques and exercises included in the training guide provided to them might be easier to use for some than for others.

Furthermore, participants will be free to work at their own pace while using the mental imagery training resources and free to refrain from using them altogether for any reason. While researchers theorize that the vividness of participants' mental imagery will improve with practice (Cumming & Eaves, 2018; Williams, 2018), at no time will the researcher require any students involved in the selected private pilot training courses to complete any of the mental imagery exercises included in the training materials provided to them. However, the researcher will ask, but not require the participants to complete the Plymouth Sensory Imagery Questionnaire (psi-Q) developed by Andrade, Deeprose, Baugh, & Ganis (2014). This will likely give each participant a better awareness of their own self-assessed mental imagery aptitude, which they can use to modify their mental imagery training strategies as described in the study design section below.

Study Design

The Participants

The initial data collection phase of this research project will involve the participation of approximately 50 student pilots enrolled in two private pilot flight courses in Liberty University's Flight Training Affiliate (FTA) Program during a 16-week academic term. The main campus of Liberty University is located in Lynchburg, Virginia and is home to the Liberty University School of Aeronautics (LUSOA). Liberty's SOA has a large residential aviation program with an enrollment of more than 500 degree seeking students. In 2013, the LUSOA established its FTA program to offer students an online option for earning an aviation degree, enabling students to complete their academic courses online and their flight training requirements at a local area flight school. Today, there are more than 85 LU flight training affiliates across the United States providing flight training to more than 3000 of Liberty's degree-seeking students (Liberty University, n.d.).

The two private pilot flight courses involved in this study are AVIA 220 - Private Flight I and AVIA 225 – Private Flight II. AVIA 220 includes all of the requisite flight training leading up to and including the student pilot's first solo flight while AVIA 225 includes cross country operations and the balance of training required to complete the FAA Private Pilot practical test. The researcher expects the number of students enrolled in each of these courses during the sample period to be approximately 25. The researcher will have an email invitation sent to all of the students enrolled in these two courses inviting them to participate in this study to explore their perceptions about their use of mental imagery training techniques to supplement their private pilot flight training. The researcher will provide a copy of the invitation to the course professors of AVIA 220 and AVIA 225 and they will post the invitation in an online course announcement that students will also receive via email. A copy of the email invitation to participate in this study is located in Appendix B.

The invitation to participate in the study will include a brief introduction of the researcher and a short summary of the research study. In addition, it will include a link to a Microsoft Form that includes fields for interested student pilots to insert their name and email address. When the students fill out the form, this will be an indication to the researcher that they are interested in participating in the study or would at least like to have access to the mental imagery training materials. A copy of the Mental Imagery Training Materials Access Form is in Appendix C. As the researcher receives each student's name and email address, he will enroll them into a Mental Imagery Training Team via the Microsoft Teams application where the researcher will store all of the mental imagery training materials associated with the study. This will include the informed consent form, an electronic copy of the Mental Imagery Training Guide document, the psi-Q imagery aptitude questionnaire, and all of the example audio podcast files. The researcher will notify the students of their enrollment in the Mental Imagery Team and direct them to the training materials. All of the students have access to the Microsoft Teams application through their enrollment at Liberty University.

Regardless of their acceptance to participate, all of the students in the private pilot courses will have equal access to all of the training materials used in the study. This will ensure that no students in the targeted private pilot flight courses will miss out on the opportunity to use the materials even if they choose not to participate in the data collection process. However, students who accept the invitation to participate in the study must sign an informed consent form agreeing to the terms and requirements of the study. A copy of the informed consent form is located in Appendix A. Participants will sign the consent form and return it to the researcher via email. This will be the researcher's indication that the student has decided to participate in the study.

Based on the nature of enrollment in Liberty's FTA program, the demographics of the sample population will likely be moderately diverse and representative of the U.S. collegiate aviation community at large. The age of students will likely range from late teens to over 50. Many of these participants will be full time college students while many others will be working professionals completing their training as part-time students.

During phase one of the data collection process, the participants will provide qualitative feedback about their experiences of using mental imagery training by describing their experiences in written format using an online data collection form provided by the researcher. The researcher will collect and review this data only from those students who have signed an informed consent form regarding their participation in the study. Based on a review of the collected written data, the researcher will create a list of participants who appear to be good candidates for sharing their insights and additional detail about their experiences during an online one-on-one interview with the researcher. The researcher will purposively select 10 to 15 participants whose written comments indicate that they may be able to help the researcher describe the essence of mental imagery use for student pilots.

In phenomenological studies, researchers purposefully sample selected students because of their likelihood to inform an understanding of the central phenomenon (Creswell & Poth, 2016). Eitkan, Musa, and Alkassim (2016) described purposeful sampling as deliberately choosing participants due to the qualities they possess. These include not only their knowledge and experience with the phenomenon, but also their availability, their willingness to participate, and their "ability to communicate experiences and opinions in an articulate, expressive, and reflective manner" (Eitkan, Musa, & Alkassim, 2016, p. 2).

Purposeful sampling of participants continues until no new information or emergent themes arise from the participants. In qualitative data collection, this is the point of saturation or redundancy as no fresh data sparks new insights or reveals new properties (Merriam & Tisdell, 2016; Creswell & Creswell, 2018). Reaching this point does not imply that the researcher knows everything there is to know about the phenomenon under investigation, but rather, it signals the point "whereby categories and their properties are considered sufficiently dense and data collection no longer generates new leads" (Breckenridge & Jones, 2009). In the current study, the researcher will continue to probe the participant population through one-on-one interviews until the point when no new information surfaces.

The criteria for purposefully selecting specific participants to obtain additional data in the proposed study will evolve as the researcher collects and reviews the written data. However, in general, participants who demonstrate an ability to articulate their experiences well and those who appear to be able to offer more clarity about the phenomenon of mental imagery use may be indicative of those who will contribute a rich set of data for further analysis. In addition, the researcher will attempt to sample participants who describe atypical experiences from those reported by the group to better understand the factors and circumstances that might have affected their experience.

Near the end of the sample 16-week academic term of the private pilot flight courses, the researcher will conduct phase two of the data collection process and use the list of purposively selected participants to invite ten to fifteen of participants to take part in a one-on-one online interview with the researcher. The researcher will record these data collection events, each lasting approximately 30 to 45 minutes. However, if new, relevant information continues to emerge through the end of the planned interviews, the researcher will host additional interviews until no new information or themes emerge. At this point, the researcher will consider the data set to be saturated.

According to Vagle (2018), there is no magic number of participants needed to conduct a phenomenological study. Researchers could spend a lot of time with just a few participants or a short amount of time with ten to fifteen participants as the phenomenon itself determines what is most appropriate (Vagle, 2018). What researchers need is an adequate number of participants to answer the questions established at the start of the study (Merriam & Tisdell, 2015).

Assessing Participant Imagery Aptitude

At the start of the study, the researcher will ask the participants to complete the Plymouth Sensory Imagery Questionnaire (psi-Q) so that they will gain a heightened awareness of their perceived mental imagery aptitude. As discussed in Chapter 2, the psi-Q developed by Andrade, Deeprose, Baugh, & Ganis (2014) enables people to measure their own vividness of imagery across a range of sensory modalities, including auditory, olfactory, taste, touch, bodily sensation, and emotional feeling. While completing the psi-Q, participants will rate the vividness of their imagery of five imagery prompts in the seven different modalities on a scale of zero to ten, with zero representing no image at all and ten representing the maximum level of vividness. According to Andrade et al. (2014), it is not uncommon for individuals to rate one or more modalities as strong and the others as weak. These ratings are based on the mean score in each modality and the mean score of the entire questionnaire.

The purpose of requiring participants to complete the imagery aptitude questionnaire is twofold. The first purpose is to help participants gain an awareness of their own self-assessed imagery aptitude level. By calculating their mean score, the participants will be able to see where they fall on the spectrum between 1 and 10 for each modality and the total mean score to get a sense of their overall self-assessed imagery aptitude based on their deviations from the median of each scale (Andrade et al., 2014). This awareness may better enable them to create their own imagery scripts or to customize the scripts provided to them to suit their needs based on their perceived level of imagery aptitude. Creating and customizing mental imagery scripts is one of the suggested techniques included in the provided mental imagery training materials. For example, if a participant's self-assessment indicates a weakness in the ability to imagine smells, then it may be beneficial to exclude references to the smells of the cockpit from mental imagery training exercises to avoid causing distractions or frustration, which could disrupt the flow and ease of such exercises. Conversely, for those who score strongly in the imagery modality of sound, it would be appropriate for them to include additional emphasis on imagining various sounds that they would hear during actual flight tasks, such as the change in wind and engine noise as the aircraft accelerates and decelerates during specific maneuvers.

A second purpose of having each participant assess their imagery aptitude is to explore any relationships that might exist between self-assessed mental imagery aptitude and participant perceptions about their experiences with using mental imagery training strategies. The researcher will explore this area during the one-on-one interviews conducted near the end of the research period by asking interviewees to describe how their self-assessed imagery aptitude affected their experiences with using mental imagery during their flight training program. A copy of the psi-Q questionnaire is located in Appendix D.

The Mental Imagery Training Materials

The researcher will store all of the mental imagery training materials provided to the private pilot students and participants of this study in a dedicated folder within the Microsoft Teams application. The researcher will enroll each student into an exclusive Team titled *Private Pilot Mental Imagery Training Team* and he will send them a link to this Team via email. All of the AVIA 220 and AVIA 225 students and the participants of the study will have access to the Teams application as a consequence of their student status at Liberty University. The materials will reside in a dedicated folder labeled, “Class Materials”, as this built-in folder prevents participants from editing, moving, or deleting the stored files. However, the students will be able to copy and download all of the files in this folder and save them to their own personal computers or other electronic devices. The materials folder will contain a Microsoft Word document titled *Mental Imagery Training Guide for Private Pilot Students* that includes all of the scripts used to record the mental imagery podcasts the students will listen to on their own devices as they progress through their flight training program. The materials folder will also include the 15 audio podcast files, plus an extra audio recording of aircraft engine background noise. Students will also find a copy of the psi-Q questionnaire in this same folder.

The researcher will direct the students in both private pilot flight courses to the training materials folder via an email link at the start of the term. The training guide instructs participants to listen to the introduction podcast first, before listening to any of the others as it explains the general concepts of mental imagery training, the techniques they can try, and the steps they should follow to complete each mental imagery exercise. A copy of the Mental Imagery Training Guide is located in Appendix K. Copies of the mental imagery audio podcast files are available to the researcher's dissertation committee upon request.

The intent of the mental imagery training guide and the audio podcasts is to inform the participants about the practice of using mental imagery to improve human performance, to familiarize them with a set of techniques they can use to potentially enhance their mental imagery experiences, and to provide them with practical examples and tools they can use to mentally practice their private pilot flight skills. The researcher has included a synopsis of each mental imagery podcast in Appendix I.

Data Collection

Phase One. Data collection will occur in two distinct phases during the study. Phase One will occur during the conduct of the private pilot flight courses (AVIA 220 and AVIA 225) during the selected 2021 fall term. During this phase, participants will apply the techniques described in the mental imagery training guide and listen to the provided imagery podcast samples to supplement their private pilot flight training. Approximately every three weeks, the researcher will ask the participants via email to share their thoughts about their use of mental imagery up to that point in their training by posting their written comments in an online participant data collection form. Vagle (2018) asserted that written contributions can serve as useful way to gather phenomenological material and suggested providing participants with guidelines about what to write about. Therefore, the header information of the participant data collection form will include some basic guidance such as, "Describe your experiences of using mental imagery training thus far in your flight training program" and "Don't be concerned about being elegant with your words, just write in your own way however you like". Vagle (2018) encouraged the use of "any form of writing that might open up the phenomenon" (p. 99).

The email sent to participants will include a link to the Microsoft Form along with a reminder about the incentive the researcher is providing to the participants for completing the data collection form. During each data collection cycle, the researcher will randomly select one participant who has provided written comments to receive a $50 Amazon gift card. Offering a nominal financial incentive is a common practice in human subject research and researchers use it to boost recruitment (Resnik, 2015). Providing an incentive also serves as a means of thanking participants for their assistance with the research (Resnik, 2015). A copy of the email request for participants' written comments is located in Appendix E and an image of the participant written data collection form is located in Appendix F.

The researcher will insert all of the participant's written comments into tables in the researcher's Phase One Data Collection Form throughout the term as illustrated in Figure 2. The researcher will associate all written comments with the participant's name and deidentified participant number and arrange them by the week of the term as illustrated in Figure 2. The researcher will perform a cursory review of participant contributions as they become available and search for significant, informative statements and comments. The researcher will highlight positive statements in green, negative statements in red, neutral but informative statements in yellow, and particularly unusual or interesting statements in magenta. In this way, the researcher will begin to get a broad sense of the data by observing the preponderance of colors. Concurrently with this search for significant statements, the researcher will begin writing memos and inserting them into the data collection form. Then, as part of the purposeful sampling process of phenomenological research (Creswell & Poth, 2016; Eitkan, Musa, & Alkassim, 2016), the researcher will create a list of participants he believes may be able to offer additional rich descriptions of their experiences via a one-on-one interview during phase two of the data collection process.

PHASE ONE DATA COLLECTION FORM					
PARTICIPANT WRITTEN CONTRIBUTIONS EXTRACTED FROM THE ONLINE DATA COLLECTION FORM					
Participant No.	**Participant Name**	**Course/ Section**	**Participant Responses**		**Researcher Summative Comments/Phrases/Memos**
P1	Jane Doe	AVIA 210-A1	**Week #3**	Paste text of Initial Thread & Replies here: Positive statements highlighted in green. Negative statements highlighted in red. Neutral but informative statements highlighted in yellow. Particularly unusual or interesting statements highlighted in magenta.	Comment 1 Comment 2 Comment 3 Comment 4 Comment 5…
			Week #6	Paste text of Initial Thread & Replies here:	
			Week #9	Paste text of Initial Thread & Replies here:	
			Week #12	Paste text of Initial Thread & Replies here:	

Figure 2: Phase One Data Collection Form

Phase Two. The second phase of the data collection process will begin near the end of the academic term of each sample flight course. Based on the data collected during the phase one data collection process, the researcher will purposefully sample participants who appear to be able to articulate their experiences well and who will be able to help the researcher capture the essence of student pilots' experiences with using mental imagery during their flight training program. To collect qualitative data in Phase Two, the researcher will conduct one-on-one online interviews with 10 to 15 participants lasting 30 to 45 minutes each. The researcher will incentivize participation in interviews by offering each participant a $25 Amazon Gift Card.

During the one-on-one interviews, the researcher will ask participants a small set of broad, open-ended questions to generate conversation aimed at answering the central and supporting research questions established prior to the start of the study and any additional questions that arise as the study progresses. The list of anticipated interview questions is located in Appendix H, however, participants will be free to expand their responses beyond the scope of the questions asked. In an effort to put each participant at ease and to illicit rich descriptions of the phenomenon, the researcher will spend a few minutes at the start of each interview engaging in ‘small talk’ with them in a light, jovial manner prior to asking the interview questions. This is a recommended interview practice in qualitative research (Goodman-Delahunty & Howes, 2016; Josselson, 2013; Lambley, 2020). The researcher will reassure participants that the information they provide will remain confidential.

To arrange the Phase Two interviews, the researcher will send an email invitation to purposefully selected students. A copy of the email invitation is located in Appendix G. The invitation will inform the participants about what to expect in the interview, including a reminder about the topic, how long it will last, and that the researcher will record it (Cassell, 2015). The email will also include a few of the open-ended questions the researcher will ask during the one-on-one interview. Providing some of the questions in advance will give the interviewees a chance to recall and reflect on them before the interviews take place (Cassell, 2015). The researcher will develop the list of interview questions based on a review of the Phase One data collected during the academic semester. However, a preliminary list of anticipated questions for each interview is located in Appendix H. The email invitation to participate will also include a link to a Microsoft Form that will serve as an RSVP to the researcher along with a selection of choices for acceptable dates and times that will fit into participants’ schedules. Upon receiving participants’ RSVPs and choices of dates, the researcher will send respondents another email that will include a confirmation of their interview date and time.

The researcher will conduct each semi-structured interview using the online meeting application Microsoft Teams, which will allow the researcher and participants to see and hear each other using their own computer webcam, microphone, and speakers. While the researcher has experience in conducting interviews, he will apply many of the techniques and guidelines for administering interviews described by Blackstone (2018) and by Merriam and Tisdell (2015). The researcher will record each interview using the record function of the Teams application. As a backup, the researcher will make an additional recording of each interview using a separate video camera set on a tripod and aimed at the screen of the researcher's computer. The researcher will make an electronic file of each recording and store them all on a password protected external hard drive that he will keep in a secure location. The researcher will destroy these files after the study in accordance with SLU's IRB requirements.

The researcher will transcribe the audio recordings of each interview verbatim and insert the transcripts into the Phase Two Data Collection Form as indicated in Figure 3. Although automatic transcription and coding software is readily available, Lathlean (2015) considers manually transcribing the data a best practice in qualitative research because it begins the process of the researcher becoming immersed in the data. Bryant and Charmaz (2007) highlighted Glaser's adamant opposition to any use of software support in qualitative research because he saw it as "undermining researchers' creativity" (p. 24). Furthermore, Bryant and Charmaz (2007) noted Hess-Biber's admonition of the use of such technology as potentially destroying the intimacy between the researcher and the data.

The researcher will link each participant's responses to the participant number as illustrated in Figure 3. However, for reporting purposes, the researcher will use pseudonyms and participant numbers when highlighting direct quotes of participants in order to protect their identities. The researcher will also include all additional clarification questions and comments used during the interviews in the response section of the data collection forms and note any significant observed body language, tone of voice, facial expressions, and other unspoken communications.

Data Analysis

Creswell and Poth (2016) asserted that the analysis of qualitative data consists of preparing and organizing the data, reducing it into themes through a process of coding, condensing the codes, and then representing the data in figures, tables or a discussion. The data analysis process in this proposed study will follow this strategy.

The researcher will merge the Phase One and Phase Two data collection forms together into one combined document and begin an exhaustive review of the interview transcripts and all of the written statements provided by individual participants. This initial read through all of the data will help the researcher get well-oriented and fully emersed in the data. The researcher will then begin searching for and highlighting significant statements in the transcripts by color as completed during the phase one data collection and review process.

During each read of the collected data, the researcher intends to write memos and insert them directly into the data collection forms next to or near the related data (Creswell & Poth, 2016). In addition, the researcher expects to write brief memos while conducting interviews, but memo writing will likely be rather extensive and potentially more elaborate during the review and analysis of the collected data. Creswell and Poth (2016) described memos as short phrases, ideas, or key concepts that help researchers build a sense of the data and track the development of ideas. Creating memos is simply the process of writing down thoughts and ideas that come to mind as the researcher collects and analyzes the data. Such memos become part of the data and help the researcher uncover emerging themes. According to Wiener (2007):

> Memo writing allows the researcher to think through ideas about a category and its properties and to search for interrelationships with other emerging categories. Thus, the central requirement of memo writing is that it be done expansively and freely,

> unconstrained by the restrictions of formal writing – that is without attention to syntax, grammar, and spelling, and without internal debate of the issue of significance. (p. 302)

Lempert (2007) regarded memo writing as a means for researchers to "engage in and record intellectual conversations with themselves about the data" (p. 249). The researcher of the proposed study will type any such memos written by free hand into the data collection forms for data management and analysis purposes.

The researcher will then begin clustering the significant statements by common themes and summarizing the main points and key concepts of each significant statement in an effort to reduce the data into "meaningful segments" as described by Creswell and Poth (2016, p. 183). The researcher will start inserting concise summary statements, phrases, and other notes into the data collection form adjacent to the applicable participant responses. As part of the data analysis, the researcher will begin developing a list of code words and categories that succinctly represent the essence of the participant's statements and the researcher's summative comments and memos. Creswell and Poth (2016) consider this process to be the heart of qualitative data analysis.

The researcher will begin to link these codes and categories to the summative statements by highlighting the text and then using the Microsoft Word "Review" toolbar to insert the code word or category into a comment box next to each statement. This action will place the code on the right-hand edge of the Word document for easy viewing as shown in Figure 3. Then, the researcher will segregate the codes inserted into the Data Collection Forms into a separate PDF document for further analysis using the following steps on a 2019 MacBook Pro computer:

1. Select the "File" tool in the tool ribbon.
2. Select Print.
3. Select "Microsoft Word" in the Print Menu.

4. Select “List of Markup” in the Print Menu.
5. Select “Open in Preview” in the Print Menu.
6. Save the resultant document that opens as a PDF file.
7. Open the new PDF for analysis.

With all of the codes and labels isolated and presented in the resultant PDF document, the researcher will run search queries to determine their frequency of occurrence and begin comparing them to one another. The researcher will group related codes together into emergent themes. The researcher will provide the full list of codes, their frequency of occurrence, and the list of emergent themes in a separate appendix in the final report of the study.

PHASE TWO DATA COLLECTION FORM		
ONE-ON-ONE INTERVIEW TRANSCRIPT		
Participant No.	**Participant Name**	**Course/ Section**
P2	John Doe	AVIA 220-A01
PARTICIPANT RESPONSES		
Question/Prompt #1: Please tell me about your experiences of using mental imagery during your private pilot flight training program.		
Participant Responses		**Researcher Summative Comments/Phrases/Memos**
Place Verbatim Transcription Here: Positive statements highlighted in green. Negative statements highlighted in red. Neutral but informative statements highlighted in yellow. Particularly unusual or interesting statements highlighted in magenta. Researcher follow-on question/clarification statement: Participant answer:		Comment 1 Comment 2 Comment 3 Comment 4…
Question/Prompt #2: Tell me about the mental imagery techniques you used and your thoughts about their effectiveness.		
Participant Responses		**Researcher Comments**
Place Verbatim Transcription Here:		Insert comments/main points here.

Hudson, Robert Louis
Code Word/Category 1

Hudson, Robert Louis
Code Word/Category 2

Hudson, Robert Louis
Code Word/Category 3

Figure 3: Phase Two Data Collection Form

Reporting the Findings

After collecting and analyzing all of the data for emergent themes, the researcher will reflect on the data and begin developing a textural description of the participants experiences with mental imagery training in vivid accurate terms (Moustakas, 1994). Phenomenological research is about describing what a phenomenon presents itself to be. With this in mind, the researcher’s aim will be to present the essence of the phenomenon of mental imagery training as described by student pilots who experienced using it. The researcher will spotlight some of the most significant statements provided by the participants and where appropriate, the researcher will include direct quotes to add depth, richness, and credibility to the discussion (Merriam Creswell & Poth, 2016; Creswell & Creswell, 2018). The researcher will describe student pilot perceptions about their experiences of using mental imagery in their flight training program as revealed in the data and he will discuss all of the common themes that emerged from the analysis of the data. The researcher will include a list of the significant statements captured during the data collection process in an appendix at the end of the report.

Validity, Reliability, and Consistency of the Study

Creswell and Creswell (2018) explained that the validity of a qualitative research study is based on determining whether the findings are accurate from the standpoint of the researcher, the participants, and the reviewers. Validity also refers to the study's trustworthiness, integrity, authenticity, credibility, soundness, and how well the research findings match reality (Creswell & Creswell, 2018; Miriam & Tisdell, 2015; Noble & Smith, 2015). Creswell and Poth (2016) recommend applying at least two validation strategies to qualitative studies. For this study, the research will apply at least three different specific validation strategies, each from a different perspective.

The first validation strategy will be from the researcher's perspective whereby he will clarify his own biases and engage in reflexivity throughout the study (Creswell & Poth, 2016). This will include disclosing his personal understandings and experiences with using mental imagery training and describing how this might shape his interpretation and approach to the study. To accomplish this, the researcher fully disclosed in this chapter his positive opinions of mental imagery training and chair flying and how he would bracket these out and put them aside as much as practical to limit their influence on his collection and analysis of the data. By articulating and clarifying his assumptions about mental imagery and his experiences with the phenomenon of mental imagery, the researcher will enable the readers of this study to better understand how he might have interpreted the data (Merriam & Tisdell, 2015). Furthermore, by making his biases and perspectives known, readers will have a better understanding of how these may have influenced the conduct and conclusions of the study (Maxwell, 2013; Creswell & Poth, 2016)).

As a second way to add validity to the study, the researcher will request feedback from the participants to gain their perspectives regarding the accuracy of the researcher's major findings, themes, and descriptions of their lived experiences with using mental imagery training – a strategy referred to as member checking (Creswell & Creswell, 2018, Miriam & Tisdell, 2015). To accomplish this, the researcher will send a preliminary draft of the findings report to at least half of the interviewed participants of the study via email and ask them to reflect on the accuracy of the researcher's account (Creswell & Poth, 2016).. The researcher will ask participants to provide their feedback, correct any misinterpretations, and to identify what might be missing (Creswell & Poth, 2016). Lincoln and Guba (1985) considered such member checking to be "the most crucial technique for establishing credibility" in qualitative research (p. 314) and Maxwell (2013) asserted that it is "the single most important way of ruling out the possibility of misinterpreting the meaning of what participants say and do and the perspective they have on what is going on" (pp. 126-127; Merriam & Tisdell, 2015). Based on the collected feedback from participants, the researcher will adjust the discussion section of the final report as appropriate to clarify information and correct any misinterpretations of the data.

To further increase the validity of the final report, the researcher will seek the perspectives of his peers (Creswell & Creswell, 2018; Miriam and Tisdell, 2015). To accomplish this, the researcher will provide a full report of the study to two of the researcher's colleagues serving as professors at a large collegiate aviation program in the U.S. and seek their critical analysis of the findings. Each of these colleagues is familiar with the phenomenon of chair flying and mental imagery training and each is highly experienced in administering flight instruction to novice pilots. The researcher will ask these colleagues to review the report critically and to provide honest feedback about the methods, meanings, and interpretations presented in the report (Creswell & Poth, 2016). The researcher will ask these colleagues to comment about how the report aligns with their own understandings of the phenomenon of mental imagery training. Based on this feedback, the researcher will adjust the report to clarify any areas of confusion and to remedy any areas highlighted as possible misinterpretations. The researcher will embed the feedback from these colleagues and from the participants into the final report as appropriate.

Reliability in research studies refers to "the extent to which research findings can be replicated" (Merriam & Tisdell, 2015, p. 250). However, when conducting qualitative research involving human subjects, the findings from conducting the same study at a different time with different participants might not necessarily yield the same results (Merriam & Tisdell, 2015). Moreover, because human behavior is multifaceted and influx, and because the information gathered in qualitative studies is a function of who gives it and the skill of the researcher analyzing it, achieving reliability in qualitative research is impossible (Merriam & Tisdell, 2015). Nevertheless, this does not discredit the results of qualitative studies as "there can be numerous interpretations of the same data" (Merriam & Tisdell, 2015). Therefore, in qualitative studies, rather than trying to ensure that outside researchers can arrive at the same results, researchers should focus on "whether the results are consistent with the data collected" (Meriam & Tisdell, 2015, p. 251).

Therefore, to ensure consistency in the proposed study, the research has provided a clear, detailed, and transparent account of how he will collect data from each participant and how he will analyze it to derive the themes and descriptions of the participants' lived experiences. This serves as an audit trail for readers to authenticate the findings of the study and for other researchers to repeat and find comparable findings (Merriam & Tisdell, 2015; Creswell & Creswell, 2018; Noble & Smith, 2015). Another strategy the researcher will employ is to use high quality recording devices to capture interview data and then transcribe them word for word being sure to indicate the trivial pauses and overlaps of the participants (Creswell & Poth, 2016). The researcher will also be sure to capture any notable body language, voice inflections, tone of voice, and facial expressions of the participants when this adds something meaningful to the data. Furthermore, during the data analysis process, the researcher will continually compare the data with the emergent codes and themes, and he will write memos about them along the way (Creswell & Creswell, 2018).

Conclusion

In this chapter, the researcher stated the central and supporting research questions of the proposed study and described the rationale for applying a phenomenological qualitative research approach to answer these questions. In addition, the researcher provided a detailed description of the steps he will take to solicit participants, to provide them with the mental imagery training materials they will use during their private pilot flight training, and to collect data from them about their experiences. This will occur via their written comments in an online data collection form and via their verbal comments during online one-on-one interviews with the researcher. The researcher then described the specific manner in which he will search for and code significant statements, how he will group codes into themes, and how he will synthesize the data into a rich textural description of the lived experiences of the participants. Chapter 4 will include a full report of the findings.

Graduate Course Assessment Form
Assess Student Learning Outcomes

Course: ASCI 6990 Dissertation Research
Semester Taught: Fall 2020 & Spring 2021
Number of Students in Course: 8 (two completed) & 9 (None completed)

Student Learning Outcome Assessed	Assessment Results: (Indicate what % of class achieved a minimum score of 80%)	Benchmark achieved? (Benchmark: 80% of students will score a minimum of 80% = "B")
4. Articulate arguments or explanations to both a disciplinary or professional aviation audience and to a general audience, in both oral and written forms.	**Fall 2020** 8/8 (100%) received a grade of IP (In Progress) 2 candidates successfully defended the dissertation. **Spring 2021** 6/9 (66%) received a grade of IP (In Progress) None of these candidates defended the dissertation	**Fall 2020** **Yes** 100% of students made positive progress toward completing the dissertation. Two candidates successfully defended their dissertation **Spring 2021** **No** Only 66% of students and candidates made positive progress on their dissertation. None of these students defended their dissertation

Course Assessment (Intended Use of Results)
The following will be used for recommendations to improve the quality of course delivery based on assessment results. These recommendations may include prerequisite change; changing course outline and adding more topics; adding a third assessment; changing the course sequence, etc.

Fall 2020
I am pleased with the progress made toward completing and defending their dissertation by PhD students during the Fall 2020 semester. Two of the candidates in this cohort successfully defended their dissertation; one with distinction.

Spring 2021
One weakness I noted in the dissertation process was the pace at which students make progress. Historically, my grading of dissertation hours defaulted to IP (In Progress) whether students made any meaningful progress or not. The final grade of S (Satisfactory) would not be awarded until successful dissertation defense. The process was more or less, pass or fail. During the Spring 2021 semester, three students enrolled in dissertation hours made no meaningful progress. The IP grade was not an accurate measure of any progress made on the dissertation. Consequently, for those students who made no meaningful progress, U (Unsatisfactory) grade was issued. My hope was to reengage these individuals in the dissertation process. To date, one of the three students who received a U grade had reengaged. I have not heard from the other students (None of the U grade students have reached candidacy). I look forward to discussing with colleagues ideas for motivating those non-performing students.

Dissertation Example 1

POWER-DISTANCE IN THE COCKPIT: A STUDY OF THE EFFECT OF AGE AND SENIORITY ON THE COMMUNICATION ASPECT OF CREW RESOURCE MANAGEMENT AMONG NIGERIAN PILOTS

Abdul A. Alliu, MBA

A Dissertation Presented to the Graduate Faculty of
Saint Louis University in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy
2020

ABSTRACT

Unequal power between two people can affect the way they relate with each other, especially in the area of communication. Clear and effective communication is crucial to safety management, more so in the flight deck of a jet airliner. Inadequate communication between the crewmembers can lead to a breakdown in teamwork and thus jeopardize threat and error management. It can ultimately lead to a wrong decision or series of decisions that can result in a fatal accident, as happened with United Airlines Flight 173 in Portland, Oregon, in December of 1978. Crew Resource Management was introduced to help the aviation industry in detecting and eliminating or managing flight crew errors by emphasizing interpersonal communication, leadership, and decision-making as joint responsibilities for all the crewmembers. Geert Hofstede classified national cultures into four dimensions, two of which can be applied to aviation: power-distance and collectivism-individualism. Crew Resource Management represents low power-distance: the free and unhindered exchange of information among crewmembers that recognize their individualism while promoting their inter-dependence. Western cultures are mostly individualistic, with emphasis on personal achievements and responsibility; low power-distance helps to sustain it. Most African cultures are collectivist: group welfare or interest comes first before the individual, and to maintain it, deference to age and seniority (high power-distance) are given priority. High power-distance in a society can, subconsciously, be imported into the airline cockpit. That can hinder effective communication among the pilots and thus affect the successful implementation of Crew Resource Management. This case study research is aimed at uncovering and explaining the effect of age and seniority as power-distance factors on the communication aspect of Crew Resource Management among Nigerian pilots.

Keywords: Aviation Safety, Communication, Crew Resource Management, Power-Distance.

COMMITTEE IN CHARGE OF CANDIDACY:

Professor Terrence Kelly,
Chairperson and Advisor

Professor Stephen Magoc

Adjunct Professor Janice McCall

Dedications

To my wife, Yasmine, for her love, dedication, and support. Thank you, baby, for believing and trusting in me; I love you with all my heart.

To my daughters, Aisha and Mariam, for the joy that you both brought into my life. My life will not be the same without you; I love each of you *unconditionally*.

To my Dad and Mom, for the spirit of hard work and perseverance that you imbibed in me. I wish you are around to witness this milestone in my life. I hope you are both proud of me.

To my aunt, Hajia Mariam Ibrahim, for being there for me at all times. Without you, the road and the journey may have been different; I will forever be grateful.

To my siblings, thank you for being my family. I hope I have been an inspiration to all of you. May the spirit of our parents continue to guide each one of you.

To all my friends and colleagues in the aviation industry in Nigeria, the United States, and elsewhere in the world, may we continue to make SAFETY our watchword at all times.

Finally, it is no coincidence that this dissertation defense took place on October 1st. On that day, 60 years earlier, Nigeria, my country of birth, became an independent nation. A nation is like a house: different components (brick, iron, wood, nails, et cetera) work hard to hold and sustain it. It withstands the storms because all those parts play their roles in supporting it. Nigeria is all we have; we can make it better by playing our individual roles to support and develop it. I dedicate this work to Nigeria - its past, present, and the future ahead.

Acknowledgements

My gratitude and appreciation go to all the people, many unsung, who have contributed in many ways to this accomplishment. First, to the 12 participants in this study: I can never thank you enough for freely sharing your precious time, personal stories, and perspectives on the topic. If this study succeeds in generating public interest in aviation safety in Nigeria, your sacrifice (and in some cases, pain) will not have been in vain. As I was finalizing this thesis, the sad news came of the loss of one of the prominent participants and supporter of the study. May God give the wife and young children he left behind the fortitude to bear his loss.

Prof. Terrence Kelly, my committee chairman, advisor, mentor, and, more importantly, a friend: I can never thank you enough for your patience, support, and guidance throughout the lengthy process. You always have something positive to say about my performance, even when I think otherwise. That inspired me to believe that I can do this. I will forever be grateful to you for your kindness and the words of encouragement.

To Department of Aviation Chair and committee member, Prof. Stephen Magoc, thank you for your support throughout the program. To Prof. Janice McCall, my committee member and friend, I appreciate your thoughtfulness, guidance, and encouragement. To Prof. Stephen Belt and Prof. Richard Steckel, thank you both for your time and suggestions. Dr. Gajapriya Tamilselvan, I am grateful for your time in reviewing my IRB protocol.

To Prof. Riyadh Hindi, Nicole Mispagel, and all the staff of graduate education at Parks College of Engineering, Aviation and Technology, I owe a part of this success to every one of you. To the entire Saint Louis University family, thank you for sustaining that conducive environment that has led to the birth of so many "firsts" in the university's 200-year history. Please keep up the good work, *Ad Majórem Dei Glóriam.*

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CHAPTER 1: INTRODUCTION

Introduction

Power-distance relationships on the flight deck have direct implications on crew communication, and the ability to effectively manage safety of flight. Nowhere is this more evident than in Africa. In 2013, Africa was home to 3 percent of worldwide commercial aircraft departures, but suffered 22 percent of the total world fatal airline accidents for that year (International Civil Aviation Organization [ICAO], 2014). Many of the accidents are traceable to human factor issues (Stolzer, et al., 2008). Peretomode (2012) further identified power-distance as a critical element in the human factor challenges facing aviation safety in Asia and Africa.

An International Air Transport Association (IATA) annual report on world commercial airline safety for 2014 indicated a global accident rate of one accident per 5 million flights on a jet aircraft; in Africa, the rate was one for every 270,000 flights (IATA, 2014). Based on, or in addition to, these statistics, the United States Government Accountability Office (GAO, 2009, p. 2) rated Africa's air safety record as "poor" while the European Aviation Safety Agency (EASA, 2017, p. 5) rated the safety compliance level of airlines from the continent as "far below" the rest of the world.

While these major international aviation stakeholders are unified in their assessment of

Africa's aviation safety record, the same cannot be said of the reasons behind the dismal statistics. ICAO (2015) posited that the safety challenges facing the African aviation industry stem largely from inconsistencies in the application and enforcement of internationally accepted aviation safety standards, procedures, and practices in the continent. IATA (2016) identified poor regulatory oversight and inadequate safety management as the major causes of the continent's air safety problems. Some aviation experts blame corruption, lack of adequate funding, deficiencies in both human and physical infrastructures, and inadequate training as the reasons behind the challenges facing the continent (Obayiuwana, 2011; Okekeocha, 2013). Irrespective of the causal factors, it is evident from the statistics that Africa's aviation industry is not in a healthy state.

On the human side of it, Daramola (2014) and Fadugba et al. (2015) reported that in the 13 months between October 2005 and October 2006, more than 300 Nigerians, including 71 high school children in one instance, lost their lives to airline accidents. This is at a time when only three domestic airlines were actively flying the country's airspace and serving four major cities (Demuren, 2007; Ibe et al., 2016). Many Nigerian families lost their loved ones or breadwinners in those accidents. Besides the shock and trauma of the losses, it is hard to gauge the subsequent costs and other effects on family members of the deceased passengers (Okigbo, 2012). Li et al. (2015), drawing on their experience from the TransAsia Airways GE222 crash in Taiwan in July of 2014, argued that besides the shock and trauma, air accidents tend to "exaggerate peoples' negative perception" of air safety and the airline industry as a whole.

Thus, aside from the human losses, accidents negatively affect people's perception of the aviation industry and their willingness to use its services (Krivonos, 2007). Deficiencies in aviation safety, or any perception of it, can stunt the growth of the industry and lead to under-performance (Faajir & Zidan, 2016). Such deficiencies can lead to the inability of local operators to compete favorably against their foreign competitors. All these, combined, can negatively impact the size of the industry, especially in Africa, where the industry is small when compared to other regions of the world (Faajir & Zidan, 2016).

To put Africa's aviation size in perspective, Schlumberger (2010) reported that while the continent is inhabited by about 16 percent of the world's population, it is serviced by only 3 percent of all scheduled air service seats in the world. By contrast, he argued, the population of North America and Europe, which if combined, is about the same size as that of Africa, has access to approximately 55 percent of global seat capacity (Schlumberger, 2010).

In terms of available seat kilometers (ASKs), that translates to about 5,083 ASKs for each North American or European citizen. In contrast, each African has access to only 154 ASKs, or 33 times fewer seats (Faajir & Zidan, 2016). Similarly, Latin American and Asian citizens have four times more access to air service than Africans (World Economic Forum, 2015). The World Bank (2017) identified this inequality in global air service distribution as a major contributory factor to Africa's low share of world economic activities and benefits. The report further stated that Africa, though home to 16 percent of the world population, accounts for only 2 percent of global GDP. Improvements in air transportation infrastructure, Faajir and Zidan (2016) argued, can change these statistics for the better, thus facilitating the rapid development of the continent.

In many African countries, deficiencies in transportation infrastructure as a whole are making it difficult and expensive to access places and markets for economic development. In Nigeria, for example, aviation is not the only area facing challenges. Uhunmwuangho and Ekpu (2010) and Ogbuagu et al. (2014) identified decaying infrastructure across all sectors of the transportation industry as a major deficiency facing the country. One area, for example, is road transportation. Nigeria has the largest road network in West Africa and is second only to South

Africa in sub-Saharan Africa (Ali et al., 2015). The latest data from the Central Bank of Nigeria (CBN, 2013) shows that Nigeria has over 200,000 kilometers of surfaced roads. However, they are so poorly maintained that they are often cited as a major reason for the country's high rate of traffic accident fatalities (Anyanwu et al., 1997; World Bank, 2009). The World Health Organization (WHO, 2018) also reported that road traffic accidents are responsible for a quarter of all injury-related deaths in the country.

The state of rail and waterway transport is not in any way better. With little or no investment in them since independence, Nigeria has little to show in either sector (World Bank, 2009; Faajir & Zidan, 2016). However, with an area spanning over 923,000 square kilometers (The Economist, 2015), a population that is approximately 200 million (US Central Intelligence Agency [CIA], 2020), and a burgeoning middle class that has surpassed many economists' predictions (World Bank, 2016), the need for a viable airline industry both as a transportation mode and an "economic enabler" cannot be over-emphasized (Faajir & Zidan, 2016).

Thus, despite the challenges, the demand for air services in Nigeria and across continental Africa has increased steadily over the past decade, with passenger numbers and freight traffic growing by 45 percent and 80 percent, respectively (African Development Bank [AfDB], 2016). The same report (AfDB, 2016) predicts that Africa will, in the next decade, be the third fastest-growing region in the world in terms of international air traffic, forecasting an average growth rate of 6.1 percent for the continent, compared to the global average of 5.8 percent. The Middle East and the Asia Pacific are expected to grow at 7.9 percent and 6.9 percent, respectively. At the same time, the forecast for South America, North America, and Europe is a modest 5.8 percent, 4.9 percent, and 5.0 percent, respectively (AfDB, 2016).

In terms of economic benefits, as in 2016, the aviation industry in Africa has directly created about 7 million jobs, and its collateral effect on travel and tourism is responsible for about USD 67.8 billion of the continent's GDP (AfDB, 2016). Forecasts by the World Bank (2017) and the African Development Bank (AfDB, 2016) indicates that the industry's overall impact on African economies, including that of Nigeria, is set to grow even more significant in the coming years. In yet another report, the World Bank (2015) stated that growth in the middle-class sector in nearly every African country is driving an unprecedented level of demand to move goods, services, and people between markets across the continent. Ohaeri (2012) also reported that by 2040, Africa will be home to one in five of the world's young people and will thus have the world's largest working-age population. Job mobility and air transportation are expected to grow, leading to more urbanization (AfDB, 2016; World Bank, 2017). Some of the new urban cities will have the capability to sustain a hub-and-spoke airline structure and, thus, help in expanding the aviation industry and the economic development of the continent.

Africa, by all these accounts, is on its way to a significant economic breakthrough in the next few decades. Iarossi et al. (2009) identified one of the major obstacles toward achieving that economic prosperity for the continent as that of connecting an estimated one billion people and its market across a landmass that is thrice the size of the United States (CIA, 2020). Expanding air travel is crucial to solving that connection problem (Faajir & Zidan, 2016). However, with jet aircraft accident rate that is 18 times higher than in the Western world (IATA, 2016: ICAO, 2016), there is an urgent need to find a lasting solution to Africa's aviation safety challenges.

Stolzer et al. (2008) identified one of the safety challenges as that posed by human factors. During the past several decades, they posited, about 70-80 percent of aviation accidents have been caused by human errors. This is so, Dekker (2012) argued, because humans, at all levels, interact the most with all the elements of the wider environment that are needed for a safe flight operation. That amount of interaction comes with a price: Human factors, Dismukes et al. (2007) posited, are "directedly linked" to the culture of the environment in which crewmembers live or are part of. That includes power-distance. The purpose of this research, therefore, is to uncover and explain how power-distance among flight crewmembers in Nigeria affect the pattern of communication between them, and the resultant effect, if any, on aviation safety.

Thesis Statement

Culture defines the African people more than anything else, and is present in all aspects of their everyday lives. Power-distance is a crucial part of that culture. Age and seniority are major factors through which power-distance is expressed in Nigeria. High power-distance culture in a society can easily be transferred into the airline cockpit by crewmembers. Such can have a negative effect on the Crew Resource Management process and aviation safety in the country.

Problem Statement

The purpose of this research is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of the Crew Resource Management (CRM) process among Nigerian pilots. The need to uncover how power-distance affects CRM, and thus, flight safety in Nigeria, is crucial because of the culture of unquestioned acquiescence to seniority and age that pervades the country ((Ejimabo, 2013; Ayodele, 2016). Nigeria is a country where loyalty and compliance with superior orders and directives are usually expected and taken for granted, even when such orders are unrealistic or illegal (Omonzejele, 2004). One of the reasons that is most often attributed to this societal attitude is that Nigeria is a paternalistic society (Henry, 2004; Omonzejele, 2004). That paternalism has been further enhanced by the many years of military dictatorship in the country (Frank & Ukpere, 2012; Unaji, 2013).

The culture of deference to people, especially those in position of higher authority, is very pervasive in the Nigerian society (Ekiyor, 2004). Superior officers often make statements or take actions, some of which are ill-informed or wrong, yet it is considered bad manners to question or correct them (Ejimabo, 2013). Doing so is seen as "violating the cultural norm" that holds the society together or trying to dilute societal values (Ekiyor, 2004). Adeyemi-Suenu (2004) also reported that within the Nigerian society, people have their assigned position in the hierarchical order, and stepping out of it is usually discouraged. Most of the time, someone older or of higher rank in the society is considered not only as superior but an authority on virtually everything (Peretomode, 2012). In Africa as a whole, power and authority are, most often, equated with absolute expertise on all subjects (Ejimabo, 2013).

Under such a setting, the elites of the society wield a tremendous amount of power on virtually everything while those at the bottom are powerless even on issues that affect their lives (Henry, 2004). Hofstede (2001) defined this as "power-distance" or the extent to which "lower-ranking individuals of a society accept and expect that power is distributed unequally" between them and their superiors. This definition has tremendous meaning for high-impact industries such as aviation, where an effective one-on-one relationship is crucial to safety management.

Ailon (2008) suggested that, under normal circumstances, "a level-playing field in communication" is a requirement for active engagement with a superior. In emergencies, as can happen in aviation, that becomes even more necessary. A study of jet transport accidents and incidents commissioned by NASA in the 1970s showed that pilot error was most likely "a reflection of team communication and coordination failures" than "any deficiency in pilot technical knowledge or flying skills" (Cooper et al., 1980). Data gathered from the first 28,000 confidential pilot reports received under NASA's Aviation Safety Reporting System (ASRS) after its inception also showed that over 70 percent of the safety infractions reported were related to communication problems within or outside the cockpit environment (Stolzer et al., 2008).

From these reports, it is evident that communication problems were prevalent for a long time in the aviation industry worldwide. However, while there has been a tremendous reversal of that trend in most Western societies (Dismukes et al., 2007), the same cannot be said of many non-Western countries, especially in Africa, where communication problems inside the flight deck is "still a major problem" (Dekker, 2012). Some of those communication problems can be traced to the high power-distance within those societies (Peretomode, 2012).

Krivonos (2007) also observed that unbalanced communication is "usually the first sign" of high power-distance. Inside the pilot crew rooms in Nigeria, it is not uncommon to hear statements such as "The captain is talking!" or "These four bars mean something!" (A. Salami, personal communication, July 28, 2018). These are warning shots or rebukes, usually from the captain, and typically directed at the first officer and other subordinates, warning them not to question the words and authority of the pilot-in-command.

Across the larger society, statements such as "Do you know who I am?" or "Do you think I am your mate?" are not uncommon during a minor argument between people (Enahoro, 1998). Doumbia and Doumbia (2004) reported that across continental Africa, high power-distance, or unequal distribution of power, between a superior and a subordinate is "a way of life." Power-distance, Unaji (2013) also posited, is on display in many areas of life within the Nigerian society, so much that it is considered "a normal way of life."

One such area where power-distance is often and prominently exhibited in Nigeria is individual titles. Titles are a status symbol for the Nigerian elite, so much that it is not unusual to see someone bearing the title of "Doctor" when that person is neither a medical doctor nor an academic doctorate degree holder (Ekiyor, 2004). Enahoro (1998) posited further that in Nigeria, professionals such as engineers and architects typically assign to themselves the titles of *Engr* and *Arch* before their respective names. The main reason for this behavior, Adeyemi-Suenu (2004) added, is that titles "enhances the visibility of those individuals," thus earning them some status, respect, and power within the society.

In the Nigerian political arena, the President and the governors are not addressed as "Mr. President" and "Mr. Governor," respectively, but as "Your Excellency" (Adeyemi-Suenu, 2004). Furthermore, a current or past member of the legislature is not a Congress-man or woman, but an "Honorable." It is a society where almost everyone has a title, and when none can be invented, the person is simply addressed as *Oga* or Boss (Enahoro, 1998). Most often, bearing multiple titles at the same time is a sign of that person's higher status in the society; addressing the person without the titles can potentially lead to bitter engagements (Maluleke, 2012).

For a society that cherishes that type of behavior, it is reasonable to expect that the same ego-worshiping mentality will be rampant among its flight crewmembers. Thus, it is not unusual to see some Nigerian pilots insisting that the title "Capt." be added to their names, even on non-professional-related documents such as travel passports and driver licenses (S. C. Asare, personal communication, April 8, 2019; A. Salami, personal conversation, August 12, 2019). Enahoro (1998) further posited that such egoistic beliefs and behaviors are widespread across the larger Nigerian society.

Thus, it can be argued that in Nigeria, as in many other African countries, power-distance is firmly rooted in the overall culture, so much that it "defines the scope and depth of inter-human relationships" in all spheres of peoples' life (Hofstede, 2001; Doumbia & Doumbia, 2004; Peretomode, 2012). The consequences of that are many. One is the general assumption among the public that superior officers, and other social elites, are entitled to some privileges primarily because they are considered to be above the rest of the public (Peretomode, 2012). Part of that privilege is the expectation of an unquestioned obeisance and loyalty from subordinates. As shown below, under Table 1, Nigeria ranks high on this behavior, measured by Hofstede (2001) as a power-distance index (PDI), when compared to other regions of the world.

Country	PDI Score
Nigeria	**80**
United States of America	40
Germany	35
Australia	36
China	80
Brazil	69

Table 1: Power Distance Ranking of Different Countries (Hofstede, 2001).

Hofstede's work on cross-cultural communication that described the effects of a society's culture on the values of its members, and how those values relate to their behavior can be a valuable reference. His construct of a power-distance index (PDI) represents "a society's level of inequality as defined from below rather than from above" (Jones, 1996). Hofstede defined PDI as the extent to which the "lower-ranking individuals accept and expect that power is distributed unequally" between them and the higher-ranking members of the same society (Hofstede, 2001). In Hofstede's view, people in societies with high power-distance are more likely to conform to a hierarchy where everybody has a place, and which needs no further justification. Within the Nigerian society, everyone has a place, and they are based on the individual's current position within the hierarchy (Doumbia & Doumbia, 2004; Paki & Ebienfa, 2011).

Another prominent manifestation of power-distance is impunity. Unbridled impunity among Nigerian elites exemplifies the extent of power-distance within the larger society. This behavior, Unaji (2013) posited, is a threat to the political, social, and economic growth of the country. In the aviation industry, the consequences of impunity can be significant. Krivonos (2007) has argued that power-distance in the cockpit serves one main purpose: inducing fear in the minds of junior crewmembers. When that happens, instead of being active participants on the flight, the affected junior crewmembers become placid observers with little or no desire to be involved in the safety process (Dismukes et al., 2007).

Under such a situation, not only is the process of threat and error management being compromised, the overall flight safety process can be affected. Instead of healthy two-way communication, the relationship becomes one-way (Krivonos, 2007). The next thing, typically, is "the creation of a disconnect" between the captain and the first officer, at both the professional and personal levels. It is easy to know why: because the junior officers feel that "their inputs are not valued or listened to by their senior colleagues," the next thing is for them to retreat and stop, or minimize, their participation in the process (Jensen, 1995).

Most often, the disconnect goes beyond intra-cockpit communication: It affects the whole concept of threat and error management, "by severing the inter-personal checks and balances that are meant to help in reducing human errors" in flight operations (Krivonos, 2007). In the absence of such inter-personal checks, the chances of making some inputs or judgments that can negatively affect flight safety are much higher (Dismukes et al., 2007).

Thus, it can be argued that hierarchy or power-distance, if not checked, can easily lead to unsavory outcomes for the aviation industry. Because communication is at the heart of power-distance, the communication pattern between a captain and first officer inside the cockpit can have a tremendous effect on the flight's safety process (Dekker, 2012). In Nigeria where the power-distance between superiors and subordinates is high (Hofstede, 2001; Doumbia &

Doumbia, 2004; Peretomode, 2012; Unaji, 2013), its unsavory effect on communication can jeopardize threat and error management, thus creating serious hindrances to an effective implementation of CRM in the country's aviation industry.

This type of problem, whereby communication defects, occasioned by power-distance, was allowed to jeopardize threat and error management on the flight line, has occurred in the past with deadly consequences. On November 13, 1995, a Nigeria Airways B737-200, operating as Flight 357, was involved in an accident at Kaduna Airport in the north-central part of the country. According to the accident report submitted by the country's Accident Investigation Bureau (AIB, 1997), after receiving Air Traffic Control (ATC) clearance to land, the captain commenced a left turn from a heading of 310 degrees to align with the runway heading of 230 degrees. They were still in the turn when they sighted the runway threshold about 1.5 miles to the left of the aircraft. At that point, the first officer suggested that they should continue flying upwind and request permission to land on the opposite runway since neither wind nor traffic were factors; the captain ignored the advice.

The captain also ignored the "watch the wing" warning from the first officer and the call for a "go-around" from the third pilot on the observer seat. Instead, he continued struggling to maintain directional control for runway centerline alignment, finally touching down at the 7,820-foot marker on a 9,840-foot runway (AIB, 1997). The airplane was unable to stop; it overran the runway and hit the ground with its right wing. The resulting fire led to 11 passenger fatalities and 14 serious injuries; the investigators described the captain's actions as "one-man show" and his inter-personal communication skills as "extremely poor" (AIB, 1997).

Also, studies by Edeaghe et al. (2006), Daramola (2014), and Munene (2016) all point to communication problems and CRM deficiencies as significant factors in many airline accidents in Nigeria. In Munene's (2016) study, CRM-related issues constitute 50 percent of the accidents reviewed. In many of the cases, the captain's decision to take-off or land from un-stabilized approaches over the strong concerns or without the acknowledgment of the other crew members led to the accidents. Munene (2016) went on to identify "large disparities in age and seniority" and thus the communication gap between the captain and first officer as "major factors" in almost all cases.

With this report and majority of the other studies on aviation accidents in Nigeria pointing towards communication and CRM deficiencies inside the cockpit as a major factor in many of the aviation accidents, there is an urgent need to address the threat posed by power-distance issues in the country's aviation industry. Unless that is done, the potential for another accident or incident in the future due to power-distance communication challenges will continue to be high. For that reason, a research such as this one, that is directed at understanding this phenomenon through the experience and perspectives of Nigerian pilots, is critical for both the safety of the traveling public and the growth of the industry.

Purpose and Justification for the Study

The purpose of this research is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of CRM among Nigerian pilots. Hofstede (2001) defined power-distance as the extent to which "the lower ranking individuals of a society accept and expect that power is distributed unequally" between them and their superiors. In line with that definition, power-distance can have an effect on aviation safety by virtue of its impact on the way senior and junior flight crewmembers deal with each other inside the cockpit, especially during non-normal situations.

Difficulties in the way flight crewmembers communicate with each other, and the inter-personal relationship between them, are critical factors in multiple accident-reports in many non-Western countries including Nigeria (Daramola, 2014; Munene, 2016). A major reason for that is the fact that in high power-distance societies such as Nigeria, hierarchy is clearly established, and "any attempt to question authority or re-distribute power" is typically resisted by the people (Hofstede, 1997). In such a situation, any attempt at challenging the actions of a flying captain by a monitoring first officer is highly resisted. When that happens, the safety purpose of having a two-person crew in the cockpit is essentially defeated and the chance of an incident or accident occurring is increased.

However, while several authors have cited power-distance as the major reason behind many of the safety challenges facing Nigeria, including its aviation industry (Daramola & Jaja, 2011; Paki & Ebienfa, 2011), there is scarcity of research that are specifically aimed at understanding the enabling role that certain cultural factors such as age and seniority play in the power-distance dynamics in the country. Olakunle (2000) identified a shortage of experienced researchers as one reason for that problem. Fuller (2005) and Gobet (2015) further clarified the difference between an expert and a professional: a professional is trained to do a specific job in a certain way while an expert is adept at analyzing and bringing forth changes and improvement on a subject. In the Nigerian context, West African Airways Corporation, the forerunner to Nigeria Airways, was founded in 1946 (Stroud, 1962). Ever since, the country has produced a large number of professionally rated pilots, air traffic controllers, engineers, and technicians to support its aviation industry (Olakunle, 2000).

While Nigeria has produced many professionals in the field of aviation, the country is still lacking in many areas of aviation expertise. Daramola (2014) sees the scarcity of research publications on aviation safety in the country as only one indication of that problem. The Organization for Economic Co-operation and Development (OECD, 2015) further defines research as the “creative and systematic work undertaken in order to increase the stock of knowledge,” and the use of that knowledge to devise new applications for solving problems. Creswell (2008) also describe research as “a process of steps aimed at increasing our understanding of an issue.” It is the process of beaming light on a subject to discover new or hidden insights (Hayward, 1997).

Researchers are the bearers of that light, and where there is a shortage of their input, a disconnection is created between what is being applied in the field and the knowledge needed to improve it. It is those gaps in the body of knowledge, specifically on the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigeria pilots, that this study aims to fill.

Research Questions

There are two research questions that this study set out to resolve: What are the effects of age and seniority as power-distance factors on the communication pattern between junior and senior pilots in Nigeria? How does the communication pattern between a junior and senior pilot in Nigeria affects the implementation of Crew Resource Management in the country? Finding the answers to these questions will help in better understanding the link between the culture of respect for old age or seniority and communication, and how it impacts aviation safety in the country.

Understanding that link is crucial for many reasons. While commercial airline fatal accidents are still rare events, Dismukes (et al., 2007) have argued that a single accident can result in a large number of deaths, "potentially altering the global fatality rate." Furthermore, the safety decisions and "the piloting skills of stick-and-rudder" that are required to operate an aircraft safely are "seldom isolated from each other" (Kern, 1998). Perrow (1999) clarified the statement further by saying that "the cognitive skills of situational awareness and other mental processes" required by the piloting profession to operate safely "often overlap with each other." Integrating those skills with good safety decisions involves a system that is "grounded on strong team communication and co-operation" - the main objectives behind the creation of CRM (Wiegmann & Shappell, 2003; Dekker, 2012).

While CRM has been widely accepted and has proliferated with airlines and military organizations across the different regions of the world, "the processes and outcomes" have not always been the same across those regions (Kern, 1998). Maurino (2009) identified power-distance in the cockpit as one of the reasons why CRM has not been successful in some regions. Considering that 70 to 80 percent of worldwide aviation accidents are attributable to human factors (Wiegmann & Shappell, 2003), the fact that a dangerous human dynamic such as power-distance exists in the cockpit in some countries, including Nigeria, is frightening. It calls for a study of this nature to uncover and explain the effect that age and seniority have, as enablers of power-distance, on the communication aspect of CRM among flight crewmembers in the country. Doing that involves taking a critical look at the cultural beliefs and ways of the society as a whole. That is crucial because, as Tanase (2015) pointed out, the beliefs and ways of a society are part of the "cultural artifacts" that its members typically carry with them to their individual workplaces.

Also, the main objective of CRM implementation is to minimize the effect of high power-distance and hierarchy among flight crewmembers by "reducing the gaps in intra-cockpit communication between them," and thus enhancing threat and error management (Wiegmann & Shappell, 2003). That goal is particularly necessary for a country like Nigeria, where hierarchical rules derived from the culture of deference to superiors have the potential to make effective communication inside the cockpit a difficult task to achieve. While hierarchy can be identified as "a cause of ineffective communication," an often-ignored aspect of its set of unsavory characteristics is its tendency to exist alongside with bureaucracy (Mandel, 1992). Hierarchy ranks individuals in accordance with their status or authority within the system (Albrow, 1970). That, in turn, leads to the establishment of some bureaucracy to accommodate it (Schwartz, 1996). Bureaucracy, on the other hand, tends to encourage "excessive formalities, procedures, and regulations" (Mandel, 1992), something Kern (1998) described as "opposites" of the open communication concept that is widely recognized as "the bedrock" of the CRM program and process.

While excessive hierarchy in any organization can potentially be an obstacle to future competitive mobility and progress (McDonald, 2003), in the aviation industry, the effect on safety can be immediate and more disastrous. Because hierarchy can affect the way junior people are granted access to their superiors or the right to express their observations and concerns freely, "the combination of two unequal pilots in one cockpit" can adversely affect the nature and manner of their interactions, including their communication patterns and how they respond to non-normal situations (Engle, 2000). Such a scenario can ultimately have a negative effect on threat and error management.

In Nigeria, high power-distance is deeply rooted in peoples' culture (Hofstede, 1997; Doumbia & Doumbia, 2004). Because of that, any attempt to eliminate or reduce it can be challenging. Kwarteng (2012) observed that part of the challenge arises from the fact that high power-distance and hierarchical rules are things that have worked favorably well in keeping African societies “in a disciplined and orderly manner” for centuries. Thus, any attempt at changing something that people believe has served them well over the years can be difficult to achieve. Maurino (2009) viewed this as a portent impediment to CRM implementation and success. That is so because CRM was founded on the Western culture of low power-distance (Engle, 2000); its success is predicated on “even communication” among the crewmembers (Kern, 1998).

However, unlike the Western culture, the communication pattern between people in Africa is “anything but even” (Matondo, 2012). That has some impact on safety across all industries in the continent, especially the high-impact ones such as aviation. Engle (2000) also observed that an impediment to any of the CRM elements can easily compromise its safety layers, thereby impacting aviation safety system-wide. In Nigeria, resolving the safety challenges facing the aviation industry involves taking a critical look at all issues that have the potential to impact it, including human factors such as age and seniority and how they can alter the communication pattern between flight crewmembers.

The need to understand the challenges posed by power-distance factors in aviation and thus be able to stem the safety lapses inherent in them are significant enough to justify a study of this nature. Cousin (2005) had posited that understanding something amounts to defining and exploring it. The choice of case study as a research strategy for exploring the effect of age and seniority on the communication aspect of the CRM process among Nigerian pilots is informed by the desire to have a “detailed, in-depth” understanding of the problem (Creswell, 2013). Aside from contributing to the body of knowledge on the topic, the results generated from this study may help the aviation industry in Nigeria to better understand the nature of the problem and how to effectively deal with it.

Generalization, Bias, and Credibility

Generalizations and Assumptions

There are generalizations in this study that needs to be clarified. For example, Nigeria, West Africa, and the African continent are mentioned inter-changeably as if they are one entity; they are not. While Nigeria accounts for about 60 percent of the population and economy of West Africa (World Bank, 2017) and is thus dominant there, the country does not equate to the whole region. Though many of the people in the region share similar cultural perspectives across national boundaries, including hierarchy and deference to age and seniority - core components of this study, there are language differences between them. Also, while Nigeria is the most populous country in Africa, the languages and culture across the component ethnic groups within the country are not all homogenous. The same applies to other countries within the continent. There are also differences in the national or official languages from one country to the other, mainly because those languages were bequeathed to those countries by the different European powers that governed them during colonial rule. Although the whole sub-Saharan Africa shares similar racial and colonial experiences, the "belief system" is slightly different from one region to the other (Henry, 2004).

Research Bias and Credibility

Bias exists in most qualitative research designs (Creswell, 2003). Also, despite its potential for impacting the credibility and dependability of a study, it is not always easy to identify and eliminate it (Prinz et al., 2011). Mehra (2002) posited that a crucial part of bias arises from the assumption that researchers are not, or should not be, interested in the outcome of their works. For example, Felin and Hesterly (2007), in describing the qualifications of researchers, referred to them as "disinterested contributors to a shared common pool of knowledge." In reality, however, Creswell (2013) captured the opinion of many when he observed that every researcher tends to bring to each study "their own life experiences, ideas, prejudices, and philosophies." Bias, thus argued Mehra (2002) and Creswell (2013), is inherently present in all research. The difference lies in the manner the researcher's prejudices "are accounted for" in the study (Creswell, 2013).

This study is aimed at uncovering and explaining the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots. The author of the study was born and raised in Nigeria; he has called the United States home for the past quarter of a century and is a citizen of both countries. As a Nigerian-born professional pilot, he has a relationship with, and a fair knowledge of, the country's aviation industry and its challenges. Such a relationship come with some privileges: Because the researcher is familiar with the people, culture, and the topic of research by virtue of his birth and career, he is in a better position to understand and expand on what is already known of the communication and CRM challenges among flight crewmembers in Nigeria.

Being an active participant in the aviation industry also aids the researcher in the identification of cases and collection of data for this research. It helps him in the selection of participants and in designing the study format. Such familiarity or "proximity to reality" which the researcher brings to the study "constitute a prerequisite for advanced understanding" of the research issue (Flyvbjerg, 2006). His knowledge of the industry, the personnel involved, and the environment where this research took place (Nigeria) is, to a large extent, a strength and an advantage. That knowledge adds value to his qualifications as a researcher, and puts him in an advantageous position to conduct a research of this nature.

Familiarity also has disadvantages: Relationship can breed prejudice, whereby the researcher arrives at a conclusion long before all facts are established. While it is important to prevent such undue bias, the desire to avoid all indications of bias can equally lead to over-correction or reverse bias - where the researcher avoids some facts mainly because they may point towards what he or she already knows.

For example, the subject of this research itself can potentially lead to bias. The dream of a safe and prosperous aviation industry that can propel Nigeria to greater heights globally is profoundly attractive to this researcher. It will most likely be for all or majority of the participants in the study. That dream calls for national participation and sacrifice, especially by those in the industry. This study, thus, can potentially be leveraged into a patriotic call for action by every Nigerian citizen in the aviation industry. Such a call will likely be well-received by many, if not all, of the participants. In that sense, the potential for bias is already well established in the research topic.

Summary

Culture is a crucial part of Nigerian life, and deference to age and seniority are essential components of it. Culture influences their values, views, desires, and worries, as a group and as individuals (Ogunbado, 2012). The ranking of people above one another based on their age, seniority, or power is a recurring part of the peoples' culture or "the way we do things" in Nigeria.

CRM was introduced to reduce operational errors in aviation by "bridging the gap that exists in the intra-cockpit communication pattern" between junior and senior crewmembers

(Engle, 2000). To achieve that objective of free and unhindered exchange of information inside the cockpit, it was founded on low power-distance. In Nigeria, the ingrained societal culture is that of high power-distance and hierarchy. Age and seniority are two of the major factors through which power-distance is expressed in the Nigerian society. This case study research, thus, is aimed at uncovering and explaining the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots.

CHAPTER 2: LITERATURE REVIEW

Introduction

Many studies have been conducted on the influence of culture and hierarchical rules in aviation accidents in various regions of the world; others have been done specifically on CRM. This study is not intended to duplicate any of those prior studies. Instead, it is meant to expand on them and fill the void that exists in the body of knowledge on a specific area: the effect of age and seniority as power-distance factors on the communication aspect of CRM among Nigerian airline pilots.

This chapter will begin with a review of the existing literature on culture in Africa and how culture is reflected in all aspects of peoples' lives in the continent. It will, thereafter, be narrowed down to the West African region and then specifically to Nigeria. Each of the reviews will be done under different sub-headings in order to give the topics a more comprehensive coverage. For example, "Evolution of Culture" and "National Culture" will each be discussed as stand-alone topics, supported by literature that pertains to them. Doing so will help in providing the reader with a better contextual background on how multiple, and sometimes unrelated, issues breed and sustain power-distance in the Nigerian society.

The discussion will be followed by an analysis of the specific literature on the subject matter (age and seniority) as well as the deficiencies in them that this study aims to fill. Heyman (2004) posited that to make progress in understanding organizational bureaucracy, one needs to observe the internal life of bureaucratic organizations. Therefore, in order to fully understand the effect of power-distance on aviation safety in Nigeria, there will be a review of literature from other parts of the world where cultural influences on pilot behavior and flight safety are also significant and have been widely researched and documented.

Evolution of Culture

The notion that societies and cultures evolve over a long period is, to some extent, self-evident (Emerson, 1983). Because human beings are social creatures, they tend to adapt to their immediate environment, and "in doing so, triggers incremental social changes" that tend to affect everything within it (Lenski, 2005). Most of the time, those changes are gradual; other times, they are not. Further, societies do, at times, create unique cultural characteristics or heroes to serve their immediate needs. One example of that is the emergence of Napoleon Bonaparte. As with many prominent historical figures of his time, the desire for someone that fit Napoleon's characteristics was ripe, and in the words of Emerson (1983), at that particular time in history, "such a man was wanted, and such a man was born." The same thing applies to many aspects of peoples' culture.

Culture, therefore, denotes that "complex network of practices and accumulated knowledge and ideas" that are "transmitted through social interaction," and which exist in most human groups (O'Neil, 2006). In essence, culture is "a social domain that emphasizes the practices, discourses, and material expressions, which, over time, express the continuities and discontinuities of the social meaning of a life held in common by a human group" (James et al., 2015). Anthropologist E. B. Tylor described culture as "that complex whole which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man as a member of society" (Taylor, 1974).

While it is evident that cultures do evolve over time, the expansion of international commerce, mass communication, air transportation, and human population over the past century has led to a more rapid acceleration of the worldwide cultural change, or what Chigbu (2015) referred to as "cultural repositioning" than expected. Those changes, however, come in different forms. O'Neil (2006) posited that even within a single society, "social conflicts, ideological shifts, and technological developments" can produce changes by altering the social dynamics that promote new cultural models within it.

Externally, contact between societies can also have a drastic effect on cultural repositioning. Under such a situation, cultural ideas may be transferred from one society to another, for example, through *diffusion*, “whereby a society’s cultural way of life is freely shared with another society,” or by *acculturation*, in which case “the core traits of one culture are replaced with another, usually by force or coercion” (Casey, 1986). An example of the former is the mutual sharing of modern technology between two societies while the latter is exemplified by the fate of many indigenous cultures after colonization, occupation, or slavery.

In a modern nation-state, cultural meanings can also be altered when that society “adopts or is coerced into accepting transformational beliefs and practices” such as science, rationalism, industry, commerce, and democracy (Panikkar, 2002). There is a long history behind this notion. Marcus Tullius Cicero, the Roman politician and orator, who was one of the first people on record to have used the term “culture,” did so while calling for the cultivation of the philosophical soul or “cultura animi” as “the highest possible ideal for human development” (Cicéron & Bouhier, 1812). Velkley (2002) further defined *cultura animi* as “all the ways in which human beings overcome their original barbarism, and through artifice, become fully human.”

As a background to that definition, in the 19th century, humanists such as English poet and essayist Matthew Arnold had used the word “culture” only in reference to what he termed as “the ideal of individual human refinement, of the best that has been thought and said in the world” (Arnold, 1869). Arnold’s definition of culture is, in many ways, similar to that of an earlier German philosopher, Immanuel Kant: He described his concept of “bildung” as the “pursuit of our total perfection by means of getting to know, on all the matters which most concern us, the best which has been thought and said in the world” (Kant, 1784).

In his treatise, Arnold (1869), also contrasted culture with anarchy. Earlier European thinkers such as Thomas Hobbes and Jean-Jacques Rousseau had defined culture by contrasting it with the prevailing state of nature then, classifying some societies as “less cultured” and “less civilized” than others (Johnston, 1986; Ritter & Bondanella, 1988). Roy (1997, citing Williams, 1983), see these classifications as “a redefinition of culture at a time when culture was associated with elitist activities such as art, classical music, and fine cuisine.” Because these activities were usually part of urban life, culture became another identification for *civilization*, thus giving birth to the concepts of “high” and “low” culture that were prevalent in the society at that time.

Bakhtin (1981) noted that this distinction between people of “high” and “low” cultures that developed in the 18th and early 19th century Europe was “a reflection of the inequalities within European societies at that time.” It can also be described as an expression of the conflict between European ruling elites and the peasants during that period. However, in many of the European-conquered societies, especially in Africa, classifying people as “civilized” and “uncivilized” was interpreted as another example of “the racial contempt” that the European masters were known to express towards their colonial subjects (Lewis, 1998).

Nevertheless, it was that low and high cultural distinction that gave rise to anthropologist Edward Tylor’s theory that, worldwide, all societies tend to pass through three primary stages of development: “from *savagery*, through *barbarism*, to *civilization*” (Bohannan, 1969). That theory redefined culture as a diverse set of developmental activities that is characteristic of all human societies (Lewis, 1998); it paved the way for the modern interpretation of national culture.

National Culture

National culture is one of the main elements that shape pilots’ actions and attitudes in the cockpit. Helmreich (1999) defined national culture as “those characteristics or behavioral patterns that are associated from birth" with people from a particular nationality. Hofstede (1980), on his part, provided a broader definition of national culture: In practical terms, "it is what people do, how they do it, and the way they think based on the beliefs, customs, norms, and traditions that are predominant" in their place of birth or origin.

While these two definitions tend to characterize national culture as a genetic heritage that comes naturally to people by virtue of their birth in a particular country, Zubrzycki (2010) sees it from another perspective: National cultures are "nothing more than interventions and enactments created and instantiated in material objects and patriotic symbols," with the primary objective of forging national identity and cohesion among the peoples of modern nation-states. This view coincides with that of Sidanius and Petrocik (2000), which calls for a clearer distinction between national identities and ethnic allegiances, especially in "a modern pluralist nation-state."

People and Bailey (2017) had characterized ethnic culture as "more demonstrative" of an inherited trait or way of life that is characteristic of a group's ethnic place of origin than national culture. Their perspective is similar to that of Omi and Winant (1986), who had earlier defined membership of ethnic culture as that which is defined by "a shared ancestry, history, homeland, language, dressing code, mythology or ritual, cuisine, and physical appearances." While these characteristics are true of most societies, Engle (2000) opined that because culture is composed "of interconnected hidden rules with multiple means of application," the defining modules tend to change from one area to the other and from one time to another. In Africa, for example, multi-ethnicity within an artificially-drawn national boundary is a common scenario (Bwisa & Ndolo, 2011); most often, people in those countries define themselves and are defined, by their ethnic cultures and characteristics rather than by their assigned nationalities.

For pilots, national culture has a critical influence on how they communicate with each other, how juniors relate to their seniors, and “how safety and operational information are shared amongst them” (Helmreich, 1999). Culture, Helmreich further opined, shapes pilots’ attitudes “about personal capabilities and ego, their adherence to operating procedures, and their use of automation.” Helmreich and Merritt (1998) listed those aspects of Hofstede’s cultural dimension that have applications in the aviation industry to include power-distance, individualism-collectivism, and uncertainty-avoidance.

Power-distance is defined as a reflection of “the willingness by the lower members of a society to accept their unequal status without question and defer to senior members of the group,” or their “unwillingness to question the decisions or actions of superiors, especially if they are inappropriate or wrong” (Hofstede, 1980). Collectivists, Hofstede posited, tend to “put more emphasis on the group’s overall objective rather than the self or individual beliefs,” making them “more likely to seek supervisory guidance” than individualists. Finally, pilots who are high in uncertainty-avoidance also tend “to take rules and orders from their superiors as sacred laws that should not be broken,” even if the interest of safety dictates otherwise (Hofstede, 1980).

Thus, for pilots, national culture is defining in many ways. However, culture itself, as observed from the different definitions above, defies a single universal characterization and understanding. With such differences in the definition and understanding of what constitutes culture as well as wide variation in its adoption and practices from one society to the other, it is not unexpected that the task of marketing a product such as CRM that aims to change a group’s cultural perspectives, using another group’s cultural ways, will be challenging.

Hofstede’s Cultural Dimensions

Hofstede’s (1980) original study on cultural dimensions around the world identified four models: Power-Distance, Individualism-Collectivism, Uncertainty-Avoidance, and Masculinity-

Femininity, which he used in distinguishing culture in different countries. The purpose of this research is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of CRM among Nigerian pilots. Hofstede (2001) identified national culture as the "enabling factor" behind power-distance among the people of many countries. Within the Nigerian culture, age and seniority are the main enablers of the power-distance phenomenon. Therefore, Hofstede's perspectives on the power-distance cultural dimension form a part of this research.

However, while Hofstede's work has been influential worldwide and is indeed applicable to many countries, there are some observed shortcomings in his study that have prompted some scholars to argue against its wholesome adoption as a valid and reliable model for all societies. One of the main arguments by Hofstede's critics is that his cultural dimensions study was based on the feedback from the middle-class cadre of a single global company, IBM. Sondergaard (1994) and McSweeney (2002) both argued that a single entity, however large it may be, can neither "be representative of the nature and depth" of any country's national culture nor does culture alone equate with nations.

Hofstede (2002) countered that his use of a single international employer has served "in eliminating the effect of corporate policies and management practices" from different companies that can influence employee behaviors in different ways, leaving only national culture to explain the observed differences. Williamson (2002) joined in the discourse with an opinion that national and work-related cultures are "not dependent variables," arguing further that factors such as "institutional influences, social structures, and economic situations" may have a more direct effect on peoples' cultures than are recognized in Hofstede's study.

Furthermore, Hofstede's (2001) study only measured power-distance in terms of the relationship between a boss and subordinate. Even though many of the measured countries, especially those in Africa, are products of Western conquer, domination, and colonization, the model did not consider any of those factors as a possible explanation for the subdued behavior of the local employee before the boss, especially where the boss is of foreign descent, belong to a different race or different gender. Considering the fact that racial and gender inequalities were living subjects then, as they still are in many parts of the world, the purpose of the study may have been better served if it had taken into account at least the race and gender of the superior person as against the subordinate staff. These are factors that can substantially influence the way people behave and relate with each other. They can also impact the results of the study.

Ailon (2008) has suggested that Hofstede's power-distance study primarily served the concerns of those who "needed to do comparative analysis" and thus created it by "coercing a culturally distinct axis of comparison" on a variety of employees. Considering the design of the research, as well as the fact that the study relied mainly on a Western perspective to probe the culture of non-Western societies, there is certainly some truth to Ailon's assessment. Maybe the result could have been different if the surveyed group had worked for a local entity rather than a multi-national corporation such as IBM. Furthermore, inequality can manifest itself in different areas and across different sections of a single society. In some countries, the power-distance may arise from the privilege of birth into a particular family lineage, race, or gender; in others, it may be measured in terms of "material wealth or social status" (Henry, 2004). Hofstede's work did not take any of these into consideration. As Elendu (2012) observed, the main advantage of Hofstede's PDI is "in observing and acknowledging that hierarchy does exist" in different cultures; it does not explain the reason why they exist.

One other limitation of Hofstede's study is language translations. Ulijin and Campbell

(2001) posited that “a single word can produce different meanings” in different cultures. This statement is more so in many African countries, especially Nigeria, that has multitudes of linguistic groups. Fletcher (2006) also observed that “different languages have different patterns of discourse,” a confirmation of an earlier assertion by Ulijin and Campbell (2001) that simple translation from other languages is not sufficient for a study of the magnitude that Hofstede did. That is primarily because “patterns of communication behavior are not all rooted in a society’s verbal language,” but also in other non-verbal signs, arts, and complexities. Elendu (2012) argued further that this is important because, in many societies, languages and cultural beliefs “are highly correlated due to their wide cross-cultural interactions,” the same way that linguistic similarity is typically taken as a sign of close cultural affinity between two groups.

In Nigeria, some of Hofstede’s assertions, especially on the uncertainty-avoidance and feminine-masculine constructs, have been severally questioned. Contrary to Hofstede’s (2001) description of Nigerian masculinity, Akintayo (2014) posited that while group cohesions do exist that foster strong loyalties among its members, Nigerian managers are not known to emphasize equity. He also observed that nowhere in Nigeria is conflicts resolved by “fighting them out because of power-distance resulting in negative implications for the disadvantaged party.” Further, punctuality is not a strong attribute of the Nigerian elite (Nwosu & Ugwuerua, 2015). If anything, the elites in Nigeria are known “to display and promote” the use of status symbols as a way of distinguishing themselves from the lower members of the society (Elendu, 2012). For example, showing up at functions after the lower members of the society are already seated and waiting is a typical way of showcasing the superior status of Nigeria’s upper class (Unaji, 2013; Nwosu & Ugwuerua, 2015). All these are contrary to Hofstede’s (2001) assertions.

Another problem with Hofstede’s (1980) original model is that it is based on the assumption that each country's domestic population "is a homogenous entity" (Jones, 2007); this is not so in many African countries, particularly Nigeria. Hofstede's critics have often challenged this assumption, arguing that many countries are made up of several different ethnic groups. As such, they cannot be portrayed based on the features of one surveyed dominant group while ignoring the many minority groups in its midst (Sondergaard, 1994; McSweeney, 2002; Williamson, 2002). Nigeria, for example, is made up of about 300 ethnic and linguistic groups (Nwankwo, 2015; Canci & Odukoya, 2016), and the minority groups, if combined, is about 40 percent of the country's population (Jega, 2000; World Bank, 2016). Treating the whole country as a single entity, without considering the differences in the component ethnic cultures, can lead to errors in the study.

Hofstede's response to these criticisms was to point out that his "theoretical constructs" are guidelines and not absolutes (Hofstede, 2002). As such, there are bound to be differences from one country to another. In his support, Gladwell (2008) argued that Hofstede was not claiming that "a cultural classification based on any of his dimensions was an iron-clad predictor" of how someone from any of those countries will behave. Rather, he clarified Hofstede's point further by asserting that every human being has a distinct personality, but "overlaid on top of that are tendencies and assumptions and reflexes handed down to us by the history of the community we grew up in, and those differences are extraordinarily specific" (Gladwell, 2008).

Nevertheless, despite the numerous criticisms and other observed shortcomings in Hofstede's work, Sondergaard (1994) has acknowledged that his research findings on power-distance confirmed Hofstede's predictions. Also, to confirm the early results from the IBM study, and to extend them to a variety of populations, six subsequent cross-national studies were conducted between 1990 and 2002. The samples included commercial airline pilots, students, civil service managers, upper-market consumers, and elites (Minkov, 2007). The combined research established value scores on the four dimensions for a total of 76 countries, which was later extended to 93. Minkov (2007) posited that the results were "strikingly similar to Hofstede's." Sondergaard (1994), Lonner and Berry (1998), and Sivakumar and Nakata (2001) all agreed on one thing: Hofstede's original work is, without question, the most influential study on national culture to date. It is also the most cited as in 2015, both in the Web of Science Database and in Google Scholar (Newbury, 2015).

Influence of Culture in Nigeria

Human beings are constructs of their culture (Zubrzycki, 2010). Culture provides them not only identity and direction but their "daily expressions and future aspirations" (Abdul-Raheem, 1996). From a broader perspective, United Nations Educational, Scientific, and Cultural Organization (UNESCO, 1994) defines culture as "the whole complex of distinctive spiritual, material, intellectual, and emotional features that characterize a society or social group." In Africa, a society's culture is reflected in, and easily recognized from, its language and the names of its inhabitants (Doumbia & Doumbia, 2004). A name bears the totality of the bearer's identity throughout the journey of life: they are designed to tell the story of the bearer and their distant ancestors (Elendu, 2012). Doumbia and Doumbia (2004) posited that in Africa, proper names "should be able to look into the future and predict positive things for the bearer." Anything other than that is considered a calamity, for the bearer and the whole community (Maluleke, 2012).

Just like the African name, culture has its unique meanings, and it also starts from birth, developing, and refining its characteristic expressions along the way. Along with name, language is an integral part of that journey (Madzingira, 2001). Doumbia and Doumbia (2004) posited that the two elements represent "the foundation of a person's cultural heritage," identity, and future personality. Madzingira (2001) further observed that this belief system explains the African position that culture is best imbibed if learned through its language. It is through its mode of expression that a "society's ways of life, beliefs, learning modules, aspirations, and family organization" can be fully experienced (Ololube et al., 2015); it is also through the experience of its language that its rich diversity can be adequately expressed (Nwankwo, 2015).

Within Africa itself, culture varies from one region to the other; it is usually a combination of the unique history and characteristics of each clan, tribe, or ethnic group that serves as the basis for the ways of life of that group (Elendu, 2012). While the continent is diverse because of the differences in languages and customs across and within each country, certain segments of its culture are very similar. In West Africa, for example, "respect and deference to senior members of the society" is universal across the region and is often imbibed right from childhood (Deba, 2005). To support that claim, Ololube et al. (2015) posited that "the degree of respect Nigerians show to authority is rooted in the culture they are raised in." They added that culture, like most things, is seldom formally taught to anyone, but rather, is silently absorbed. Children start by learning from their elders how much deference they should give to an older sibling, a parent, or a teacher (Deba, 2005). Later, in life and career, the same perspective dictates how they view relationships with their bosses, peers, and subordinates (Elendu, 2012).

Nigeria's Aviation Industry

The introduction of aviation as a transportation model in the early 1900s marked a huge technological leap for humankind. It provided enormous opportunities for the mass movement of people and goods across nations, far and near. A major advantage of aviation is that unlike ships, “airplanes are not limited to the availability of oceans and seas” to navigate through (Munby, 1968). Also, compared to road and rail transport systems, air travel is not constrained by the presence of mountains and oceans. In Africa, as in other parts of the world, aviation paved the way for interconnecting people at a scale and speed never seen before. More than any other transportation module, air transport has contributed to the overall socio-economic development of African nations “by providing a fast, reliable, and safe means of conveyance of persons, goods, and services” (Filani, 1986; Hassan, 2007).

The first airplane to land in Nigeria was from the British Royal Air Force squadron stationed in Helwan, Egypt. On November 1, 1925, “it did a technical stop on a polo strip in Maiduguri,” north-eastern Nigeria, on its way to the northern city of Kano, under “the command of then Squadron Leader Arthur Coningham” (Orange, 1992). That flight, argued Bamigboye (2000), opened Nigeria to aviation and led to the introduction of aircraft navigation and landing facilities throughout the country.

In the mid-1940s, when air transportation formally started as a commercial venture in Nigeria, it was strictly regulated. Due to the substantial economic investment and the safety processes necessary to sustain it, the government took upon itself the task of regulating the industry and acquiring ownership of the airports and the national airline. That process left no room for any private participation in the industry (Hassan & Dina, 2015). The result was that for almost half a century, the government was “the regulator, the business owner, and the service provider” in the Nigerian aviation industry (Hassan, 2007). Oghojafor and Alaneme (2014) observed that the government-owned airline, Nigeria Airways, was the face of the whole aviation industry for that period until the era of deregulation that started in the early 1990s.

The deregulation of the Nigerian airline industry not only opened up the market for competition, it led to the opening of "more routes, lower prices, better service, and more value for consumers' money" (Bamigboye, 2000). Deregulation broke the monopoly of Nigeria Airways in the country, opened the industry for mass participation, and brought to light "the inadequacy of a centrally-controlled economic entity in meeting the challenges of modern commerce" (Ogbeidi, 2006). Hassan and Dina (2015) summarized some of the advantages of airline deregulation to include the following:

(1) Wealth creation: Public participation in the industry has led to more economic activities and the generation of economic benefits for the investors, employees, and government. It also led to the creation of more job opportunities for Nigerian citizens.

(2) Infrastructural development: Deregulation led to more investment in physical, technological, and human infrastructures, all of which are of immense benefit to the Nigerian public. Those investments help in freeing the government to concentrate its resources on the other pressing sectors of the economy.

(3) Consumer gains: The competition among private airline operators to attract and retain customers led to more efficiency, which in turn led to lower ticket prices, more routes, better connectivity, and improved services to air travelers.

These are tangible benefits for the Nigerian people. They justify air transportation as an industry that "connects people, countries, and cultures, and whose economic and social benefits to the world are unprecedented" (IATA, 2014). However, according to Kern (1998), those gains can only be sustained and improved upon if the safety regimen that underpins aviation success is "expertly and diligently applied." From that perspective, air safety should be viewed not only in terms of safeguarding the lives of the traveling public but also in ensuring that public confidence in air travel is "sustained and protected through a rigorous safety culture" (Wiegmann &

Shappell, 2003).

Safety culture is a reflection of the beliefs, values, and perceptions that people have or "share in relation to risks within an organization" (Glendon et al., 2006). In practical terms, safety culture reflects how people and groups identify and interact with each other, and how they view the institution, organization, or community they work or live in. Cooper and Findley (2013) posited that whether it is a workplace, school, or community, safety culture is a part of organizational culture, and it is typically influenced by the national culture of the people in that environment.

Aside from binding us together as members of groups, culture "influences the values, beliefs, and behaviors that we share with other members of groups" (Helmreich, 1999). Also, while organizational cultures can be created and amended to suit a particular purpose, national cultures are more resistant to change, mainly because they surround an individual from birth. Within the context of the aviation industry, all three cultures (national, organizational, and professional) are "of importance in the cockpit because they influence critical behaviors," such as stress, personal capabilities, and the relationship between junior and senior crewmembers (Helmreich, 1999). However, while all cultures are crucial in shaping and defining the individual and group, it is typically the national culture of a people that influence its organizational culture, which in turn, lays the foundation for an effective safety management system in that organization (Shenkar, 2001; Stolzer & Goglia, 2016).

Safety Culture

The Concept of Error

Actions are termed erroneous if they unintentionally fail to achieve their intended goal when the potential for successful outcomes exists (Reason, 1990). It is a deviation from intention or expectation and an indication that "something has been done that was not intended by the actor; not desired by a set of rules or an external observer" (Senders & Moray, 1991). Gelfand et al. (2011) classified errors as the outcomes of unintended deviations "from set objectives and standards," while violations are the products of intentional deviations.

Errors will always appear in human actions because of the way the human mind works (Gigerenzer & Todd, 1999; Kahneman & Klein, 2009). Reason (1990) also affirmed that those who commit errors do not do so in a vacuum, and that human errors can still occur even with the best of intentions. The reason, Strauch (2004) posited, is because "other mitigating factors, or antecedents," can and do, adversely influence an actor's actions. Because of the vast magnitude of these antecedents, combined with the limitations in human capabilities, "a majority of aviation accidents are, in one form or the other, attributable to human error or errors" (Wiegmann & Shappell, 2003). In Africa, many of the human error accidents in the aviation industry are caused by CRM deficits occasioned by power-distance among the crewmembers (Munene, 2016).

Aside from aviation, errors happen in other industries too (Strauch, 2004). Cook et al (1998) gave the example of a hospital environment where doctors and nurses function in a very hectic and stressful state. They posited that during emergencies in hospitals, communication errors are common, and they can easily lead to fatalities. Nevertheless, because those errors and the resultant fatalities in health care delivery usually affect only one individual at a time, they are typically not very visible or dramatic. In the aviation industry however, the opposite is the case: a single accident in a remote location is capable of captivating the whole world for some time (Wiegmann & Shappell, 2003). Most often and ironically, "such widespread publicity is what ultimately provides the needed impetus" for radical improvements and changes to the system (Strauch, 2004).

While accidents typically represent places within a system in which failure has occurred, the greatest challenge for operators is in recognizing "which of the focal points represent the more urgent threat" and, therefore, immediate resolution (Kern, 1998). In the absence of any guide in that direction, Reason (1990) went on to posit that most often in a complex system, latent errors tend to pose the greatest threat to safety "mainly because they are often unrecognized for a long time," despite the fact that they can easily metamorphose into different types of active errors.

It is mainly because of that mistake that for a long time in the aviation industry, the typical response to errors was to focus on active factors while ignoring the latent ones. The desire to turn away from that direction is what informs the current attention being given to latent factors such as the inter-relationship between humans, tools, technology, and the environments in which they operate (Kern, 1998). It is that shift that informs the current emphasis being given to topics such as power-distance in certain cultures. It informs the need for a research of this nature that is aimed at uncovering and explaining the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots.

Error Management

Accidents rarely happen as a result of a single event. Most often, they arise from a chain of unusual events occurring "either separately or concurrently" (Helmreich et al., 1999). That happened on July 23, 1983, when Air Canada Flight 143, a B767-200 operating a domestic flight from Montreal to Edmonton, ran out of fuel at an altitude of 41,000 feet (Transport Canada Accident Report T22-64, 1985). The crew succeeded in gliding the aircraft, later nicknamed "Gimli Glider," safely to an emergency landing at a former Royal Canadian Air Force base in Gimli, Manitoba. According to the report, a combination of factors led to the accident, namely:

maintenance issue (inoperative fuel gauges), corporate failure (non-assignment of a responsible person for fuel load verification), and human error (calculating fuel in pounds instead of kilograms). A combination of all of these events in a single day led to the aircraft being fueled with insufficient fuel for the flight (Transport Canada Accident Report T22-64, 1985).

Airplanes are allowed to carry open maintenance items for a specified period before they are fixed. This is designed to allow for continuity, especially when such items are not overtly critical for the safety of flight or if there are redundant means of assuring their functions. Mistakes can be made in converting fuel loads from metric to non-metric units, but constructive communication between the ground and flight crew are effective ways of detecting the mistake. In cases of fuel leakage inflight, a functional fuel gauge should alert vigilant pilots to the situation. Therefore, in retrospect, if just one of the events - maintenance, corporate or human, that coincided on that day had not happened, or had been mitigated, the accident might have been averted.

In his original work on the cumulative act effect, or what has become popularly known as the Swiss cheese model (Figure 1), Reason (1990) likened a human system to “multiple slices of Swiss cheese, stacked side by side,” in which the risk of a threat becoming a reality is mitigated by the different types of defenses set behind each slice of cheese.

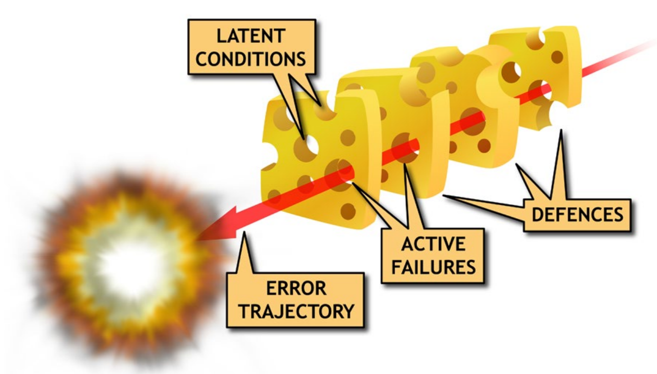

Figure 1: The Swiss cheese model. *Adapted from Reason (1990).*

The model indicates that, theoretically, lapses and weaknesses in one defense should not be sufficient for a risk to materialize, since other defenses are there to mitigate the failure of one or two weak defenses. It typically takes more than one failure to cause an accident; most often, multiple factors are involved. Reason, thus, opined that most accidents happen "as a result of the interconnections between one or more of the four main domains: organizational influences, supervision, preconditions, and the specific acts of error" (Reason, 1990).

From the Swiss cheese model, there were both *active* and *latent* pre-failure conditions in the Air Canada Flight 143 accident. The active failures are the unsafe acts that can directly be linked to the accident, such as the lifting of less fuel than planned. Latent failures include the contributory factors that may lie dormant for days, weeks or even months before they contribute to an accident. They include the inoperative fuel gauges, the use of metric and non-metric fueling systems at different locations, and the absence of a system or checklist for verifying fuel uploads, especially at foreign stations where differences in languages and procedures can be other contributing factors. For as long as those latent factors remain in place, the chance of the active failure happening and thus leading to another accident is very high, irrespective of the skill level of the operating crew. In the case of Nigeria, power-distance is a latent factor in its aviation industry; it has the potential of escalating into an incident or accident if it is not mitigated.

With this understanding of the Swiss cheese model, Helmreich et al (1999) went on to identify the error process as a *troika* of avoidance or prevention, detection or trapping, and mitigation or management (Figure 2). Error prevention, they posited, involves an adequate analysis of the inherent risks, the development of a long-term anticipatory plan of intention and action, and the avoidance of wrong actions. If an error cannot be avoided, then it must be detected as early as possible. Detecting it in a timely manner means that the actor must expect that an error could occur and be prepare for it. The next step is that of mitigating it (Gelfand et al., 2011). As the industry gained more knowledge of the reasons behind errors, human factors, including power-distance relationships, started to gain prominence in the error discourse. The desire to avoid all errors and, where that is impossible, to be able to trap and mitigate their effect, is the main reason behind the introduction of safety programs in the aviation industry.

Figure 2: The Error *Troika* (Courtesy of Helmreich et al., 1999).

Evolution of Aviation Safety

Safety has one single objective: protection from errors, harm, or danger (Helmreich & Merritt, 2000). Dekker and Woods (2010) defined safety in terms of “the potential frequency and severity of harm” that is associated with a particular activity. Others such as Hallowell (2010) see it as nothing more than the relative difference in the level of risk of an organization. Bennett and Summers (1996) describe safety as “a process of risk reduction,” while Lanzilotta and Sheridan (2005) sees it as “the minimization of risks.” While the definition of safety varies from one commentator to another, the majority opinion is that absolute safety is non-existent in any industry (Hallowell, 2010). That means that an activity, organization, or industry can be classified as safe or unsafe only in relative terms.

While safety has been an integral part of aviation since its inception, the history and processes are not the same from one country to another. In the United States, for example, the role of the federal government in aviation safety began not as a regulator, but as an industry operator. From 1918, the U.S. Air Mail Service served an extensive route system in the U.S., "using government-owned airplanes and government-employed pilots for its operation" (Commons, 1978). To safeguard its economic interest in the new industry, the government implemented an array of safety programs, including strict criteria for selecting pilots, intense aircraft inspections, and regular powerplant and airframe overhauls (Bennett & Summers, 1996). Preston (1998) wrote that while the financial cost of the safety regimen was huge, the benefits were immediately apparent: the fatality rate for Air Mail Service pilots between 1922 and 1925 was 1 per 789,000 miles flown; for the itinerant commercial pilots, it was 1 per 13,500 miles.

The high level of safety attained by the Air Mail Service within that period prompted industry leaders in the U.S. to start agitating for government involvement in safety oversight (Jamieson, 2001). Prominent among their pleas are claims that the public is "likely to suffer from badly engineered, badly built or badly repaired aircraft" and that "fatal accidents may occur to people carried in airplanes by inexperienced pilots using aircraft that have not been inspected." These insider calls and the need to develop the industry led the U.S. government to pass the Air Commerce Act of 1926, which established the Aeronautics Branch of the Department of Commerce as a regulatory agency (Jamieson, 2001).

In Africa, the story was a completely different one. African countries started gaining independence from their European colonial masters in the late 1950s. It was after independence that they started developing their aviation industries by way of national airlines. MacKenzie (2002) noted that most of the post-independent African aviation infrastructures, including the safety and regulatory processes, were copied directly from their colonial masters. In West Africa, the influence of the European governments on their former colonies is evident from the structure of the region's emergent national airlines. The British government was instrumental in establishing the West African Airways Corporation (WAAC) in 1946 that encompasses its former colonies of Nigeria, Ghana, Sierra Leone, and The Gambia (Stroud, 1962). The French, on the other hand, overwhelmingly backed the establishment of Air Afrique in 1961 to cater to the interest of the Francophone countries in the region (MacKenzie, 2002).

West African Airways Corporation (WAAC) was dissolved in September 1958 after all the shareholder countries except Nigeria decided to establish their national carriers (Stroud, 1962). As the sole remaining major stockholder of the airline, the government of Nigeria continued to run the operation as WAAC Nigeria. It was re-branded as Nigeria Airways and made the country's flag carrier in October 1958 (Guttery, 1998; Akpoghomeh, 1999). Hassan and Dina (2015) posited that for three decades after that, the airline was the face of the aviation industry in the country. Nigeria's perception of aviation safety culture was limited to what happened within the operations of Nigeria Airways. That period also marked when safety culture began to emerge globally as a crucial aspect of error management infrastructure in high-consequence industries, including aviation. In spite of that early start, in Nigeria, national culture and safety culture are still misaligned due to power-distance relationships.

Safety as a Culture

On April 26, 1986, a catastrophic nuclear accident happened at the Chernobyl Nuclear Power Plant in the then Ukrainian Soviet Socialist Republic of the then Union of Soviet Socialist

Republics. The Chernobyl accident was one of the most disastrous nuclear power accidents in history. A post-Chernobyl accident review meeting was held in Vienna, Austria, in August of the same year; its summary report was the first document ever to use the term “safety culture” (International Atomic Energy Agency [IAEA], 1986). The report went on to describe safety culture as the “assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.”

Since then, several experts and researchers have published broader definitions of safety culture. Patankar and Sabin (2010) call it a “dynamically-balanced, adaptable state resulting from the configuration of values, leadership strategies, and attitudes that collectively impact safety performance at the individual, group, and enterprise level.” It has also been described as the way an organization or individual behaves when no one else is watching (Hendershot, 2012). Safety culture is, in basic terms, “the end-product of a shared sense of norms, beliefs, attitudes, artifacts, and values across an organization” (Mould, 2000), or, in a nutshell, what Pronovost et al. (2009) plainly referred to as ‘‘the way we do things around here.”

Thus, while the concept of “safety culture” originally arose from a major organizational accident, it is now being used in describing the extent to which safety considerations influence high-level decision-making and management actions in workplaces. Gadd and Collins (2002) posited that “with each accident, our knowledge base of accidents’ pre-disposing factors increases tremendously.” Along the way, it is becoming more apparent that the failures that precipitate an accident do not always originate from individual crew error, technological vulnerability, or environmental factor. Most often, it is “the overall ingrained organizational policies, procedures, and standards prevailing in an organization,” in some cases, “over a long period," that predates and precipitate the catastrophe (Dismukes et al., 2007).

Also, the way safety is perceived, valued, and prioritized in an organization is usually a reflection of "the real commitment to safety at all levels in that organization" (Cooper & Findley, 2013). From a stricter perspective, an organization's safety culture "is not mere statements of objectives," but a product of the combined efforts of "the organization's internal culture, its professional culture, and the national culture" where it operates (Yule, 2003). In Nigeria and many African countries, power-distance relationships continue to hinder the process of aligning the professional and national culture of its members to achieve a stronger safety culture.

In the U.S. however, safety culture has progressed in stages over the past one hundred years. Kelly (2013) reported that in the first half of the past century, during the technological age, the focus of aviation safety was aircraft reliability. Over the years, however, technological advancement in aircraft engines and maintenance has increased the level of reliability and safety beyond what was previously imagined (Strauch, 2004). While this has led to a decrease in aviation accidents, it has also led to the discovery of another critical factor in the safety paradigm: human factors, or what Geller (2004) referred to as "behavioral-based factors." Lercel (2013) wrote that while the technological age was outcome-focused "with a complete emphasis on equipment and its past performance," the human factors age is antecedent-driven, given its focus on personnel and how their thoughts and actions can affect present and future air safety.

This emphasis on human factors has evolved into a new concept that focuses more on the "big picture" mentality, whereby accidents are seen not merely as individual human errors, but as organizational issues that have multiple layers, some of which are outside the confines of the aircraft cockpit (Dismukes et al., 2007). Because of that, safety has evolved into a process that requires a systematic approach to cultivate and nurture it at the individual and organizational levels. This new process is called Safety Management System (SMS) and its focus is on implementing safety goals, policies, practices, and sound organizational performance (Figure 3).

Figure 3: The evolution of safety thinking (ICAO, 2009).

The definition of safety has consequently changed from the “absence of accidents” to the “absence of existing conditions that harbor or promote avoidable risks” (Stolzer et al., 2008). Power-distance relationships among pilots is an “existing condition” that has the potential of harming aviation safety. In Nigeria and many African countries where the power-distance between members of the society is significant, the possibility that such behaviors can play a role in promoting “avoidable risks” in the cockpit, if not mitigated, is alarming.

Crew Resource Management (CRM)

In the Beginning:

Mistakes do happen in every industry, some with more damaging consequences than others. In the early 1900s, errors were widespread in the medical field worldwide, and often, miscommunication had a lot to do with it (Dekker & Woods, 2010). To reduce the communication errors, industrial engineers Frank and Lillian Gilbreth developed the concept of “call-back” when communicating in the operating rooms (George, 1968). Based on the call-back concept, if a surgeon called for a “scalpel,” the nurse would repeat “scalpel” before handing it over, as a way of verifying the two-way communication. Also, “speaking out loudly reinforces the request,” and “provides the surgeon with an opportunity to make a correction” if the request was for the wrong tool (Dekker & Woods, 2010). Thus, was born the “challenge-response” communication system that is now used globally in the aviation industry.

Worldwide, pilots are required to read back instructions or clearances given to them by the Air Traffic Controller (ATC) as a confirmation that they have received the right instructions. Dismukes et al. (2007) observed that, as in the surgeon’s operating room, reading back the clearance “advances the safety process by giving ATC an opportunity to correct any information that may have been wrongly transmitted” or misunderstood. Gelfand et al. (2011) noted that these measures are crucial as, over the years, communication has emerged as the most vulnerable aspect of human activity where mistakes or errors can easily lead to deadly consequences.

Communication errors in this context, Dekker and Woods (2010) posited, refers to “a wide range of lapses” that can be caused by language barriers, cultural inhibitions, or physical challenges. The link between them and accidents become significant when one considers the fact that in the past half-century, human error has been implicated as a major factor in about “70 to 80 percent” of aviation accidents worldwide (O’Hare et al., 1994; Wiegmann & Shappell, 1999). Of that number, communication errors form a significant part of it (Gelfand et al., 2011). This is significant, considering that these are data from combined Western and non-Western societies. For high power-distance societies such as Nigeria, the combination of unmitigated communication errors alongside communication lapses caused by power-distance between the captain and first officer in the cockpit can ultimately lead to a major disaster.

From Accident to CRM

On December 28, 1978, a United Airlines DC-8, operated as Flight 173, crashed a few miles from its destination of Portland, Oregon. The cause was fuel exhaustion, though the airplane had departed Denver, Colorado, with 46,700 pounds of fuel, more than double its planned trip fuel. The National Transportation Safety Board (NTSB) investigation revealed that "when the landing gear was lowered for landing, a loud thump was heard, accompanied by abnormal vibration and yaw of the aircraft." The right main landing gear retract cylinder assembly had failed due to corrosion, making the right gear to free-fall. Though it was down and locked, the rapid and abnormal free-fall of the gear damaged one micro-switch so severely that it failed to complete the circuit to the cockpit green light, which normally indicates to the crew that the gear is "down and locked" (National Transportation Safety Board-AAR-79-7).

As per the airline's procedures, the pilot, Capt. Malburn McBroom, abandoned the approach and went into a holding pattern in order to have time to resolve the problem (NTSB-AAR-79-7). Because there was no problem with the landing gear to start with, the crew found none after many attempts at running the checklist. In spite of that result, the captain was preoccupied with the situation so much that he forgot to monitor his fuel situation. The first officer and the flight engineer both tried to give subtle hints of the fuel status to the captain, but neither of them was firm enough in their declarations. The airplane ran out of fuel in one of its holding circuits and crashed into a neighborhood, killing 10 out of the 189 passengers and crew on board (NTSB-AAR-79-7; Syed, 2015).

While the accident took the lives of 10 people and led to a tragic ending for Capt. McBroom's career, it also became the moment the airline operators and regulators came to the realization that human factor issues are becoming a significant part of the industry's safety challenges and that in order to improve its record, it needs to change its safety culture for the better. Dismukes et al. (2007) noted that "many pilots in Capt. McBroom's situation could have made the same mistake" by failing to notice their aircraft's low fuel level while busy trying to fix a gear problem. So, the issue was not the actions of Capt. McBroom alone, but the other crew members inside the cockpit. Why did they not speak up clearly and emphatically about the low fuel situation? What was the working relationship between them and Capt. McBroom?

These questions are what led to the idea of a new concept of a working relationship in the cockpit, one that calls for the active involvement of all crew members (Syed, 2015). The new concept will essentially put captains and first officers on the same level "when it comes to safety and the need to speak up" and take the necessary action when something is not right (Maurino, 2009). Questions, however, arise as to how that program will be marketed to captains who, Syed (2015) observed, were not in a hurry "to turn the cockpit into a democracy."

To resolve the issue, United Airlines partnered with a University of Texas, Austin, human factors team led by Prof. Robert Helmreich (Helmreich et al., 1999). Helmreich et al. (1999) explained that the United program was modeled closely after the "Managerial Grid" concept developed by psychologists Robert Blake and Jane Mouton (Blake & Mouton, 1964). The first program included captains, first officers, and flight engineers that were trained with only their peers in rank. The participants were thereafter divided into teams, composed not of like-minded people, but complete opposites (Dismukes et al., 2007). People "who hate smoking were put on teams with ardent smokers" while those who are known not to get along were teamed together (Syed, 2015).

Within a short period, United Airlines succeeded in formalizing the program and transforming it into "a systems-based process" that soon became a model for other airlines in the industry (Kern, 1998). Dismukes et al. (2007) explained that as the program matured across different airlines, studies were also being conducted by researchers aimed at investigating how crewmembers typically function. Among the many things they analyzed were "how crewmembers communicate, how the different personalities of captains affect performance and error, how crews make decisions as individuals and as a group, how teamwork should be defined, the dynamics of authority, and how CRM programs could and should be evaluated" (Dismukes et al., 2007). All these investigations helped in guiding the evolution of CRM as a safety program.

CRM was formally launched based on the recommendations of the NTSB in the aftermath of the United Airlines Flight 173 investigation (Kern, 1998). The NASA psychologist, John Lauder, who coined the initial term "Cockpit Resource Management" in 1979 defined the concept as that of "using all available resources - Information, Equipment, and People, to achieve safe and efficient flight operations" (Lauber, 1984). While retaining a command hierarchy, the concept was intended to foster a less authoritarian cockpit culture wherein first officers are routinely encouraged to question their captains if they observe them making mistakes, a concept that pilots from many high power-distance societies, including Nigeria, are still struggling with.

Helmreich and Foushee (1993) posited that CRM was introduced as "a tool for enhancing aviation safety by resolving those crew cultures or behaviors that inhibit" *communication* and *teamwork*. Kern (1998) defined CRM's role further as that of "breaking the pre-accident chain of events" or what he referred to as "latent pathogens," that are the precursors of an accident. In doing so, Jing et al. (2002) posited that culture is the main target of the program because of "its potential to significantly influence" the way a pilot handles the trio of personal interaction, communication, and information-sharing inside the cockpit. Nigeria is one of the countries where the culture of deference to people based on their age and seniority has the "potential to significantly influence” the way pilots handle their safety obligations.

CRM has since become a successful program that has been widely copied by civilian airline and military operators worldwide (Kern, 1998). While it is true that the program arose out of the unfortunate United Airlines Flight 173 accident that claimed the lives of some people, the lessons from it have helped in mitigating threats and errors within the industry ever since. Kern (1998) noted that, ironically, “it was another unfortunate incident that contributed immensely to the popularity, and ultimate acceptance, of CRM” worldwide: The United Airlines Flight 232 accident in Sioux City, Iowa, on July 19, 1989. The actions of Capt. Al Hayes, who was in command of the flight, especially his decision to involve a non-operating pilot from the cabin to help with the situation in his cockpit, was lauded across the industry as “classic Crew Resource Management” (Fisher & Phillips, 2000). Those actions left “clear lessons for many generations of pilots to come” and made Capt. Hayes the symbol of CRM success (Kern, 1998). Such collaborative efforts and down-play of personal ego, aimed at achieving a common safety goal, is what defines CRM; it’s outcome in Sioux City sends “clear lessons” to pilots from high power-distance societies on the benefits of information-sharing and collaboration in the cockpit.

The Challenges of CRM

In flight operations, “the challenges of communication, personal interaction, and information-sharing” can arise as a result of multiple factors (Kern, 1998). Graham (2010) identified one of those factors as ego or “the unwillingness of certain individuals to share control of the decision-making process” with their professional colleagues. He attributed this problem to the actions of some crewmembers who assume that by virtue of their position in the cockpit or longevity in the industry, their knowledge of aviation safety is absolute or better than everyone else’s. With such individuals in charge, inputs from others are “seldom sought, or seldom accepted" (Kern, 1998), and safety to them implies "the heroism of the self or individual" and not a team effort.

Unraveling the mentality of this type of pilots is similar to telling the story of the early days of aviation. Even though there was no live television when aviation started in the early 1900s, many pilots risked their lives to perform aerial stunts as barnstormers and wingmen for cheering spectators (Dwiggins, 1968; Gwynn-Jones, 1991). In 1797, a Frenchman named Jacques Garnerin experimented with the world's first parachute jump using a non-rigid frame (Nevin, 1980). Misty (2005) reported that Garnerin started his career "by jumping from tall trees and thereafter from a hot air balloon at 3,200 feet." Many former World War I fighter pilots also risked their lives by engaging in death-defying rolls in the "then unregulated skies, mainly for the purpose of showmanship" (O'Neil, 1981). Misty (2005) reported that even aviation legend Charles Lindbergh was a barnstormer and wing-walking stuntman before he became famous.

In those early days, pilots were defined more as macho men, based on their conquests as individuals rather than as a crew. Such men routinely boasted of their invulnerability and basked in their extreme dare-devil attitudes (Gwynn-Jones, 1991). They were the pioneers and heroes who paved the way for most of the achievements of today (Caidin, 1991). However, times have changed, and for the better. Present-day pilots realize that they do not possess the "power of invulnerability" (Stolzer & Goglia, 2016). They understand the advantages of being a team participant and the stupidity of creating one's own rules, especially in mid-air.

Modern-day pilots also understand the need for CRM: the management of "all available resources to reduce pilot error" and enhance safe flight operations (Stolzer & Goglia, 2016). This understanding is crucial because majority of pilots involved in fatal and non-fatal accidents were typically unaware of the situational and human calamity approaching them until the "disaster maturation" stage is reached, a stage that both Kern (1998) and Helmreich (1999) identified as "the intersection of the three forces of the machine, the environment, and the human" (Figure 4). It is the movement towards this negative stage that CRM aims to correct within the system (Stolzer et al., 2008). In Nigeria where power-distance, machoism, and "the heroism of the self or individual" are prevalent, the need for a functional CRM to mitigate its negative effect on flight safety cannot be overemphasized.

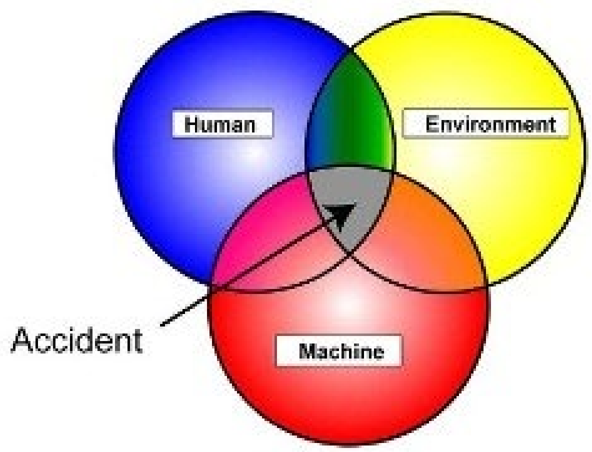

Figure 4: The Forces of Machine, Environment, and Human (Helmreich, 1999).

CRM in non-Western Societies

Commercial aviation accident rates differ from one region of the world to another. Statistics from the United Kingdom (Civil Aviation Authority [CAA], 1998) indicate that Africa and Asia have higher accident rates (8.0 and 5.1 accidents per million departures respectively) compared to either Europe or North America (1.0 to 1.5 accidents per million departures). The underlying causal factors also show some differences: Unlike in the Western nations, "failures in CRM are the most cited circumstantial factors" in aviation accidents in Africa and Asia (Wiegmann & Shappell, 2003).

While there is limited data on the number of aviation accidents in Nigeria caused by deficiencies in the CRM process, similar studies in other non-Western societies where the power-distance is as high as in Nigeria provide some important results that can be applied to the country. Li et al. (2008) used the Human Factors Analysis and Classification System (HFACS) to analyze accidents involving Taiwanese airlines. They found that poor CRM "have a relationship with the subsequent errors in decision-making, perceptual errors, and violations in procedures" that eventually resulted in accidents. They concluded that these error categories occur 30 to 40 times more in Taiwan than in the Western nations, mainly due to the absence of a robust CRM process there (Li et al., 2008).

Another study was done on the application effectiveness of CRM with emphasis on adherence to Standard Operating Procedures (SOP) by pilots with diverse cultural backgrounds operating for a single major airline in the Middle East. The results from the study indicate that cultural traits and beliefs among pilots from different nationalities can influence their behavior and attitudes toward SOP, including how they behave in the relevant unsafe performance events of hard landings, unstable approaches, and pilot deviations (Al-Romaithi, 2014).

In other instances, however, the ineffectiveness of the CRM process has more to do with the power-distance relationship between a captain and first officer from a homogenous society. Such was the case with the China Airlines A300 accident at Nagoya, Japan, on April 26, 1994. In that accident, the captain intervened after the first officer had accidentally activated the take-off/go-around (TOGA) mode during the approach (Japan Aircraft Accident Investigation Commission [JAAIC], 1994). After taking over controls of the aircraft, the captain flew it into a stall, with the resultant accident killing all souls on board. The investigators reported that at no point did the first officer made any effort to question his captain's inappropriate procedures.

For cases such as that of China Airlines' accident, the solutions were predicated on changing the general attitudes and behaviors within the flight deck to overcome the reticence of junior crewmembers in questioning their captains when the right procedures are not being followed. Harris and Li (2008) posited that while the provision of such "culture-sensitive CRM training" may seem politically-correct, they hardly ever work in Asian cultures. The reason, they argued, is because "power-distance runs deep in the larger society" and assertiveness by junior pilots, for whatever reason, is "contrary to the highly ingrained cultural norms" of most Asian societies. The same argument can be made for the Nigerian and many African societies.

Also, modern cockpits are designed based on the concept of two pilots cross-monitoring each other's actions. As such, operating procedures are based on "monitor and cross-monitor" and "challenge-and-response" (Harris & Li, 2008). Those concepts are predicated upon "a general assumption that either of the two crewmembers will openly alert or question each other" about any observed errors or irregularities in the procedures (Stolzer et al., 2008). Implicit in that assumption of a crew member action is a fundamental philosophy - that of low power-distance in the society, something that is not prominent in many African cultures, including Nigeria.

African Culture and CRM

The Challenges of Power-Distance

Communication, coordination, and teamwork amongst flight crewmembers are "very crucial elements" in normal, and more so, in emergency situations (Dismukes et al., 2007). Zastrow (2001) posited that when effective communication is at work, "whatever signal a sender transmits is exactly what the receiver will decode." Inside an airplane cockpit, when a team member, especially the captain, displays a "do not disturb" sign even in the subtlest manner, the chance is high that the other team members will interpret it correctly (Syed, 2015). When that happens, “intra-cockpit communication and teamwork can be stunted, and a disconnect created” between team members that are not appropriate for effective threat and error management in the cockpit (Stolzer et al., 2008). Thus, the power-distance between flight crewmembers has an effect, not only on their communication pattern, but also on “the style and nature of their teamwork, decision-making, and the overall safety” of the flight (Stolzer et al. 2008).

In many parts of Africa, the captain, being the leader, is often expected to be “competent, decisive, and self-sufficient” (Munene, 2016); the first officer is seen as a servant or, at best, a distant subordinate who is expected to know his or her place and not question the captain’s decisions or actions. That master and servant dynamic is very prevalent across the continent and is so because of the emphasis that society places on seniority (Soetan, 2001). Elendu (2012) posited that among Africans, “authoritarianism is expected and accepted” as normality. Under it, power and authority are typically concentrated in the hands of the leader or elder “for the good of the society” (McLaughlin, 2007). Westbrook (2005) noted that the rationale behind the adoption of that style of leadership in certain cultures is the belief that during an emergency or disaster, “a single authority is better suited and more capable at correctly and effectively managing an organization” or group in a timely manner, with dedicated focus and less chaos.

While the origin of authoritarian behavior in African societies is not clear, there is no doubt that the European occupation and subjugation of the continent during the period of colonization and slavery supported and re-enforced that culture. During colonization and slavery, the white European was the master, while the black African was the servant. In those days, the master was always right, and the servant was not allowed to have an opinion (Elendu, 2012). By virtue of his position, the master made all decisions, and even when he is wrong, no mechanism existed for the servant to question or correct him. That system went on for decades, and today, the vestiges of European colonization and subjugation are still there. Elendu (2012) also noted that when the Europeans left, the first-generation of black Africans to be empowered by the colonial system and who found success in politics, academics, business or the professions, became the new masters, and just like the Europeans, they had servants.

This type of system has its consequences. Within a high power-distance culture such as Nigeria (Hofstede, 2001), the less powerful typically accept the inequality with their superiors. Matondo (2012) posited that while the "inequality may be in social status, power, or gender," one common denominator among the victims is that they gradually and continuously accept their increasingly unequal status because that is what their culture and upbringing has taught them to do. Under such a situation, there is no level-playing field. The hopelessness of that society's low-level victims, Nabalamba (2013) argued, is "the greatest tragedy" of power-distance.

However, while the ills of power-distance have been well-documented and its effects portrayed in negative terms by many commentators, there are those who hold glowing views about it. In the opinion of Keller et al. (2015), power-distance does not always have to be examined from a disparaging viewpoint. They posited that as in a family unit, an unequal distribution of power in a workplace could lead to a successful and disciplined organization or be "an asset in maintaining control and mitigating disorder" within that organizational family. The same model can be applied to certain societies.

In that respect, it may be argued that high power-distance can actually lead to positive outcomes for societies such as Nigeria, where, as Canci and Odukoya (2016) had noted, "the regulatory and legal frameworks" are not fully developed. Under such environments, the gaps left behind by weak institutions are filled by powerful individuals such as captains, while efforts are being made to develop the institutions. This type of argument has been severally made in the past to justify the preponderance of what Matondo (2012) referred to as "the strong men of the African political scene." As in politics, the same case may be made for African cockpits.

Age and Seniority as Drivers of Power-Distance

Different societies deal with age in different ways, depending on their culture and historical background. Condon and Yousef (1975) posited that the value of age has been dominant in most cultures for a long time mainly because the elderly was traditionally considered as "the locus of societal knowledge, history, and wisdom." Among the Chinese people, the Confucian teaching of Five Code of Ethics dictates a rigid hierarchical structure of human relationship in which seniority is accorded a "wide range of authority, power, and status" (Knutson et al., 2000). The structure allows senior persons to enjoy "more freedom in initiating an idea, a topic, or a decision in family and public discourses" compared to the rest of the populace (Sebenius & Quan, 2008). Most often, seniority "not only determines whether a message is considered important, but what could be publicly discussed or criticized" within the larger Chinese community (Knutson et al., 2000).

In Nigeria and most African societies, this culture of deference to old age is the same. It is further demonstrated by the honorific linguistic codes and gestures used to show respect to the elderly and by "the special treatment given to them in family and community gatherings" (Madzingira, 2001). Doumbia and Doumbia (2004) posited that within many African societies, the old and senior members of the clan are revered as custodians of the "group's history, wisdom, and knowledge." They added that old people's wealth of experience "represents the past, present, and in many cases, the future." Because of that belief, they are routinely consulted for guidance and direction on almost all matters. Most often, Soetan (2001) posited, "age and seniority are the most critical factors in determining a person's authority and status" within the clan and community; they are usually the main locus of control in the decision-making process across many African societies.

Across Nigeria, this emphasis on old age has been largely aided by the country's long-term culture of collectivism, interdependence, group-orientation, cooperation, harmony, group loyalty, and conformity (Hofstede, 1997; Ekiyor, 2004; Frank & Ukpere, 2012; Peretomode, 2012). Ejimabo (2013) posited that in a typical Nigerian group, "the overall decision-making process is ceded to the most senior person or the eldest as a way of avoiding conflict, ensuring team cohesion and discipline, and achieving result." The rest of the team function mainly to "provide support, loyalty, and at times enforcement," for the group's beliefs, objectives, and direction (Ekiyor, 2004).

This model is, in many ways, similar to other age-valuing societies. Sebenius and Quan (2008) posited that within Confucian-orientated societies, seniority is the main way of gaining power. Those who hold power make the decisions, which explain why, in many Asian cultures, decision-making is more likely to be in the hands of older managers (Bond & Hwang, 1986; Doumbia & Doumbia, 2004). Similar to the Confucian tradition, African cultures teach "filial piety" or ultimate respect and deference to the elderly. The belief is so strong that any abandonment of it is considered as "deeply shameful and dishonorable" (Ejimabo, 2013).

The African culture of respect for and deference to older people typically translates to everywhere, including the workplace. Among the working class, military, or public service, a higher-ranking person is also more likely to be older. This, according to Doumbia and Doumbia (2004), is because that person will have worked their way up the ladder over the years to get to where they are. So, in many cases, they are going to be both older and senior to the younger people in the same organization. In such cases where age and seniority are co-located, it bestows on the bearer vast power and authority.

Within the aviation industry, a captain is more likely to be older than the first officer because of the time he or she has spent in that profession as compared to the later. Also, because the compensation scale is based on position and length of service, the captain typically earns more than the first officer (Hirsch, 2007). With such advantages of age, position, and renumeration in his favor, the captain wields a tremendous amount of power when compared to the first officer. In Africa, where elite impunity is rampant (Soetan, 2001), the combination of such powers in one hand can mean progress or total disillusionment for the subordinates.

In most Western societies, however, this orientation towards value for age and seniority has diminished over time. Condon and Yousef (1975) posited that three distinct value orientations have evolved, over time, towards age: *youth*, *middle age*, and *old age*. Many Western societies have evolved into a youth-valuing culture in which idealism, vigor, and individualism are continuously being emphasized. For example, Age UK (2011) surveyed attitudes toward age and seniority across 28 European countries. The main question centered on whether people would rather have a boss who was 30 years old or a boss who was 70. The overwhelming preference among Europeans was for a 30-year old boss. The result of a similar survey in Japan favored an elderly boss. The vast majority of Japanese people believed that a 70-year-old boss would have "more knowledge, wisdom, experience, and compassion" than a 30-year old one (Karasawa et al., 2011).

The same view about old age is predominant in Africa. Doumbia and Doumbia (2004) posited that African societies remain age valuing ones where age and seniority are celebrated as "proponents of wisdom, experience, knowledge, and power." In a traditional African society, the aged are perceived to be "the mediators between this world and the next, the representatives of the ancestors," and the creators and guardians of all cultural traditions (Eboiyehi, 2015). They are believed to be "endowed with patience, experience, and wisdom" (Brown, 1985; Sijuwade, 2009). This belief made people defer to them and hold them in high esteem.

Also, Africans typically believe that old age was "an ancestral blessing" bestowed on those who have lived their life righteously (Amosun & Reddy, 1997). It is therefore considered a necessity for "those who want to grow old" to bestow respect on elders and follow their guidance (Ekiyor, 2004). In that way, the same respect and deference will be accorded to them when they grow old. This belief in treating the elderly with respect, hoping that the same gesture will be bestowed upon that person when they grow old extends to junior pilots in Nigeria.

Among Africans, older people are so respected that many have devised some non-human names or words to describe them (Amosun & Reddy, 1997). Such names, Eboiyehi (2015) added, include "the big person" among the Shona tribe of Zimbabwe and the "Owanlen" (the wise one) among the Esan people of Nigeria. Former Kenyan President, Mzee Jomo Kenyatta (1965) described the importance of age and seniority within African societies in this way:

> As a man grows old, his prestige increases according to the number of age grade he has passed. It is the seniority that makes an elder an almost indispensable in the general life of the community. His presence or advice is sought in all functions. In religious ceremonies, the elder holds supreme authorities. The custom of the people demands that the elder should be given his due respect and honour.

This belief among many African societies that aged people are the mediators between this world and the next one had added some "power, invisibility, and prestige" to their status (Hooyman & Kiyat, 2002). In his study of the Xhosa people of South Africa, Sagner (2001) also found that the Xhosas see aging as a process that indicates "experience, wisdom, and perfection." He observed that, typically, "only senior male members of the society are entrusted" with the power to relate with the ancestors; women are excluded. But, as soon as the women reach old age, the restriction is removed, and their status and power are automatically deemed to be the same as that of men (Sagner, 2001).

Eboiyehi (2015), in his study of old age culture among the Esan tribe of Nigeria, observed that the special place that age occupies in peoples' mind is linked to the belief that as someone gets older, that person "is drawing closer to the spirit" and is therefore "more in touch with the ultimate source of knowledge, greatness, and discernment." Such an older person is often highly respected because they are seen not only as a representative of the ancestors but as someone who can actually "commune with the spirits" and relate "messages from the dead ancestors" to the living beings (Sijuwade, 2009).

Because of that important spiritual perception in the society and the power associated with it, older people typically command much respect. Because of that, the decision of such an older and senior person is usually final, and questioning or ignoring orders from him "is similar to disobeying the spirit of the ancestors" (Sagner, 2001). Eboiyehi (2015) stated that this type of behavior among the Esans is boosted by the African traditional culture of group living that typically involves up to three generations – grandparents, parents, and children, in the same house. Under such a living arrangement, he added, "exchange of support and services between the old and young is pervasive," and disciplinary authority is determined, not by relationship, but "by age and rank" within the household. This emphasis on age and seniority as instruments of authority among the Esan people is widespread across other Nigerian communities (Ekiyor, 2004). Consequently, it is prominent within the country's aviation industry.

Power-Distance and Communication in Aviation

The aviation industry is composed of different parts. Its successful operation is a complex one that requires continuous integration of those different parts. Integrating and coordinating "individual safety duties with other team members" are necessary for achieving a desirable level of safety in the industry (Viera et al., 2014). Dickinson and McIntyre (1997) posited that the biggest obstacle against a successful safety regimen in the industry remains "the sharing of all relevant information through an effective communication mechanism that enables people, processes, systems, and technology" to interact simultaneously and cooperatively.

As in any other industry, communication in aviation can be challenging. It can lead to both positive and negative outcomes, depending on the timing and circumstances. While open communication is a vital part of CRM, there are other times when casual communication is discouraged as a crucial part of the safety regimen. For example, as part of the safety process in the industry, there is a requirement for silence or cessation of all non-operational communication by flight crew members below ten thousand feet as a regulatory policy (FAR 121.542; FAR 135.100). The rationale is to discourage non-essential communications at lower altitudes which has the potential of creating distractions at a time "when the chances of safety infractions are much higher and its consequences more dangerous" (Stolzer et al., 2008).

Aside from those quiet times during the take-off, climb, descend, and landing phases of flight, free and open communication among crewmembers inside the cockpit helps in advancing safety and flight operations efficiency (Stolzer et al., 2008). Verderber and Verderber (1992) posited that for the purpose of clarity, verbal communication is an ideal and best way for one-on-one communication in an enclosed environment such as inside the cockpit. One of its many advantages, they argued, is that in using words to convey meaning, it creates a clearer and verifiable medium of information transfer.

Another crucial advantage of verbal communication is that it allows for "explanation and negotiation of meaning" between participants, therefore, allowing them to overcome problems of message distortion and misunderstanding (Connell, 1995). However, as Cooper and Findley (2013) argued, the clarity of any communication, irrespective of the actual message, is dependent on "the role of other factors such as tone, stress, and vocal infection" that are typically part of the conversation module. Those factors play the role "of conveying the emphasis, emotions, and the deeper meanings of the speaker's intentions" to the listeners (Samovar et al., 2009). This is especially so in Africa, where "pitch level" determines meaning in many of the languages (Childs, 2003).

Verbal communication can also be interpreted in many ways to give different and sometimes multiple meanings depending on the context. Stolzer et al. (2008) posited that unlike the verbal communication between pilots and air traffic controllers that is "synchronous but with no physical presence," the communication between the captain and the first officer inside the cockpit is developed on "a person-to-person" basis. While the process may or may not be synchronous, it typically involves the physical presence of the issuer and receiver, most often accentuated by other non-verbal indices.

Therefore, the non-verbal aspects of the communication process such as "eye contact, facial expressions, gestures," and time interval that helps in constructing deeper meanings of the exchange can become more critical or defining under certain circumstances (Cook & Woods, 1994). This line of thinking informs the social constructivists' view of communication as "a final product of all interactants that are involved in creating a meaning" (Craig, 1999). The implication is that meanings in communication can be constructed or invented through a social process. In other words, "how something is said determines the message much more than what is said" (Craig, 1999).

In the cockpit environment, while anyone can theoretically initiate the communication process, most often, it is the captain who sets the tone of *how* to say things, *what* to say, and how *much* to be said. The amount of listening ear and conducive environment that the captain set at the beginning of the flight is what determines how much the subordinates speak out when they observe something abnormal (Stolzer et al., 2008). Cooper and Phillips (2004) argued further that "the tone of voice" during that first contact between crewmembers makes much difference in any subsequent communication, or the lack of it. Most often, a wrong tone of voice, body signal, or gesture can provoke a greater reaction from people than spoken words. This is especially so when the person expressing the gesture is the one at the upper end of the power structure. As Madzingira (2001) posited, most often, words only "give the expression" to what a person wants to convey; the gesture is what shows the actual thinking of the person and their "level of sincerity and commitment."

However, while verbal communication is less cumbersome and more useful in mitigating system errors, it also has a higher potential of exacerbating personal conflicts when such arises (Krivonos, 2007). This, Connell (1995) argued, can be more potent inside the confines of an aircraft cockpit due to "the limited room for personal space" within it. Thus, verbal communication, while desirable, has its drawbacks. One of them is the potential for conflicts during face-to-face communication.

Vieira et al. (2014) have argued that "for the dual purpose of minimizing the chances of personal conflict and for documentation purposes," many organizations typically encourage their employees to use the company's online portal to communicate with their supervisors and avoid approaching them personally. They pointed out that though person-to-person communication has the added advantage of "deepening the conversation because of the availability of non-verbal indicators," there exists an equal risk of conflict if any part of the verbal communication process has specific meanings that contradict what the non-verbal indicators are signaling. This warning is particularly crucial in African societies because of the abundance of what Madzingira (2001) identified as “unique non-verbal characteristics and norms” that have the potential of further “accentuating communication contradictions” more than in most Western cultures.

For example, while assertive first officers can be a positive resource in the cockpit “because of the improved information flow that can make the detection of red flags on possible risky situations easier” (Krivonos, 2007), in Africa, where the culture of deference to seniority is an integral part of everyday life, an assertive comment or inquiry from a junior officer, especially when accompanied by an equally assertive voice, can easily be perceived as a sign of disrespect by a senior team member rather than a proactive safety process. That can change the communication pattern and set in motion a hostile working relationship between the two crewmembers that have the potential of jeopardizing flight safety down the line.

Another issue that can potentially worsen the communication challenge inside the cockpit is the vertical nature of communication in Africa. Spencer-Oatey (2000) posited that unlike in Western societies where the communication channel is “mostly diverse and wide,” it is “much more hierarchical and vertical” in Africa. Because of that hierarchical communication pattern, serious discussions in Africa typically takes place between senior and older people only. Any complaints or deficiencies they observe are taken to an expanded clan and community meetings by the most senior elder among them. At each level, decisions are taken by the elder or selection of elders on behalf of everyone in the group (Agar, 1994).

Chen (2013) postulated that under this kind of arrangement, each member of the group has a responsibility to not only abide by the elders’ decision, but to enforce it within and, where necessary, outside the group. Most often, those who disagree or lose out in the process have nowhere to go for redress; they let go of their positions and stay loyal to the group (Agar, 1994). This type of communication pattern can be counterproductive when it comes to aviation safety. It perpetuates power-distance between members of a group and has severe consequences for high impact industries such as aviation, where free and timely sharing of information is a critical part of the safety process.

However, as consequential as hierarchical communication patterns may be for industries such as aviation, its use in the general African society is necessary for several reasons. One is the need for clarity on individual roles and responsibilities due to the fragmented spread of rural African societies (Matondo, 2012). Another is the desire for consistency and accountability (Eboiyehi, 2015). Also, because African societies are organized in small groups, a single spokesperson serves to articulate the people's needs and grievances better. Most importantly, it is necessary for societal discipline (Ailon, 2008). Therefore, though dictatorial, the use of hierarchical communication procedures is key to clarity and maintaining discipline within African communities both in times of peace and crises (Madzingira, 2001).

Culture and Technology

Culture is very influential in the way people view, learn, and adapt to new things. It helps in constructing their view of the world (Holland et al., 1998). Maurino (2009) noted that while aviation was built on a technological framework, its operation is embedded with the operator's cultural characteristics. Along the same line, CRM and other aviation safety programs were designed with Western cultural perspectives as their foundation and background. While the intentions behind them are laudable, Mazonde (1998) opined that the main reason why many Western-designed programs hardly ever work in non-Western societies such as Africa is because the processes do not always align with "the cultural and cognitive learning ways" of the non-

Western users of such products and services.

A good example is education. Mazonde (1998) argued that the reason why Western-style education has not produced substantial success in Africa, “in spite of the huge resources expended on it,” is because “it has not shown its relevance” to the needs of the African society. For instance, educational structures and curricula in the continent are typically formulated by, or copied from, European colonialists whose “cultural background and meanings” are different from those of the local Africans who are supposed to be the beneficiaries of the programs (Mazonde, 1998). In doing that, a cultural, and thus learning disconnection, is created between the product and its African users. While the average African can see the benefits of education, the learning process that will get them there “does not always align with their cultural beliefs and ways of understanding and processing things” (Mazonde, 1998; Maluleke, 2012). The same can be said about aviation and its safety programs.

Maurino (1998) also made a crucial point that “aviation was and remains a Western-dominated industry” (p. xvii). That is to say that the bulk of aviation’s products, programs, and processes are domiciled in Western institutions and facilities. They were conceived and developed with Western cultural characteristics and beliefs as the background and foundation (Wilkesmann et al., 2009). Elendu (2012) added that typically, those regions of the world that shares similar cultural background and perspective, or that have “experienced long periods of cross-cultural interactions or bonds” with the originating society, stand at an advantage of easily understanding and assimilating the contents of such programs.

Africa’s first and major contact with Western culture was through occupation, colonization, and slavery (Falola & Heaton, 2008). In order to survive the brutal onslaught on his person and culture, the African man developed a double-face mentality: “deep inside him, he resents the Western domination and brutality, but publicly he praises the master" (Madzingira, 2001). Ogunbado (2012) posited that the outcome of that experience was not an interaction between cultures as in other societies, but "the subjugation of one culture by the other."

That survival strategy also led to the emergence of some false premises about the African man's inner nature. Because his presentation of himself to his European master was not factual, the master never gets to know or understand his real nature (Madzingira, 2001). Therefore, Europeans built ineffectual programs in their image, "some of which they honestly believed will benefit the African, based on the image of the African they think they know" (Falola & Heaton, 2008). That mode of interaction has not changed much over the years.

In many areas, the African man still has his true identity shrouded in secrecy for multiple reasons. Around him, there are not many tangible technological advances or programs that bear an affinity to his cultural identity, and not many that he can relate to in his language or dialect (Matondo, 2012). So, in order to "understand" the world and be part of its progress, the African man always has to look through the "Western mirror" in order to conjure an image of himself, his family, and his physical and intellectual capabilities. Elendu (2002) opined that most often, what the African man sees in the mirror "is not him, but he pretends it is." That is the only way he can be welcomed to the "world table" and not be dismissed as "primitive" (Matondo, 2012).

Another issue that has held Africans backward in assimilating products and services that has global relevance is the lack of a single language that serves as a symbol of cultural integration and uniformity across their national boundaries. The balkanization of Africa by European powers in the 19th century has left the continent with "wholly artificial boundaries" whereby many countries are inhabited by "people with different, if not adversarial, ethnic identities" (Ade-Ajayi & Crowther, 1971). Under such situations, many African nations have ended up with multiple "national" cultures that are anything but national, and the process of forging a single identity for them has become a difficult task (Matondo, 2012). Elendu (2012) posited that this lack of a single national language or "a near-homogeneous cultural identity" in many African nations has negatively impacted their abilities to utilize all the benefits of certain programs, including CRM, that was built around cultural characteristics and behaviors.

The language of CRM is English, as with all other aviation products and services (Engle, 2000). However, as Elendu (2012) explained, language is not the only barrier between Africans and Western societies; it is "the whole cultural perspective." Merritt and Maurino (2004) theorized that as long as human beings stay "within their cultural boundaries," their thoughts and actions are "always fairly predictable." Problems usually arise, Elendu (2012) asserted, when they leave their comfort areas or are confronted with members or instruments (for example, policies, procedures, and regulations) from other cultures "that do not fit into their world-view." All of a sudden, they become less predictable and more uncertain, and require more cognitive efforts to actualize their thoughts and actions (Merritt & Maurino, 2004).

CRM was created based on the Western concept of low power-distance. Africans have no history of low power-distance; inventing it, while at the same time trying to absorb a technical process such as CRM, using a language that is not affiliated to theirs, can be a challenge. Kirby (1997) had posited that "a communicator's words cannot communicate the desired meaning to another person unless the listener or reader has had some experience with the objects or concepts" to which those words refer. In the Western societies where CRM originated from, the language and the socio-cultural identity that serves as the foundation and background for the program are "nearly homogenous among its constituent members" and has been so for a long time (Merritt & Maurino, 2004). Such is non-existent in Africa, where people are still in the process of forging a common language and cultural identity for themselves (Elendu, 2012; Matondo, 2012). Therefore, for the African people, the road towards a successful CRM is still a work in progress.

Besides language and culture, there is also the challenge inherent in knowledge transfer. Merritt and Maurino (2004) posited that new and advanced technology, although beneficial to all and sundry, "can sometimes be very problematic for first-time users." This is so because in the absence of any prior experience on an earlier or related version of a product, "users can potentially face a significant gap in the knowledge and skill level required" to successfully operate and maintain a new technology (Seva et al., 2007). For example, an airline that is already operating Boeing airplanes "has a better chance of safely and successfully operating a newer version" from the same Boeing compared to an airline that has never operated a Boeing airplane before (Merritt & Maurino, 2004). That, in essence, summarizes the challenges that many non-Western societies sometimes face with Western-built technologies and programs.

CRM and Safety Challenges in Nigeria

A lot of research has been done on national and workplace cultures in Nigeria and how they relate to safety and productivity. Oghojafor et al. (2012) did an empirical study of bullying incidences amongst 300 workers in a Nigerian workplace. Their study found that a large percentage of bullying is directed at junior employees and is done by both senior managers and clients. They concluded that disparity in power between managers and junior employees is at the root of workplace bullying in the country (Oghojafor et al., 2012). A similar study of American workers conducted by Zapf et al. (2003) found that 50 to 80 percent of bullying perpetrators are managers; in most of the cases, they are men.

However, while most workplace bullying incidences are perpetrated by those in positions of higher authority, that is not always the case across all sectors of the society. For example, a recent study of 1,008 adult American workers by the Workplace Bullying Institute showed that while 60 percent of workplace bullying is still done by superiors, 40 percent of the perpetrators are either peers or subordinates of the victim (Workplace Bullying Institute [WBI], 2017). A previous study conducted by Rayner and Cooper (2006) showed similar results: bullies can be peers or subordinates as much as they can be superiors.

Another salient point about workplace bullying is that its occurrence cuts across both low and high power-distance cultures globally, as revealed in another survey by the duo of Duncan Chappell and Vittorio Di Martino on behalf of the International Labour Organization (Chappell & Di Martino, 2006). They found that workplace bullying happens in the U.S. almost as much as it does in Nigeria. Because of these reasons, it can be surmised that while the link between power-distance and workplace bullying is compelling, it should not be directly interpolated with cockpit culture in Nigeria.

Madzingira (2001) carried out a program of research on the inter-relationship between peoples' culture and their communication patterns, and how the two elements complement each other in spear-heading national development. African communities, Madzingira posited, relied mainly on "oral, face-to-face communication, using verbal messages, songs, drums, poetry, and codes" that relish and reflect on their glorious historical pasts. While technology has done a lot in changing the face of communication in the Western world, those changes have taken place at a much slower pace in Africa. The reason for the disparity, Madzingira (2001) argued, is that there is a "disconnection between the traditional African way of communicating and the emerging Western communication styles and technologies." Elendu (2012) and Ekiyor (2004) argued further that because Africans have no clear understanding of the ways of the new technology as compared to their own, they typically choose to stay with what they already know: their traditional system.

While Madzingira's (2001) work is quite informative in highlighting the power of culture in inhibiting or advancing communication within a general African population setting, it has its shortcomings when applied to a pilot group. One difference is that unlike the general public, "pilots have extensive training on the use of modern communication gadgets" as part of their job module (Kern, 1998). Also, they are generally more educated than the average African population (Akpoghomeh, 1999). Because of that higher educational level and the advanced skill required for their job, pilots are more exposed to current communication technologies available around the world compared to the general public. Therefore, Madzingira's findings, while very important, are not directly applicable to the pilot force within the continent.

Other studies in Nigeria point to the multi-faceted nature of the problems confronting aviation safety in the continent. For example, Uhuegho et al. (2013) did a study on how culture affects the Safety Management System (SMS) implementation in an approved Aviation Maintenance Organization (AMO) in Nigeria. Their findings showed that even though over 80 percent of the respondents indicated that a strong SMS is being implemented in their workplaces, their difficulty in mentioning any specific data collection and processing method or any safety management tool in use at their workplaces indicates "a noticeable lack of an effective safety management education, training, or motivation regime," key concepts that influence the safety management implementation process (Uhuegho et al., 2013).

Relying on the responses to the questionnaires that they sent to employees within the aviation industry, the authors concluded that "either there is lack of a coordinated approach to the

SMS application in the country or a majority of the employees lack a basic understanding" of the inherent culture beneath the SMS process. While the survey in the study by Uhuegho et al. (2013) was directed at all aviation workers as a way of gaining insight into their understanding of the SMS operational process, this study is specifically aimed at uncovering and explaining the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots. While the focus of the two studies are different, their processes and outcomes are predicated on the perspectives of people who were all raised and influenced by the Nigerian culture. Culture is thus, an underlying factor in both studies.

Hofstede (1980) defined high power-distance societies as those characterized by centralized authority, autocratic leadership, paternalistic management, multiple hierarchical levels, large numbers of supervisory staff, acceptance that power has its privileges, and "an expectation of inequality and power differences amongst the citizens." This description fits into many aspects of the Nigerian culture that defines the country's space and activities (Henry, 2004; Omonzejele, 2004; Ayodele, 2016). Besides paternalism, Nigerian culture is one with considerable dependence of its people on "power holders" (Hofstede, 1997). Within the aviation industry, captains are power holders.

Kern (1998) noted that the desire to "counter the over-bearing influence" of power-holders inside the cockpit and to "mitigate the negative effects of over-dependence" on them by junior crewmembers was the main reason behind the creation of the CRM program. However, despite its noble objective, the fact that it was conceived and designed based on the Western cultural perspective of low power-distance makes its implementation a difficult task in many non-Western societies that do not share the same view on power-distance. As Jones (1996) explained, a person who tries to interpret another culture using the rules of his own will always find the “other culture” to be exceptionally “strange, irrational, and unpredictable.” That is so because the rules of one culture do not always mix well with those of another.

In Nigeria and many parts of Africa where societal hierarchy is deeply ingrained, rigid, and top-down, trying to absorb the Western-inspired CRM process using the dictates of the local culture is fraught with tremendous challenges. The reason is simple: As Maurino (1998, p. xxiv) observed, “no matter what overt behaviors humans might have been indoctrinated into,” or overt behaviors they might exhibit during routine situations, when it comes to “emergencies and life-threatening situations,” they always revert to their deeply-rooted behaviors, because that is what they know best. Such is the power of culture.

However, despite the vast differences in cultural beliefs and ways worldwide, Strouhal (1989) opined that the technological interface between people can still be established if there is some level of prior cultural affinity between them. In support of that argument, Merritt and Maurino (2004) pointed out that the cultural affinity between the dominant people of North America, Western Europe, and Australia/New Zealand is reflected in their near-equal level of aviation successes. Because most of the aviation artifacts originated within their economic, political and cultural context, Merritt & Maurino (2004) argued, the people from nations that share in that cultural background tends to benefit more from the prosperity of those aviation products and resources than others who are not part of the group.

The implication is that countries such as Australia and U.S., which have shared history, common language, and similarity in religion and political systems, are very culturally-affiliated, despite the physical distance between them (Merritt & Maurino, 2004). Australians are, thus, in a better position to absorb the contents and contexts of aviation artifacts from the U.S. with minimal hindrance. That is in sharp contrast to, for example, Mexico and the U.S., which are geographically close, but culturally far apart (Merritt & Maurino, 2004). They posited that as a result of the cultural affinity between them, the civil aviation accident rate in North America, Europe, and Australia is less than one per 10 million departures. By contrast, the rate is as high as one per 100,000 departures in some developing countries that are not culturally-affiliated with the Western society.

From that perspective, it can be argued that culture has a way of creating a bond between its core members, irrespective of the geographical distance between them. However, while there are advantages, as explained above, for membership in a group that shares cultural affinity, there is also the danger posed by "cultural conditioning," something that has not been given its due attention in the literature, considering its relevance to safety. Kelly (2013) put some emphasis on this when he posited that "culture educates the group" and, in doing so, develops "mental models that serve as the basis for the unquestioned assumptions held by the group."

Strouhal (1989) also argued that culture does not only educate the group, it indoctrinates its members with favorable beliefs and characteristics, "creating assumptions and perceptions about themselves, the group," and most especially, about "the others." Most often, those beliefs and assumptions are neither factual nor established. People and Bailey (2017) opined that because members of the group believe them, those assumptions and perceptions become sacrosanct and are added to the list of that society's history and culture. In Nigeria, and many other African cultures, age and seniority are highly revered. People with either or both are believed to be higher beings and are communicated to in a different way than the rest of society. That deference, given to age and seniority, while a source of pride within the Nigerian cultural space, can potentially harm the CRM process if carried into the cockpit.

Summary

There are no statistics on how many lives have been saved or crashes that were averted as a result of the introduction of CRM in aviation. However, considering "the outstanding global safety record of commercial aviation in the past few decades" (Maurino, 2009), it is not unreasonable to assume that the vast majority of errors are well managed and inconsequential. That is due "in large measure to effective CRM implementation" by flight crewmembers (Stolzer et al., 2008), even though the success rate may differ from one region of the world to another.

Geert Hofstede's seminal study on different cultural dimensions worldwide laid the foundation for a considerable body of knowledge that is available today on the role of national culture in flight crew behaviors (Hofstede, 1980; 1997). His work, alongside the foundation laid by United Airlines, based on Blake and Mouton's (1964) "Managerial Grid" model (Helmreich et al., 1999), and the role of Dr. John Lauber (1984) in the conceptualization and design of CRM, are explained in the chapter. So are Helmreich and Merritt's (1998; 2000) work on cross-cultural perspectives among pilots from different nationalities and cultures.

While there is an abundance of literature on power-distance in Nigeria, there is hardly any on its effect on pilot communication and CRM. In fact, there are not many studies on aviation safety in Africa that are authored by African researchers. One explanation for this deficiency, as stated in the chapter, could be a lack of the requisite expertise in the field of aviation safety in the continent. This research aims to bridge that gap by creating an understanding of the effect of age and seniority as power-distance factors on the communication aspect of CRM application among Nigerian pilots. Such knowledge and understanding may lead to the adoption of better strategies or the strengthening of existing ones to mitigate the deficiencies identified in the problem statement of this study, and thereby create a sustainable environment for aviation growth in the country.

CHAPTER 3: METHODOLOGY

Introduction

The objective of this study is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots. In the previous chapter, a review of the available literature on culture and power-distance in Nigeria and other parts of the world was done. This chapter will provide the analysis to justify the researcher's decision to use a qualitative research methodology that employs inductive thinking for this study.

Bruner (1996) has noted that narrative has a role to play in the way we make sense of our world and our surroundings. Narrative inquiry will thus be used in gathering data from Nigerian professional pilots on their experiences of power-distance, specifically on the effect of age and seniority on the communication pattern between the junior and senior members of the group. Also, records from the country's aviation regulatory and accident investigation agencies will be used to analyze and give meaning to the collected data.

Research Philosophy and Assumptions

Research philosophy or theoretical perspective is the set of beliefs that represents a researcher's world view. It informs what personal history and political and ethical perspective that the researcher is bringing to the inquiry, or what Guba (1990) identified as the "basic set of beliefs that guides action." In interpretive frameworks such as this one, the philosophical assumptions of the researcher are typically embedded or "folded into the framework" used in the research (Denzin & Lincoln, 2011; Creswell, 2013). In this study, however, the ontology, epistemology, and other assumptions, including how they are related to the study, are stated.

While epistemology focuses on what is known to be true, ontology is concerned with the existence of, and relationship between, different aspects of society such as social actors, cultural norms and social structures (Snape & Spencer, 2003). It is basically the assumptions we make about the kind and nature of reality and what exists (Denzin & Lincoln, 2011). Interpretivism, as used in this study, is a philosophy that aims to integrate human interest by involving the researcher in interpreting elements of the study. Interpretivism is well suited for inquiries which have a lot of grey areas, like power-distance among a pilot group, as in the case of this study. Understanding why or how somebody feels or behaves in certain ways cannot be achieved through the analysis of numbers. Instead, it requires in-depth assessment of words, actions and behaviors of that person, including their environment (Hallebone & Priest, 2009).

For an interpretivist researcher, therefore, reality is multiple, and is socially constructed; the goal of the research is to seek understanding of an issue (power-distance), using the inductive approach (Saunders et al., 2012). Also, in interpretivist research, knowledge is generated through meaning, using a subject/researcher relationship that is interactive, cooperative, and participative. The data desired from this research include participant's thoughts on CRM, the kind of power-distance challenges they are confronted with, how they deal with those challenges, and the subjective meanings of their realities (Hennink et al., 2014).

As in the constructivist tradition, this study uses the assumptions of an emerging design. It assumes that reality is co-constructed between the researcher and the researched, and the outcome is a reflection of the way both sides "look at the world and make sense of it" (Crotty, 1998). It accepts participant's personal experiences associated with observation, feelings, and senses, along with subjective meanings, as a valid source of knowledge (Saunders et al., 2012). Such variety of data is necessary for a study of this nature that is aimed at generating a meaning – that of understanding and explaining the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots.

Constructivism also believe that there is no truth; rather, "truth is relative and constructed by the individual or society" (Denzin & Lincoln, 2018). It is an epistemological paradigm with a belief that knowledge is made up largely of "social interpretations rather than awareness of an external reality" (Stake, 1995). Reality is a construct of the human mind and is therefore subjective. Because of that, human behavior and actions are based on "the relative experiences they have of the society" and their perceptions of it (Porta & Keating, 2008). Crotty (1998) identified several assumptions about constructivism, three of which are related to this study:

(1) Human beings construct meaning as they engage with the world they are interpreting.

(2) Human beings engage with their world and make sense of it based on their historical and social perspectives.

(3) Meaning is social, arising in and out of interaction with a human community.

Furthermore, the constructivist starts by studying "the uniqueness of every human being," as defined by his cultural environment (Chowdhury, 2014). Therefore, the central role of the researcher is that of "gatherer and interpreter" because "the world we know is a particularly human construction" (Stake, 1995). In this study, the researcher "begins the research with some prerequisite knowledge" (he was born in Nigeria, he is knowledgeable about power-distance, and he is an airline pilot), knowing that the next step in the process "can bring to light something new about human behavior that he has never explored before" (Chowdhury, 2014).

Qualitative Research Methodology

The way people are, and how they understand the environment around them, is central to how they "interpret and make sense of their own life experiences" and the world in which they live in (Bohannan, 1969). Minichiello and Kottler (2010) reported that the qualitative research method was developed within the social and human sciences based on this perception about human beings. The methodology is particularly useful "in discovering the meanings that human beings attach to the events they experience" (Denzin & Lincoln, 2005); it is warranted when "the nature of the research questions require exploration and explanation" (Stake, 1995; Bogdan & Biklen, 2003). The main advantage of the qualitative methodology, Jones et al. (2006) further observed, is that through its in-depth examination of issues, it "can give researchers the ability to illuminate," and society the means to better understand, "the totality of a person or a problem."

While the traditional quantitative research methodology uses a deductive approach to test existing theories or hypotheses, the qualitative method uses an inductive approach "to build concepts and theories," usually because of the complexity of issues involved (Hatch, 2002). Thus, quantitative research is based on measurable quantities (Cowan, 2007) as opposed to the qualitative method that is an "ongoing process of reviewing different components and assessing them for goals, theories, questions, and methods" (Maxwell, 2005). Merriam (1998) posited further that because qualitative interviews are not limited to particular questions or scopes, "they can be redirected or guided by researchers or subjects for the purpose of discovering or revealing more knowledge" or data. Follow-up questions can also be formulated instantly to gain a clearer understanding of the persons and issues involved.

Furthermore, because qualitative data is dependent on human experiences, Cowan (2007) considers it to be "more compelling and powerful" than data gathered from quantitative research. This analogy applies to Nigeria, mainly because of the complexity of the country's cultural setting. The potential effect of culture on high-impact industries such as aviation in Nigeria is very concerning; resolving that concern makes the adoption of a deductive research methodology such as case study a good option. Part of the advantage lies in the method's overwhelming ability to "identify patterns and relationships" from the collected data (Yin, 2009) and thus "generate meanings" from them (Creswell, 2013).

Case Study Strategy

Since its introduction by Frederic Le Play in 1829 (Healy, 1947), the case study strategy has been used in various disciplines and described in multiple ways (Gay & Weaver, 2011).

Harrison et al. (2017) posited that of all definitions of a case study, the most common ones are those from the work of Stake (1995), Merriam (2009) and Yin (2014). They singled-out Yin, suggesting that Yin's main concern in case study is on the "scope, process, and methodological characteristics of the case." Yin (1984) had defined case study method as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used." Case study research is a useful strategy when there is need for a research that is aimed at doing "an in-depth or detailed examination" of a subject matter or case (Yin, 2014).

Stake (1995) view case study research as "the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances." The focus of case study, Stake (1995) argued, is on "what is studied (the case) rather than how it is studied (the method)." Merriam (2009), not only shared this view with Stake, but went further to include "what is researched" in a case study and "the outcome of the research" as part of what is needed in order to have "an in-depth description and analysis of a bounded system" that defines a case study.

Also, Creswell (2013), in describing what a case study does, posited that it can be used for "a concrete entity, such as an individual, a small group, an organization, or a partnership." The key issue, he emphasized in the same paragraph, is that a case study must have boundaries, or be describable "within certain parameters, such as a specific place and time." A case study method, thus, may be selected because of the unique value or inherent interest of the case or because of the circumstances surrounding it. It may also be chosen because of "the researchers' in-depth local knowledge" of the case (Fenno, 2014). Where researchers have such local knowledge, they are in a better position to "soak and poke" and thus be able to "offer reasoned lines of explanation" for the case based on their rich knowledge of the local environment, setting, and circumstances (Fenno, 2014).

Yin (1994), while explaining the advantages of a case study, also suggested that the methodology can be used to study "an event, an entity, an individual or even a unit of analysis." As an empirical inquiry method, it can be used to investigate "a contemporary phenomenon within its real-life context" through the use of multiple sources of data (Yin, 2009). Anderson (1993) added that because case studies are more concerned with "how" and "why" things happen, it is suitably equipped to afford the investigator an opportunity to study "contextual realities" and even "the differences between what was planned and what actually happened." Furthermore, Zaidah (2007) posited, the detailed qualitative accounts often produced in case studies, not only helps in "exploring and describing the data in real-life environment," but in "explaining the complexities of real-life situations" that are typically not captured during most survey research.

All these definitions show that case study methodology is better suited for research of this nature where the intent is not to study the entire aviation industry in Nigeria, but to understand a specific problem (effect of age and seniority on the communication aspect of CRM) within an environment (Nigeria) where the researcher has some amount of "local knowledge" of the issue (Fenno, 2014). Also, in terms of the different methods of exploration, Yin (1984) and Dudovskiy (2018) divided case studies into three main groups: *explanatory* case study where the focus is on a phenomenon that needs explanation; *descriptive* case studies whereby the researcher aims to analyze the sequence of interpersonal events after a certain amount of time has passed; and, *exploratory* case study in which the researcher tries to answer "how" and "why" an event happened or is happening.

This research is an *exploratory* case study, aimed at finding the answers to the “how” and “why” of the power-distance phenomenon inside the Nigerian cockpit. It is aimed at generating a meaning, with the intent to understand a specific problem – the effect of age and seniority on communication among Nigerian pilots. An analysis of the collected data will be done in order to have an “in-depth understanding” of the problem. *Exploring* and *understanding* the effect of age and seniority on the communication aspect of the CRM process among Nigerian pilots will add to the body of knowledge on the subject of power-distance among pilots.

Advantages of Case Study

There are multiple reasons for choosing a case study strategy to conduct this research. First, it offers the researcher an opportunity to gain “a holistic view” (Zaidah, 2007) of two instruments of power-distance (age and seniority) within a Nigerian institution. Secondly, given the many sources of evidence that will be used in the study, it provides the researcher with a rounded picture of the issues (Gummesson, 1991). Thirdly, it is more suitable in an exploratory analysis of this nature where the goal is to provide answers to the “how” and “why” questions which aim “to explain a certain phenomenon” (Yin 1994). Fourthly, a case study is useful in capturing the hidden issues emerging from a society that is deeply enmeshed in “complex cultural milieu” (Hartley 1994), as Nigeria is (Falola & Heaton, 2008; Hassan & Dina, 2015).

One of the reasons for the recognition and subsequent adoption of case study as a research strategy is that “researchers were becoming more concerned about the limitations” of quantitative research methods in providing “holistic and in-depth explanations of the social and behavioral problems” being investigated (Lovell, 2006). Tellis (1997) also posited that through the use of case study methods, researchers could gain “a better understanding of the process and outcome of a phenomenon” through the participants’ perspectives. That has an application in this study where the objective is to have a holistic and in-depth understanding of the power-distance phenomenon inside Nigerian cockpits.

Another advantage of case study includes the fact that “the examination of data is most often conducted within the context of its use,” or more accurately, “within the situation in which the activity takes place” (Zaidah, 2007). For example, in this research, the author is interested in uncovering the effect of age and seniority as power-distance factors on the communication aspect of CRM among Nigerian pilots. To explore that relationship between a senior and junior pilot in Nigeria, the researcher must seek the perspectives of the subjects or observe them within their cultural environment. This, Zaidah (2003) posited, contrasts with experiment, for instance, which “deliberately isolates a phenomenon from its context.”

In this research, the objective is to examine the data on the effect of age and seniority amongst Nigerian pilots “within the context” of the country’s high power-distance culture (Hofstede, 2001). Cowan (2007) observed that finding answers to the safety lapses in a system often requires many approaches due to the complexity of the problem. The complexity of the social and human constraints in Nigeria makes the case study strategy the logical choice for a better understanding of the failures within its institutions. Part of the reason for those failures lies in the country’s complex cultural boundaries and restrictions that foster high power-distance (Falola & Heaton, 2008). Age and seniority are major vehicles through which power-distance is expressed among Nigerians. Thus, any serious attempt at gaining a better understanding of the effect of age and seniority on the communication aspect of the CRM process among Nigerian pilots require the case study approach because of its ability to draw on the participants’ personal experiences, stories, and perspectives to get “an in-depth description” of the issue.

The Problems with Case Study

Case study research has many “points of interest” and “variables” that intersects and overlaps with each other (Stewart, 2014). Because of that, defining a case or unit of analysis and bounding it can sometimes be difficult (Zaidah, 2007; Merriam, 2009). Yin (2014) listed three types of criticisms against case study. Number one is rigor. “Rigor is a challenge in case study research,” because “too many times, the case study investigator has been sloppy,” and has allowed biased views “to influence the direction of the findings and conclusions” (Yin, 2014).

Another common argument against a case study research, Yin (1984) posited, is that it provides “very little basis for scientific generalization because of the small number of subjects.” The typical question, Yin pointed out, is: “How can you generalize from a single case?” Merriam (2009) answered that question by stating that non-generalizability is inherent in case study “by virtue of the high level of detail” and the time it takes for it to be completed, which in turn, “makes it imperative that fewer people will be studied” as compared to quantitative research.

The third case against case study is that it is “often labelled as being too long, difficult to conduct and producing a massive amount of documentation,” especially on case studies of ethnographic or longitudinal nature (Yin, 2014). The major danger with this, Tellis (1997) added, comes when the data are “not managed and organized systematically.” To resolve these concerns, Yin (2014) proposed three remedies: the use of multiple sources of data, the establishment and maintenance of a chain of data, and the possession of a draft case study report that is available for participants’ review after the study. In this study, multiple sources of data were used, a chain of data was created and maintained, and a rough draft of the data was sent to each participant for their review and comments before the final report.

Institutional Review Board Approval

The United States Department of Health and Human Services (DHHS) defines a human research subject as "a living individual about whom a research investigator (professional or student) obtains data through (a) intervention or interaction with the individual, or (b) identifiable private information" [32 CFR. 219.102(f)]. Research, on the other hand, is defined as "a systematic investigation, including research development, testing, and evaluation, designed to develop or contribute to generalizable knowledge" [32 CFR. 219.102(f)].

This project is a social science investigation with human subjects that involves human interaction as defined by DHHS [45 CFR 46.102(f)]. It involved the use of human beings as survey respondents and interview subjects for a program of research. As such, the Saint Louis University guidelines on the use of human subjects in research was fully complied with. All promotional materials and a roadmap for the research process received the approval of Saint Louis University Institutional Review Board (Appendix A) before the research was started.

Case Design

This case study research is shaped by "a thoroughly qualitative approach" that relies on narrative, phenomenological descriptions (Yin, 1994). Consistent with a case study design, pilot participants were purposively selected for surveys, questionnaires, and video interviews for data collection. The intent of the study is to understand a specific issue (power-distance) within a bounded system (communication and CRM process among pilots) in a real-life, contemporary context or setting (Nigeria) (Yin, 2009). Because the intent is to understand a specific issue or problem, it is considered an *instrumental* case study (Stake (1995).

In terms of design, Yin (1994) identified five components of research design that are crucial to a successful case study research of this nature, and which this research aims to follow. They are:

(1) Research questions: This refers to the “how” and “why” questions and their definitions. In this research, the two questions are: What are the effects of age and seniority as power-distance factors on the communication pattern between junior and senior pilots in Nigeria; and, how does the communication pattern between a junior and senior pilot in Nigeria affects the implementation of Crew Resource Management in the country?

(2) Case proposition or purpose: For an *exploratory* study of this nature, this refers to the purpose or “criteria upon which the success” of the research will be judged (Tellis, 1997). As clearly stated in Chapter 1, the *purpose* of this study is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of crew resource management among Nigerian airline pilots.

(3) Case unit or units of analysis: This is the primary unit of analysis that defines a case study. For a successful case study analysis, it is crucial that the unit of analysis is “firmly tied to the research questions” as well as being the focus of analysis itself (Yin, 2009). This study’s “case units” or “units of analysis” are *age* and *seniority* within the context of the high power-distance culture that is prevalent in Nigeria.

(4) The logic linking the data to its proposition or purpose: The connection between data and purpose is typically made as themes emerge following the data collection process (Tellis, 1997). Campbell (1975) identified pattern-matching, whereby pieces of information “from the same case” are connected to “some theoretical proposition” (Tellis, 1997) as a tool for achieving it. As data is analyzed, the emerging patterns are matched against the theoretical propositions of the case study. Those themes will serve to answer the research questions.

(5) Criteria for interpreting the findings: This requirement and that of “linking the data to its proposition” (component 4, above) are typically the two least developed aspects of any case

study research (Yin, 1994). In a case study of this nature, however, the coding typically occurs before theme development (Yin, 2009). After theme development, the "meanings" from the findings will be used to decide how well the research objectives have been met and the implications for any future inquiry.

Research Setting

The research setting can be described as the physical, social, and cultural site in which the researcher conducts a study. The focus of this study is on power-distance, a cultural issue that "people in a certain environment adhere to" (Ailon, 2008). Because of the need to capture the requisite data from people who are involved in their "normal cultural environment," it makes sense that the setting for this study should be in that locality, which in this case is Nigeria. That was done, virtually. Due to the impact of COVID-19 pandemic, and the associated closure of national airspaces in many countries of the world, the research setting was changed form person-to-person interview to online video interviews. So, from his location in the U.S., the researcher conducted the research by video with the respondents from their homes in Nigeria.

Online research refers to situations where the researcher places themselves within the research context, becoming an active participant-observer in the online setting (McKee & Porter, 2009). Data collection involves significant interaction between the researcher and participants. The greatest challenge to online research such as this one, is with security and privacy issues (McKee & Porter, 2009). To minimize the chance of a security or privacy breech, the researcher of this research followed all the guidelines established in the data protection section.

Research Participants

This study used purposive sampling to select 12 Nigerian pilot participants, comprising of 6 captains and 6 first officers. There were 10 men and 2 women in the group. All of the participants were selected based on the following five qualifiers:

(1) Participants must be qualified and licensed pilots with a minimum of Commercial Pilot License (CPL), Instrument Rating (IR), and Multi-Engine (ME) Rating.

(2) They must currently be flying for a Nigerian-registered company (if holding a non-flying position, must have flown in Nigeria for not less than five years in the past ten years).

(3) They must be Nigerian-born citizens.

(4) They must have been raised in Nigeria (through elementary and high school ages).

(5) They must be at least 23 years old.

The above qualifiers for participation in the study are established for the sole purpose of attaining base selection standards in the research. The requirement for Nigerian-born citizenship, for example, is necessary for a study of this nature where the objective is to generate meaning on a cultural issue that is prominent in Nigeria. For that reason, pilots whose parents are Nigerian citizens but who were born and raised in a foreign country and who, after that, moved to Nigeria are excluded from the study. The rationale behind that decision is the need to ensure that different cultural values acquired during childhood upbringing do not interfere with the distinct Nigerian cultural perspective on age and seniority that is the focus of the study. Also, because the experiences and perspectives of captains on power-distance are not representative of the first officers' in the study, the participants were purposively selected, and sampled separately, depending on their position in the cockpit.

This case study is designed to be accomplished with 12 participants, inclusive of all the research qualifying characteristics. Guest et al. (2006) proposed that saturation, or the point where additional participants do not provide any new insights, often occurs at around 12 participants. Crouch and McKenzie (2006) have also opined that for practical purposes, fewer than 20 participants in a qualitative study helps the researcher in building and maintaining a close relationship with them. Having a few participants can also improve the open and frank exchange of information between them and the researcher that are valuable for trust, complete data collection, and future engagements.

As of December 2019, there are approximately 2,500 pilots actively flying in Nigeria (Nigeria Civil Aviation Authority [NCAA], 2019). Of that number, 2,380 are males, and 120 are females. Of the total number, about 2,350 are Nigerian citizens, out of which 42 percent are captains while the remaining 48 percent are first officers. Air Peace and Arik Air are the two major airlines in the country, employing about 50 percent of the pilots (NCAA, 2019). Other airlines, charter operators, and corporations combined employ the remaining 50 percent.

Because of the small number of pilots scattered across a relatively large number of small-size airlines in the country, the researcher made a decision to broaden the participant pool by making the research open to all qualified Nigerian-born pilots, irrespective of the company they work for in the country. He also decided to purposively select participants that meet the set criteria for the research. This type of purposive selection, Kuper et al. (2008) posited, are necessary for sampling the appropriate number of subjects with the ability to "inform important facets and perspectives related to" the issue being studied.

To gain an "in-depth understanding of the relevant and critical issues in case study investigation," purposive sampling is a good strategy because it can lead to the choice of participants that "can contribute to the richness in the range of data collected and help increase the possibilities of uncovering multiple realities" (Patton, 2002). Wan (2019), shared the same view, acknowledging that while “humans can be a difficult factor to control among the variables in research,” the “researcher’s judgment in selecting information-rich individuals” for a case study is “critically important” for its success.

Thus, aside from meeting the set criteria, the participants were selected based on this researcher’s “judgment” that such individuals will be able to provide “the information-rich data needed for the research” (Mills et al., 2010). In the case of this research, age and seniority are power-distance factors derived from the national culture of the Nigerian people. Any attempt at understanding how those factors impact people’s lives and thus contribute to the high power-distance in the society, and by extension, its aviation sector, requires the selection of participants who are “living and experiencing” those factors within the society (Liamputtong & Ezzy, 2009).

As a way of gathering “information-rich data” for the study, a purposive selection of captains with a minimum of 15 years’ experience in the industry was made. The need for captains with 15 years’ experience was informed by the need to draw on the experiences of pilots who lived through what has become known in the Nigerian aviation industry as the “pre-2006 era.” 2006 was the year that a new aviation policy was promulgated in Nigeria. It was that policy that led to the introduction of CRM in the aviation industry. The first officers were selected based on their responses to the online survey which indicates substantial personal experience in the industry’s power-distance issues. Table 2 below shows the participants’ demography.

Research Participants’ Demographical Information

Participant ID	**Position**	**Gender**
XPB	Captain	Male
XPC	Check Captain	Male
XPF	Captain	Male

XPG	Captain	Male
XPK	Captain	Male
XPL	Check Captain	Male
XPM	First Officer	Male
XPO	First Officer	Female
XPT	First Officer	Male
XPV	First Officer	Male
XPW	First Officer	Female
XPY	First Officer	Male

Table 2: Participants' demographics.

Researcher-Participant Relationship

This research relied mainly on each participant's voluntary co-operation in giving detailed responses to surveys, questionnaires, and interviews. Ethical research, Lave and Kvale (1995) posited, is about reciprocity. Reciprocity, they added, is about the balanced pattern of "giving and taking" that takes place between two people or groups. In return for the participants' contribution in voluntarily participating in the research process, the researcher showed that he was actively engaged and attentive as they shared their stories. Active listening and engagement are crucial, especially in research that is aimed at "advancing social dynamics or investigating the root causes of human conflicts" (Charmaz, 2006). Samovar et al. (2009) posited that disengagement and poor listening skills are at fault in many cases of "misunderstanding in day-to-day communication," including research works. In this study, the researcher's decision to place ample emphasis on active listening and engagement was instrumental to the successes that he enjoyed with the participants.

Furthermore, an excellent researcher-participant engagement involves "evaluating and scrutinizing the participants' words and emotions," being part of their life stories, and "making them valued partners" in the research process (Samovar et al., 2009). That was done early in the process, and the researcher discovered that the participants were willing to be engaged for as long as they get his attention and interest. Marx (1998) termed this type of relationship "engaged listening," and it signifies to the participants that the researcher feels *what* they are feeling, understands *why* they feel that way, understands *how* they see things, is interested and concerned about *what* they are saying, and does not wish to judge them or change their opinion. This type of researcher-participant relationship, Van de Ven (2007) posited, is what sets the tone for the "direction, process, and eventual outcome" of a good research. It did so in this research.

Data Collection Procedures

Collection Process

Because of the challenges posed by the COVID-19 epidemic at the commencement of this research in early 2020, the decision was made, and approval granted, to conduct the entire survey and personal interviews using the online video and audio services available from Zoom and Skype. That eliminated the need for physical contact or "face-to-face" interviews, thus abiding by the social distancing regimen that both the World Health Organization (WHO) and the U.S. Center for Disease Control (CDC) recommends for curbing the spread of the disease.

The National Association of Airline Pilots and Engineers (NAAPE) is the umbrella trade union for all Nigerian pilots, inclusive of all airlines. They have a robust presence online, and many of the pilots are active on it. Another group is the West African Aero Club. Its members are very active in using the online social media Telegram to exchange ideas on the aviation industry in the country and globally. A vast majority of the over 2,000 Nigerian pilots are active online through either or both groups. The researcher utilized the services of both groups to recruit potential participants for this study.

Once the approval for the research was secured from Saint Louis University Institutional Review Board (Appendix A), a formal contact was made with Nigerian pilots through those professionally-based media outlets. A recruitment statement (Appendix B) was posted on both groups' website, inviting all interested pilots to contact the researcher. As soon as the participants' responses were received, a research document form (Appendix C) was sent to them by email, seeking their consent to be part of the study. The consent form details the purpose of the study alongside an explanation of the risks and benefits involved. It explains the ethical protection for all participants in the study, alongside a provision for the respondents to sign and return it to the researcher electronically.

After agreeing to participate in the study and signing the consent form, an online survey (Appendix D) was emailed to the participants. The research survey is designed to guide the researcher in identifying pilots who meet the research criteria, based on previously mentioned characteristics. In order to obtain the most abundant possible source of information to answer the research questions meant to guide the study, the survey seeks for demographic information on the participants that are deemed necessary to satisfy the research requirements.

When the responses from the preliminary research survey were received, the researcher analyzed them to select the best respondents (captains and first officers) that met the research criteria. After that, a formal invitation letter (Appendix E) was emailed to the participants, inviting them to participate in the study. The names of the selectees and any other identifying information was secured by way of letter codes. A master key to decipher the letter codes was kept in a safe and separate double-locked location for security. All information about the location and content of the said master key will not be made known to anyone besides the researcher and the research supervisor.

In the data collection process, no time limit was placed on the in-depth interviews. That was meant to give participants sufficient time to share the breadth of their experiences with power-distance and its influence on CRM in the industry. Thus, on average, each interview lasted between 2 and 3 hours. The audio portion was digitally recorded after the researcher had obtained the participant's permission to do so. After that, the recordings were transcribed verbatim and reviewed word for word for accuracy by the researcher. The interview transcripts were sent to the participants (Appendix G) for their "review, debriefing, and comments" (Denzin & Lincoln, 2005). The recordings and other research documents will be destroyed after the research is completed, as described under data protection procedures. Also, to protect the privacy of the participants, they were advised, ahead of time, to pick a convenient and safe location, preferably in the privacy of their homes or hotels, for the interview.

The survey in this study is composed of questions that are semi-structured and open-ended. Guba and Lincoln (1994) posited that semi-structured questions offer sufficient flexibility to approach different participants and their experiences in different ways, while still covering the same areas of data collection. An open-ended question, Patton (2002) added, "are without presumptions," and thus, "allows the respondent to express himself or herself freely on a given subject." Because they are non-directive, they allow respondents to use their own terms and direct their responses at their convenience.

Open-ended questions can also be used "to see which aspect stands out from the answers" and could thus be interpreted as "a fact, behavior, or reaction typical to a defined panel of respondents." The format helped in keeping the conversation on the topic and in obtaining as much information as possible. Jakobson (1990) posited that when people answer *what* and *how* questions, they usually have to respond “in full sentences.” In that way, their responses are more detailed, and gives less room for non-factual claims, than they would be if the questions were of the ‘Do you…’ type, which typically elicits the more straightforward “yes” or “no” answer.

Another main advantage of an open-ended question is that it allows for “clarifications on some responses that are considered not adequate” (Hancock & Algozzine, 2015). An example of such a question in this study is, “Can you remember any incident or conflict between you and your captain in the cockpit (No Names) that you think is not good for safety?” From the question format, respondents are free to describe their experiences “in their own words.” Their responses and choice of words, Hewson (2014) added, can be useful in developing follow-up questions. For example, after describing a specific incident in response to the above question, the interviewer may ask for clarification on one or some of the aspects mentioned by the respondent.

One critical characteristic of the open-ended question format however, is that it may produce unexpected results during research (Konstantakopoulou et al., 2014). This, Hancock and Algozzine (2015) added, is what makes the research “more original and valuable.” The down-side of it, Weller et al. (2018) posited, is that “uncontrolled” interview formats can become “the impetus for interviewees to evoke their emotions on situations that they feel strongly about,” thus, compromising the dependability of their responses. For example, during a discussion on how to improve aviation safety in Nigeria, one respondent abruptly veered into contemporary politics and asked, “What’s the point of this research? Don’t you think you are wasting your time? Do you really think these people in government are going to read your paper and act on it?” When the researcher tried to explain to him that the research is an academic work aimed at generating knowledge on the topic, he smiled wryly and responded: “What knowledge? And what purpose is that knowledge if it does not lead to changes?"

To minimize such "uncontrolled" situations, Lewis-Beck et al. (2004) suggested that it is essential for the interviewer to give respondents "a framework" when using open-ended questions. Without a framework, interviewees "could be lost in the full range of possible responses," and that "could interfere with the smooth running of the interview." Another justification for a framework in qualitative research, they added, is to help the researcher "in evaluating participant responses" and in developing follow-up questions. To achieve those objectives and minimize the chance for bias, this researcher made sure that there are no leading questions. The questions were sequentially-arranged, with the less-sensitive ones asked first.

Data collection, as explained earlier, was a continuous process. As it progressed, the researcher documented the answers emerging on the nature of the data, their meanings, and the incidents that they represent. Also, the memos, as recorded, were explicitly designed to capture the researcher's perspective on the data, any question or observation that may arise from the data analysis, and any inherent bias present in the process.

In making sure that every theme emerging from the collected data represents an experience of age or seniority and thus be able to answer any question that may arise from the subsequent constant comparison process (Glaser & Strauss, 1967), "theoretical sampling" was conducted on some of the data. Theoretical sampling involves the exploration and verification of some aspects of the participants' experiences and statements, especially on some of the concepts that are eye-catching or what Glaser (2008) described as "grabbing," to be sure that they are truly representative of a power-distance cultural phenomenon that exists in the Nigerian society.

For example, when a participant made a claim about "training fraud and cover-up" concerning his dispute with a senior colleague, this researcher decided that the accusation is unusual or “grabbing” enough to warrant further exploration and verification. To verify the story and justify its relevance to the research topic, the researcher searched newspaper archives from the time of the incident. He talked to officials of the country’s aviation regulatory agency who investigated the incident at the time for further verification. After the researcher has established that the fraud allegation was factual and the act of covering it up was “partially successful” (Punch Newspaper, 2019) due to the influence of seniority within the pilot group, he decided that it is worth being included in the study.

The interview format, as initially designed, was amended on a case-by-case basis during the research. Some of the amendments were due to situations that are beyond the control of the researcher and participant. Others were done for participant convenience. For example, one participant’s interview was conducted using Skype audio due to weak and unstable internet connection. Another participant was video-interviewed twice; the third time was a phone interview due to insufficient time on his part. The researcher followed the same process of explaining the procedures and participant’s rights before each of the interview sessions.

Another issue that presented both challenges and opportunities in this research is the lockdowns, occasioned by the COVID-19 pandemic. The inability of the researcher to meet the participants for a face-to-face interview was a challenge. On the other hand, the lockdown meant that most people were confined to their homes for a long time. For professional pilots who are accustomed to being away from home, the challenge of being restricted to their compounds was unraveling for many of them. It was, however, an excellent opportunity for the researcher, as he had unfettered access to most of the participants.

With time on their hands and probably free of other responsibilities, many of the participants were willing to talk to the researcher at all times, including night times. Some called to add to or correct their previous statements; others called to know if the researcher has follow-up questions for them. While some of them followed the script in the way they responded to the interview questions, others jumped from one topic to the other at will, making it difficult to control the interview's flow and direction. Most of the respondents were motivated and attentive to the discussion; a few were distracted, and from their body language, would rather be discussing contemporary issues in domestic and international politics than aviation safety.

While many of the respondents were motivated and believed that "something good" will come out of the research, others held pessimistic or mundane views about it. In one instance, a respondent asked how much the researcher was being paid to conduct the study, and if part of the money will be "shared" with the participants. When the researcher pointed out that all that information is detailed in the recruitment statement (Appendix B) and the research document (Appendix C), copies of which were signed by the respondent and available to him, he feigned ignorance for some time. After a few seconds, he replied that he thought that the documents he signed were "just official documents to make things look legal," but that "the rest of the arrangement" will be discussed in privacy between him and the researcher because that is "the usual way of doing business in Nigeria."

This type of unrehearsed questions and comments occurred regularly in the research. It put the interviewer in an unexpected position, and where he has to be able to respond candidly and informatively to the participant. That particular incident highlights the challenges of doing research in an environment where corruption or "the usual way of doing business" is rampant, and people are reluctant to partake in any venture without inducement, especially when they believe that every promoter of a project and people with power "always has something to gain" from the process. It also brought to fore the need for interview rehearsals by the researcher, as suggested by Labra et al. (2019), before undertaking a study of this nature that involves social and cultural issues where people are, most times, very passionate about their positions and willing to ask impromptu questions.

Types of Data

The types of data collected in this study included surveys, recorded interviews, notes and observations.

(1) Surveys: The questions in the survey are semi-structured and open-ended, thus, allowing for clarifications. The surveys were conveyed to the participants primarily via secured emails as well as by links to the online Qualtrics portal.

(2) Interviews: All interviews were conducted individually using the online video and audio services provided by Zoom or Skype (Appendix F). Only the audio portion are recorded using a digital voice recorder and, after that, transcribed for analysis. Such voice recording will be destroyed after the research and after the names and other identifying information on them are deleted as per the Saint Louis University (SLU, 2018b) data security management policy. The interview settings for the study is such as to encourage open discussion, mutual interaction, and challenge and response between the researcher and participant. Mayring's (2003) concept of "communicative validation" that allows participants to re-affirm, amend, or add to their initial responses was fully encouraged.

(3) Notes and observations: Aside from the surveys, one-on-one videos, or audio interviews, the researcher wrote down descriptive and reflective notes that cover his observation of the attitude, demeanor, body gesture, and the communication style, tone, and pattern of the participants during each Zoom or Skype video interview session.

Data Protection

This study was conducted using the online video and audio services provided by Zoom and Skype. Thus, there is an increased need to protect participant information in the study. The Personally Identifiable Information (PII) from the research data falls within the *Coded* category as defined by the Institutional Review Board (IRB) of Saint Louis University (SLU, 2018a). That means that all identifying information, such as name or social security number, was replaced with a number, letter, symbol, or a combination thereof (the code), and a key (master key) to decipher the code exists somewhere; that key can be used to link the identifying information to the participant data. In this study, however, the PII that is available for coding are participant names, age, gender, and current and previous airline jobs (SLU, 2018a). Protecting that information is critical for participant confidentiality, trust, and research credibility.

The IRB has confidentiality guidelines that must be maintained by investigators who conduct research involving human subjects (SLU, 2018b). Part of that guideline is that restriction should be put on the amount of data and identifiers collected during the research to the minimum required; it also advocates restricting the number of people who have access to the data and its storage location. The researcher strictly followed those guidelines to ensure that all data are entirely de-identified and securely protected throughout the research period.

Other measures that are aimed at ensuring maximum data protection and participant confidentiality during the research process includes the following:

(1) The procurement and use of a brand-new laptop for conducting the research.

(2) The installation and use of Virtual Private Network (VPN) on the laptop for the research.

(3) The use of an encrypted external device for storing the collected research data.

(4) The use of a second encrypted external device for storing the master key containing the identifier codes.

(5) The provision of a separate digital audio recorder for each interviewee, and the encryption of such with passwords, to record the audio portion of the Zoom or Skype interviews.

(6) The use of complex passwords that combines different types of alphanumeric characters in unique ways for accessing the applications, operating systems, and encryption schemes used in the research.

(7) The use of top-coding, whereby values which might uniquely identify a subject, are replaced with flat values. For example, a pilot who has worked in the airline industry for twelve years, and another one who has worked for seven years are both assigned "6+" as years of service. Such alterations are specifically aimed at decreasing the risk of information disclosure and the accuracy of inferences that anyone can make out of the data if it is ever compromised.

(8) The destruction of all voice data recordings after the research, and after the names and other identifying information on them are changed or removed as per the Saint Louis University (SLU, 2018b) data security management policy.

Data Analysis Techniques

This study employed thematic analysis procedures for analyzing the transcripts from the collected data. Thematic analysis, Braun and Clarke (2006) suggests, is the first qualitative method that should be learned by the researcher, as "it provides core skills that will be useful for conducting many other kinds of analysis." It aims to extract "themes" from a conversation or statement by analyzing each word and sentence for a recurring pattern of words that "are important to the specification of a phenomenon" (Mills et al., 2010). As done in this research, coding is part of the thematic analysis process: its main objective is to provide flexibility in interpreting an extensive data set by sorting through it to find commonly-used words and concepts in the narrative.

To expedite the process, a thematic analysis software, NVivo 12, was deployed for coding the data. The software scanned the data to identify common themes - topics, ideas, and "patterns of meaning that come up repeatedly," during each conversation (Guest et al., 2012). One of the main advantages of the software, aside from the fact that the researcher does not need to set up the codes and themes in advance, is that it can easily capture the "unknown unknowns" of categories that the researcher may not have been able to spot in a manual procedure (Nowell et al., 2017). Its use, thus, helped in achieving an efficient and expedited thematic analysis process in the research.

In order to assure a thorough thematic analysis process, the researcher followed the six steps of analysis, as developed by Braun and Clarke (2006):

(1) Familiarization: This step involves getting to know the data. The researcher made a concerted effort to understand the collected data before analyzing them for individual items. That involved transcribing the recorded audio conversation into text, reading through the text and taking notes, and "looking through the whole data to get familiar with it."

(2) Coding: Coding is the process of highlighting sections of the data text - typically phrases or sentences - and coming up with a proper label or "code" to describe their content. The researcher used NVivo 12 software to scan the interview transcripts and highlight words that "jumps out as relevant or potentially interesting" in the text. Such words or collection of words

were subsequently collapsed into a single word or code that best explains the emotions that the respondents were trying to convey.

A typical example is a description of “scared,” as narrated by a participant: “He (meaning the captain) looked and talked in ways that made me scared of him.” Using the *inductive coding* process, the researcher determined that “fear” as a code is strong enough to adequately represent the negative emotional state that the participant was trying to convey. Thus, “fear” is deemed to express the deep meaning of scared, afraid, and fear in a single word. The development of such codes offers a condensed overview of the main points and common meanings that recur in the data. Below is another example of coding as developed from the text of a conversation with a respondent.

> I am not sure. I think there is power-distance between captains and first officers, but I believe things are changing. People say we should trust the white people because they are the experts, but who is to say that white people don’t have their own agenda for pushing this narrative? I am not saying they are wrong; I’m just saying we should not completely trust what they are telling us. The procedures are changing every day. Even the CRM process has changed many times. The industry is continuously evolving.

From the above transcript, the codes emerging from the conversation include the following:

(*a*) *Uncertainty*: “I am not sure;” “I am not saying they are wrong;”

(*b*) *Distrust of outsiders*: “who is to say that white people don’t have their own agenda for pushing this narrative?” “we should not completely trust what they are telling us.”

(*c*) *Change*: “I believe things are changing.” “The procedures are changing every day.” “The industry is continuously evolving.”

(3) Generating themes: From the codes, the researcher identified the patterns among them, and started collapsing them into “themes.” For example, the three codes of uncertainty, distrust of outsiders, and change, discovered under “coding” above, can be grouped into a single theme with the title of “doubt” or “uncertainty.” In this process, some codes were discarded

either because they were considered too vague or not relevant enough; other codes were considered strong enough to become themes.

(4) Reviewing themes: This is a review step during which the researcher compared the generated themes to the data to know if anything is missing or if there is anything that can be done to improve it. In this process, some themes were split or combined while others were discarded. The objective is to be sure that the themes are useful and accurately represent the collected data. The researcher repeated this process until it was inevitable that theoretical saturation has occurred, evidenced, according to Crouch and McKenzie (2006), by the fact that no new properties, dimensions, or relationships are emerging from the data anymore.

(5) Defining the themes: This step, according to Braun and Clarke (2006), is that of coming up with an appropriate name for each theme, defining them, and figuring out how they help in understanding the data. In this step, the researcher made concerted efforts to match the theme names with the contents.

(6) Memoing: This is the final step in the process, and it involves writing the analysis of the data, including the name and meaning of each theme and what they represent in the data. It is the accumulation of all written ideas or concepts that will eventually transform into research findings. Memoing, thus, enables the researcher to “conceptualize the boundaries and properties” of each category and to “illuminate gaps” in the emerging discovery, thus leading the researcher to areas that need sampling (Savin-Baden & Major, 2013).

Because of its importance in refining and keeping track of ideas that develop when “comparing likes to likes,” Glaser (1998), believes that memoing represent “the core stage” of qualitative research. Corbin and Strauss (2008) also believe that memoing is essential as a way of avoiding bias, and “as an aid in smoothing the researcher’s ideas” and “gaining analytic distance." Avoiding bias is essential, especially in a research of this nature where the author, as the sole researcher, is affiliated with the country and the industry, and the research topic is one where the participants' perspectives can be extremely subjective.

Trustworthiness

Credibility Tests

Interpretive researchers view social reality as being "embedded within social settings" (Giorgi and Giorgi, 2003). Thus, they tend to interpret reality through an analytical process rather than a hypothesis testing process. That, Bitsch (2005) posited, raises fear in some quarters about the "credibility and dependability" of interpretive research. He thus proposed a series of ways to ensure credibility in research, such as the need to re-check data and interpretations with subjects. To achieve that, the researcher, as mentioned earlier, conducted as many interviews as possible until all categories were saturated, and no new themes were emerging.

Because of difficulty in determining when categories are saturated, Creswell (2013) has suggested the use of *discriminant sampling* – where the researcher gathers additional data from sources outside the research participants. The purpose, Hatch (2002) argued, is to "corroborate" some of the participant statements with other industry members. This was done in this study, as exemplified by the "training fraud and cover-up" claim stated earlier. This research also followed Denzin and Lincoln's (2005) suggestion that additional verification should be made by way of *member-checking*, whereby rough drafts of the project are sent to the research participants for their "review, debriefing, and comments" (Appendix G).

As detailed in the data collection section, member checking was done in this research. A transcript of each interview conversation was sent to the interviewee for comments. Some of them called the researcher to make additional comments. Others wanted to clarify some of the points they had made earlier. In one instance, a participant called several times and left messages for the researcher. When he finally got through to the researcher, he pleaded that some of the negative things he had said about another crewmember should be deleted. He stated that he got the information that day that the individual he used those negative words against had passed away. As a Muslim, he stated that it is against his religion to say negative things about someone who is no longer alive to defend himself. Besides, he added, “it is against African tradition to say evil things about a dead person.”

In another instance, a participant called the researcher on the phone and wanted him to know that it is “perfectly okay” to mention his real name in the research papers. He stated that the challenges facing the Nigerian aviation industry is bigger than him as an individual. As such, if he should lose his job or “face any other problem” because of his opinion, he is “ready for it,” as long as his voice is heard alongside his name. He followed it up with a selfie picture of himself to the researcher and insisted that it should be added to his statements in the research so that “the powers-that-be can know” that it is him. “I want them to know it’s me. I am not afraid of anyone,” he proclaimed. The researcher explained to him that this is an academic research and not a protest document; and that his request is against Saint Louis University research guidelines and as such, is not acceptable. He grudgingly accepted the researcher’s explanation and after that, offered an apology for “misunderstanding the intent” of the study.

Reflexivity

Reflexivity refers to the part a researcher plays in the generation of knowledge (Lincoln & Guba, 1985; Denzin & Lincoln, 2003). Giddens (1976) described reflexivity simply as “self-awareness” while Gouldner (1970) elaborated further on self-awareness by positing that the concern of the researcher during the research should not be "with discovering the truth about a social world regarded as external to the knower," but rather with "seeing truth as growing out of the knower's encounter with the world." Hatch (2002), on the other hand, described it as a measure of the researcher's ability to "keep track of one's influence on a setting, to bracket one's biases, and to monitor one's emotional responses."

In order to prove that reflexivity and a state of awareness have occurred, Gouldner (1970) has argued that there are key questions that must be answered: how has the research transformed the researcher and how has it changed the participants' awareness or knowledge of the subject? Berger and Luckmann (1966) posited that during data collection and analysis, "reflexivity should be filtering through the existing information, beliefs, and experiences of the researcher." It is that filtering of data into the belief system of the researcher that creates self-awareness. However, as Hatch (2002) explained, problems can sometimes arise when researchers' attention is so focused on the research subject that they lose sight of the "self."

The loss of the "self" in this context refers to the possible failure of researchers to create assumptions about themselves, the way they do about the research participants. For example, in this study, the researcher is conscious of the fact that as a captain, he is regarded as a power-holder in the industry by certain people. Because of that, there is a probability that some of the junior crewmembers will not be forthright with him in answering the research questions, thus displaying the same power-distance between unequal crew members that is the subject of the study. To resolve those concerns, the researcher made an effort to create a level-playing field in his communication with the participants. Thus, he insisted on a first-name relationship with all of the participants as a way of enhancing low power-distance.

However, while the researcher took those steps to resolve his assumptions about the research participants, he may not be making any assumption about himself: What ego or other personal attributes did he bring to the study? Did he use his seniority to his advantage in getting research information from the participants who are junior to him? What personal question or conflict was he trying to resolve by choosing this topic? Is he doing it as an answer to some of the issues he encountered when he was a first officer? In the context of this research, these are some of the often-unrecognized assumptions by a researcher about the "self."

Alongside the need for this self-awareness is the researcher-participant relationship dynamic. Lave and Kvale (1995) have opined that "the only instrument that is sufficiently complex to comprehend and learn about human existence" is another human. Thus, in constructivist thinking, it can be argued that "virtually no information about a person, group or social system exists without a relationship with that person or social system" (Berg & Smith, 1988). As such, in research such as this, where the topic is one with which the researcher has a "relationship" by virtue of his birth and upbringing in a country with a high PDI (Hofstede, 2001) and will be working with participants who are professional colleagues, the need for self-criticism and self-reflection cannot be ignored.

Reciprocity

Reciprocity is about the balanced pattern of "giving and taking" that takes place between two people or groups (Lave & Kvale, 1995). While research relationships are not always or necessarily reciprocal, a good research ethical practice requires that researchers consider what they take from research participants as well as what they give in return (Denzin & Lincoln, 2005). Instead of continuously focusing on the researcher as the sole driver of success, it aims to recognize the participant as an important and indispensable partner and collaborator to the success of the study.

In this research, concerted effort was made to make the participant a valuable partner and collaborator in the project. Collaboration implies reciprocity. While there is no any financial or material compensation involved in the project, the friendship, camaraderie, and mutual respect gained from the research collaboration implies "mutual responsibility and reciprocity" between the researcher and the participants, something that can potentially lead to a win-win situation for both sides (Lather, 1986).

Summary

This chapter set out to describe the methodology that was employed in this case study research, the purpose of which is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots. The general characteristics of case study, its processes, and procedures were discussed. The chapter talked about the opportunities that case study design has afforded researchers, especially in seeking or generating meanings and explanations that deal with complex phenomena in social life. It explained that participant-observation in case studies make the researcher an active participant in the events being studied.

The researcher's interpretivist philosophy and constructivist worldview that guided this research, the rationale behind the adoption of qualitative research methodology for the research, and the advantages inherent in the case study strategy were discussed. The data collection process was explained, especially the need to use the facilities offered by online video and audio services such as Zoom and Skype as a way of abiding by the social distancing rules that are aimed at reducing the spread of the Covid-19 epidemic. Also, the need for multiple forms of data, sources, and methods to corroborate the covered evidence was described as necessary in triangulating the collected data, and in creating credibility for the research. Data analysis techniques, including coding and memoing, were explained.

The procedures applied to ensure that the research is credible and trustworthy such as triangulation, member-checking, reflexivity, double-reflexivity, and reciprocity, were also discussed. Finally, ethical measures aimed at protecting the fundamental rights and privacy of the participants in the study, as well as the mutual benefits of a researcher-participant partnership that can outlast the research process, were explained.

CHAPTER 4: RESEARCH FINDINGS

Introduction

The two questions that guided this study are: What are the effects of age and seniority as power-distance factors on the communication pattern between junior and senior pilots in Nigeria? How does the communication pattern between a junior and senior pilot in Nigeria affect the implementation of CRM in the country? To answer those questions, a case study strategy was used to gather research data from 12 Nigerian-born pilots. The results are detailed here.

Even with the researcher's cultural familiarity with the Nigerian environment and his many years of experience as a professional pilot, the findings in this study were startling in light of the threat posed to aviation safety. It revealed critical weaknesses in the CRM application process and overall aviation safety in the country that needs to be resolved. Those weaknesses emanate from the power-distance culture that is prevalent in Nigeria and most African societies. The need to improve aviation safety in Nigeria calls for an immediate resolution to those CRM weaknesses. Resolving them, however, starts with an understanding of the causative factors.

Analysis of Survey Questions and Responses

A review of the responses to the survey questions reveals that all the respondents have a clear understanding of the link between CRM and aviation safety. However, 33% of the participants do not believe that there is any link between Nigeria's national culture and the application process of CRM in the country's aviation industry. Linking the two together, one of the respondents insists, is not only disingenuous, but a ploy to "confuse the issues." The issues, he explained, are straight-forward: "Respect is a crucial part of our culture. When the followers respect the leader and follow instructions, there will be less rancor in the society. Progress can only happen when there is peace and harmony. The same applies to aviation safety." Another captain explained further: "The captain is in charge, and that is the way it has always been. Any first officer who wants to exercise the captain's powers will have to wait for his time. A junior first officer cannot disrespect a senior captain in a cockpit and assume that there will be peace. It can only lead to chaos."

While the remaining 67% of the participants agreed that culture has some effects on aviation safety, only half of them see it as "definitely" an impediment to implementing a functional CRM in the country. The other half sees it as "possibly an impediment." For the last group, they are uncertain whether a change in culture is a solution. In the context of change, unsure of its implication for the industry, one first officer asked: "Are you implying that safety can only be assured if we have two captains in the cockpit? How will that work?" Another one was more direct to the point: "How can I question a captain who is old enough to be my father?" He continued: "That man was already a captain when I was a toddler. He introduced me to aviation and taught me everything that I know today. How can I disrespect him?"

These statements on age and seniority in Nigeria presents compelling perspectives on the prevailing culture in Nigeria. They also expose the *relevance paradox* of the issues that these pilots perceive as relevant to them. The International Society of Air Safety Investigators (ISASI) Guidelines on Investigating Human Factors defines *relevance paradox* as that which occurs "when people only seek or expose information that they perceive as relevant to them" (International Society of Air Safety Investigators, 2009). Under such a situation, any other information, data, or general truth that are not perceived as relevant are not given any prominence or are relegated to the background. When that happens, "tunnel vision" sets in and the focus becomes one directional.

In the case of these first officers, their reference point for safety is what they recognize as the top post that they aim to achieve in their career – captain. Any finding that can be viewed as uncomplimentary of their captains is outside their relevance paradox and are not given attention. Their statements also help in striving towards that "holistic understanding of cultural systems of action" that Feagin et al. (1991) defined as the "quintessential characteristic of case studies."

These definitions have some application for this study that is aimed at understanding an issue that is part of the "cultural systems of action" or beliefs among Nigerians. In this study, one of Nigeria's cultural systems of action is power-distance. Age and seniority are two of the significant enablers of power-distance. While the former is applied society-wide and derives its power strictly from the tradition of deferring to people of older age, the latter may be described as the combination of age and other social indices such as rank or status and longevity in a position. They are the major pillars behind the power-distance phenomenon in Nigeria.

Codes from the Data

Coding, as done in this study, is not just about labeling passages that explain "what the respondent is saying," it is also meant to "link the data to the research idea" (Gibbs, 2007). The use of NVivo 12 software was particularly helpful in expediting the coding process. Ninety-eight codes emerged initially from the data. The process of "refining and fine-tuning" the codes multiple times reduced it to a manageable number of 12. They are the following: Seniority, Age, Authority, Respect, Fear, Trust, Arrogance, Competency, Relationship, Uncertainty, Harassment, and Changes. Six of the 12 identified codes, alongside the raw data that generated them, are listed below (Table 3). The remaining six were identified in a similar way.

Some codes emerging from the data

Raw Data	Initial Codes	Final Code
I have been in this industry for 40 years. I know what I am talking about.	Seniority	*Seniority*
Seniority must be respected! These four bars must mean something!	Respect/Seniority	
I am afraid nothing will happen if I report him. He is *too senior*!	Power/Seniority	
He is not your *age mate*. If nothing else, you should *respect his grey hair*.	Age/Respect	*Age*
I was the youngest person there. I was too scared to say anything.	Age/Power	
It felt like I was asking my older brother or uncle to run an errand for me. I felt very bad.	Age/Respect	
I am the captain. He has to do things *my way*, not his way.	Control	*Authority*
I am just a co-pilot. The captain is *in-charge*. He has all the *power* and can do whatever he like.	In-charge Power	
He told me that my job is "gears up"	Control/Power	

and “gears down” when asked to.		
He is in *control*.		
He has no *regard* for his seniors.	Regard	*Respect*
I am telling you, that boy is very *rude*!	Rude	
I deserve some *respect*! I am still the captain and I am not his mate!	Respect	
How can I *respect* someone who has	Respect	
no *regard* for anyone?	Regard	
Just because he is the captain?		
He (captain) looked and talked in ways that made me *scared* of him	Scared	*Fear*
I was *scared*. Many guys are *afraid*	Scared/Afraid	
to fly with him. He is a *bully*!	Bully	
A good captain is respected, not *feared*! Those who lead by *fear* are not leaders, they are cowards!	Fear	
I don’t *trust* our government or	Trust	*Trust*
management. CRM is just a cover to *undermine* captains!	Undermine	
Many of the co-pilots are here	Spy	
to *spy* for the management. They	Distrust	
are nothing but snitches.	Snitch	
Who is to say that white people	Distrust	
don’t have their own *agenda*	Agenda	
for pushing the CRM narrative?		

Table 3: Six of the 12 codes emerging from the data

Theme Development

The typical question researchers ask themselves when deciding on whether and how to define themes is, “if I code the text this way, is it likely to help me build my understanding of the data?” (King, 2012). Such a question is crucial, considering the importance of coding and theme development in research. Theme helps the researcher in producing a visual account of the data. It also helps with deciding on priori themes. Priori themes are allowed in qualitative research where “the importance of certain issues” in relation to the topic being researched is “so well-established that one can safely expect them to arise” in the data (King et al., 2003). A priori theme is typically identified by the researcher in advance, based on the assumption that certain aspects of the phenomena under investigation are so crucial to the study that “they deserve an unadulterated focus.” One example is that of a researcher investigating patient experiences of chronic illness. Such a researcher may feel, ahead of the facts, that “uncertainty” may be used as a priori theme, “given its prominence in the literature” on chronic illness (Johnson, 1998).

In this study, age and seniority can safely be selected as priori themes due to their “prominence in the literature.” That did not happen because the researcher wanted the data to “speak for itself.” Thus, the codes and themes that were identified in this study emerged solely from the researcher’s engagement with the data. In that process, a total of 12 codes were identified after several refinements and fine-tuning. As in coding, the process of developing themes was iterative; the researcher ran the data several times to ensure that the words from the interview statements were assigned the right codes, and by inference, the right theme.

There were many changes in the process of identifying the themes. Those changes included the merger of some themes and the splitting of others. The use of NVivo 12 software helped in making an otherwise time-consuming process much faster and efficient. In the end, the 12 codewords of Seniority, Age, Authority, Respect, Fear, Trust, Arrogance, Competency, Relationship, Uncertainty, Harassment, and Changes were collapsed into three broad themes, based on their patterns of similarity. The themes are Seniority, Respect, and Fear (Table 4):

Themes developed from the Codes

Theme	Collapsed Codes
Seniority	Seniority, Age, and Relationship.

Respect	Respect, Authority, Competency, Trust, and Relationship.
Fear	Fear, Uncertainty, Harassment, Changes, Arrogance, and Authority.

Table 4: Themes developed from the Codes

The three themes identified in Table 4 above represent participants' pivotal views on power-distance. As in the codes, the themes are not discrete; they have considerable overlap. Most often, participants' responses addressed multiple issues at a time. They give varied information on the themes: some talked at length on issues that addressed one or two themes at a time; others made nearly equal contributions across all themes. Thus, authority can mean fear to someone and respect for another. In most cases, the researcher placed the narrative wherever it appears to fit the most. However, doing that presents some consequences: Data are not merely containers of meaning; they typically carry "multiple meanings" (Krauss, 2005).

A central challenge in qualitative analysis is that the research participants' subjective meanings and social reality are appropriately conveyed (Schreier, 2012). Thus, a text with multiple meanings usually requires researcher's serious effort in identifying and processing the individual meanings separately (Morse, 2008). Due to the cultural underpinning of this research, each statement is comprised of several meanings. Each theme represents "an attribute, descriptor, element, and concept" (Ayres et al., 2003). This researcher made a concerted effort to convey the participants' subjective meanings and appropriately interpret their social realities in the themes developed from the data.

Analyzing the Themes

Seniority

In this study, seniority featured frequently in all discussions, including pilot skills and competence. For example, whenever a critical comment or aviation safety suggestion is made by a junior crewmember in the public domain, the usual response from the senior pilot is to dismiss the junior pilot's comment as "irrelevant" or "unnecessary." An example was the interview granted an online media in the country by a young captain. That captain made some suggestions on how to strengthen the safety regimen in the aviation industry. During a discussion on aviation safety, this researcher asked Capts. XPG and XPF for their opinion on that suggestion. Both pilots dismissed his comments with statements such as "he is still a small boy" and "he doesn't know what he is talking about."

However, when a retired captain inappropriately suggested who was to blame in an aircraft incident where the investigation had not yet started, the other captains' reaction was more subdued. Their responses were more of affirmation. Thus, in place of dismissal, their comments ranged from "he is a senior captain in the industry" and "he is senior enough to know what is going on" to "he has seen it all" and "he knows what he is talking about."

In another instance, as a follow-up question, the researcher asked Capt. XPC if he think his superiors are giving him the necessary support to deal with the issues he encounters on the line, especially in his role as a check captain. He responded by first praising his chief pilot: "My chief knows what he is doing. When someone has been around for as long as he has, that person will not have any problem making the right decisions." He praised his airline's management for "valuing and empowering experienced and competent captains" such as himself and his chief pilot. "That is one thing I like about this airline – they value seniority," he added.

The value system in his airline, he posited further, contrast with another airline where the chief pilot is much younger, "a young boy full of arrogance." He added that he was there "when aviation started in this country. I have seen it all, and believe me, I know what I am talking about." He continued, "we have a saying that the young bird does not crow until it hears the old ones! You need experienced people who understand things, to make things work in aviation. There are no shortcuts to the top of the palm tree!"

As a follow-up to Capt. XPC's comments, First Officers XPV and XPT were asked what they think should be the criteria for the appointment of a chief pilot. Without hesitation, they both mentioned experience and seniority. Probed further if they think that seniority and flying experience necessarily equates to leadership, they nodded affirmatively. "He will be able to handle things better because he is not a kid," commented First Officer XPT. "Besides, he will be able to look the other senior guys in the eyes without fear," First Officer XPV said. "That's very important in our environment here where power flows down from the top," he added.

This emphasis on age and seniority by the respondents as sole yardsticks for measuring competence, and thus leadership position, is a reflection of the general belief within the society that aging is what leads to "an increase in experience, wisdom, and perfection of adulthood" (Eboiyehi, 2015). In the eyes of many Africans, wisdom is an exclusive preserve of the aged or the initiated, while competence is measured by seniority. Ejimabo (2013) submitted that Africa's system of education is two-fold: "a revealed front-view of information" that is available to the general public, and "a concealed back-view which is reserved for initiates." Only those with age on their side can claim both, and thus the wisdom, required for leadership roles.

One of the immediate challenges to that culture of deference to age and seniority, as practiced in Nigeria, is in cockpit crew pairing. Capt. XPL related an experience he once had flying with an older first officer. Most of the first officers he had flown with in the past are younger than him or about his age. In the same way, most of the captains he had flown with when he was a first officer are older than him. “I faced a situation in the cockpit that I did not know how to handle,” he confessed. He was not the only one who was conflicted; the first officer was too. “That man (first officer) was so fearful of talking to me or looking at me in the eyes. He will not address me by my first name even when I encouraged him to do so!”

Another challenge is the unique ethnic characteristic that defines one of Nigeria’s main languages, the Yoruba, which both men speak. In the Yoruba language, a plural word is used when addressing or referring to an older or senior individual in the third person. Thus, “him” becomes “they” while the singular “you” is transmitted in a plural form. On the other hand, someone younger or junior is addressed in singular terms: “he” is “he” and “you” is “you.” Because of this complicated format of *respect* inherent in their native Yoruba language, Capt. XPL and his first officer struggled with their communication choices. To minimize the awkwardness of the situation, both men converse with each other in English, an uncommon scenario between two members of the same ethnicity in Nigeria. “I was at a loss on how to address him, because he was my junior, but also my elder! He must have felt the same way. I know, because his communication with me was very few and far between. I can feel it.”

Capt. XPC related a similar experience while seating inside the cockpit as an off-duty pilot during a flight a few months before this research. According to him, the first officer on the flight had difficulty passing the piece of paper he had copied the destination weather on over to the captain with his left hand. Even when the first officer was updating the waypoint times on the flight plan with his right hand and the captain handed him a document for inclusion in the flight envelope, he dropped his pen and used the right hand to accept it before returning to what he was doing. In many parts of Africa, the stigma of the left hand as being dirty, filthy, or “even sinister” remains a common belief. McManus (2002) reported that throughout much of Africa, the belief is that “you eat your food with your right hand, and you cleanse your body and do the unclean parts with your left hand.” Such belief about the role of left hand in social interactions is very prevalent in Nigeria. Therefore, using the left hand to pass a message, or even gift, to someone, especially an older person or one higher in rank, is mostly seen as an insult to that person.

Capt. XPK also talked about his experience flying with a senior and older pilot as his first officer. The first officer (referred to here as Brother J.) was already a captain when he (Capt. XPK) was hired as a first officer in his previous job a decade earlier. Brother J. eventually left the aviation industry to do something else. After an extended period, he returned, and for whatever reason, he had to start as a first officer at a new airline where Capt. XPK works.

Flying with him was challenging for Capt. XPK. “First, he is older than me. So, I have to give him some respect for his age. I also have to deal with the fact that he is my senior.” Thus, he explained, he had some difficulty in asking Brother J. to do some specific duties. “I struggled with it. I felt like I was sending my elder brother or uncle to run an errand for me.” He claimed that even when Brother J. asked if he (XPK) wanted him to do anything, it felt awkward for him to respond in the affirmative. “I didn’t know how to deal with him. I mean, this man was a captain when I was a new-hire first officer. To imagine that he will be sitting on the right seat for me is unbelievable!”

He went on to say that he was used to saying *Dan Labai* (meaning The Boss or Master in the Hausa language) to Brother J. all the time he had known him. “Now, I don’t know how to address him! It’s hard when he calls me Captain. On the other hand, I don’t know how to address him other than Captain!” Furthermore, according to Capt. XPK, when Brother J. misses something in the cockpit, such as radio calls from ATC, he finds it difficult to correct or rebuke him as he would typically do with other first officers.

In his submission, Capt. XPD reported that seniority has always been “the most important thing” in the aviation industry as far as he could recall. He added that during pilot interviews at “almost all” the airlines that he knew of, captains are typically not put through the rigors of interview questions. “The interviewers know all the captains in the country. So, if you are a captain and they invite you for an interview, it means you are already hired.” The case is different for first officers. Because first officers are “not yet tested and known as much as the captains,” they need to prove themselves through the interviews.

There is some similarity in the captain recognition analogy as related by Capt. XPD and old age recognition as practiced in a typical African community. In many African cultures, older people usually do not face the same scrutiny as younger people. For example, among the Esan people of Nigeria, an “old man’s grey hair” is his “passport and key” to any place, function, or activity (Akpoghomeh, 1999). On the other hand, younger people have to “prove themselves” and “seek recognition.” As in the case of captains in the aviation industry, old age people in the society are “fewer and already well known” within the society. Thus, there is no requirement for them to prove themselves (Okogie, 1994). Such is the power of age and seniority within the Nigerian society.

Respect

Respect indicates attention, regard, esteem, admire, or consideration. Merriam-Webster (2020) describes it as “esteem for or a sense of the worth or excellence of a person, a personal quality or ability, or something considered as a manifestation of a personal quality or ability.” Among the captain participants in this study, respect is a significant part of their concerns. That is understandable, considering the fact that there is a great weight placed on respecting senior people within African cultures. It is one of the fundamental values that are imbibed in children from their early days. However, while respect for people based on age and seniority is still significant in Nigeria, younger people have started questioning its relevance in a modern society.

Beach et al. (2007) in their work on the moral obligation of health professionals towards their patients, argued that a physician's respect for a patient is about respecting the "autonomy" of that person as a patient, which is "independent of that patient's personal characteristics." They went ahead to distinguish between a physician's respect for the patient in the broader individual sense and the respect that is accorded to them as patients. The former, they submitted, is a universal obligation that people have toward other people in general. The latter, while it can be viewed as a further specification of the first duty, is only applicable by virtue of the existing physician-patient dynamic.

From their clinical perspectives, while physicians are trained and obliged to respect every one of their patients, the question has always been whether there should be any distinction between "the perfect patient who is able to persist in spite of serious illness" as compared to the repeated drug addict (Beach et al., 2007). In other words, "How can you respect someone who doesn't respect himself?" Such questions appeared often in this research. In the context of this study, how does one differentiate between respecting someone as a captain as distinct from his personality? Can a junior crewmember put a distinction between two captains inside the cockpit because one is "not worth respecting" because of his or her character? Within African societies, are elders respected because of their age or because of their personalities?

In this study, many of the captains talked a lot about the importance of respect, and how the "wholesome adoption of Western-based ideas" by present-generation Nigerian youths has negatively impacted "the good African ways of life that we all grew up with." Capt. XPB sees all the challenges facing the African countries today, including crime and corruption, from that perspective of African cultural abandonment or what he termed IWC – Imported Western Culture. Capt. XPF thinks that the situation is worse than IWC; he called it ABA – Anything, but African. He claimed that today, Africans, young and old, are so “ashamed of their own” that they are ready to follow anything, except their own culture.

Capt. XPF gave examples of Africans whom he claimed are bleaching their skins with “poison bleaches,” produced by white corporations “to help them look white.” He also linked that societal desire for “anything foreign” to Africans’ craves for Chinese products, “even with products that we don’t need, and which are not useful to us.” Both men see every aspect of non-traditional African attitude or behavior, including “wearing worn-out jeans and t-shirts to a public function” and “talking when more senior people are talking” as part of the larger “cultural adulteration of Africa.”

From that perspective, Capts. XPF and XPB argued that there is nothing called “power-distance” in the cockpit. Power-distance, they posited, is an African culture. “The real problem,” Capt. XPF added, is “the abandonment of the African culture of respect for seniority by the younger generation.” Capt. XPB recalled that in his days as a first officer, “not only do you carry your captain’s bag for him, you sometimes go to his house to help with household chores!” He explained that while doing those things is not a requirement, “having a boss who likes you,” in the cockpit or any other workplace, “can make a big difference” in terms of one’s career progression. Capt. XPF agreed with him, adding that the problem is that “first officers of these days” do not see their captains as “their superiors anymore.” He continued further:

> In our days, you don’t interrupt your captain. Who are you, a bloody co-pilot, to talk when your captain is talking? Nowadays, everyone is talking at the same time, shouting CRM! What is CRM? When I joined the airlines over 40 years ago as a young co-pilot, I was a nobody. I did one leg of initial training and everything stopped! All my colleagues finished training, but nothing was happening on my side. Finally, I talked to one of the guys and he told me the secret. That weekend, I went to the training captain’s

house, helped with his house chores and washed his car. After that, I went to the market and did some grocery shopping for his wife. That's it! The following day, my name was on the roster and two weeks later, I was done with my training and checked-out as a junior first officer! That's the way it was in those days. You either take it or leave it. There is no other way around it.

Capt. XPF lamented the lack of respect by present-generation first officers for their senior colleagues, "the same way we respected those who were here before us." He continued that "after all, we are not asking them to wash our cars the way we did for our seniors. All we are asking for is respect inside the cockpit, nothing more!" He went on to say that "it is nothing compared to what we went through." When this researcher asked him if he thinks that a majority of his new-hire classmates did the same thing as he did to get through their initial training, he immediately sensed that he might have "talked too much" in his comments. He tried to reverse himself and quickly added that "everyone is different," and "moreover," because of the many influences they had in their time, including external cultures acquired during their foreign training, he does not expect "every first officer" to "still behave like a true African."

As indicated earlier, the researcher followed Denzin and Lincoln's (2005) suggestion that additional verification should be made by way of member-checking, whereby transcripts of the interview are sent to each participant for their "review, debriefing, and comments." When Capt. XPF received his transcript, he immediately called the researcher to "talk about it." While he did not deny any of his earlier statements, he was quick to point out that his comments on "helping the captain at home," especially "if the captain is a single guy," was his and "a few other" first officers' choices as a way of "cementing the brotherhood" between them and the training captains. That, he added, is "a normal way of doing business" in Africa.

He insisted that while it is "not a requirement" to do such things "even in those days," the first officers who did "are all successful captains today." That outcome, he argued, justified the approach that they took. It was “a win-win” African solution to a complex problem for which the Western-produced flight operations manual “has no solution for.” He further narrated how one captain left his “brand-new sports car” for him to use when the captain was traveling outside the country for training. He argued that that kind of good-will could only have come from the captain because he (XPF) had prepared the ground for it by being “a good co-pilot.” Because the captain trusted him, he could leave his “expensive sports car” in his care, “without a second thought.” In the same way, such a captain will not have any problem with “trusting” him “to fly the airplane” any time they are in the cockpit together.

With such a background of “good relationship” between captains and first officers in “the good old days,” Capts. XPB and XPF see no justification in the current crave “to erase power-distance as if it is a plague.” They posited that “even in a best-case scenario,” the “sole purpose” of CRM was to “chip the wings of captains by taking away their authority in the cockpit.” Capt. XPB, in trying to justify his “chipping the captains’ wing” theory, insisted that the rationale behind linking power-distance and CRM was to curtail “the wonderful culture of respect” amongst Africans.

He claimed that since the time of slavery, “white people have been looking for ways to control Africans” without success. One of the secrets to Africans’ survivability, “even during the brutality of slavery,” he noted, is their culture. Respect for each other is a crucial component of that culture. “As much as they tried,” he claimed, the Europeans were never able to break the Africans’ “overwhelming tradition of respect for each other.” This “strong cultural attribute,” Capt. XPB argued, is based on a sound premise:

> African culture is based on respect for our elders. There is a reason for that. In this industry, there are many people who paved the way for us. They are our seniors who sat on this seat (captain’s seat) and wore this uniform with four bars, before us. We stand tall today because we are standing on the foundation already laid by those people. We owe

> our success to them and we are grateful to them. We respect and honor them for leading the way. In the same way, we expect the younger ones to respect and honor us for being here before them. Is that too much to ask? As our elders say: Everybody has been young before, but not everybody has been old before. Any young person who wants to be old will have to treat those of us ahead of him with respect and dignity.

These views mostly represent Nigeria's culture or "way of doing things." It starts with a system of family relationships that are mostly guided by a strict system of seniority (Omonzejele, 2004). Embedded in that system of seniority is a social stratification order that aims to recognize and reward or subjugate people based on age differences (Doumbia & Doumbia, 2004). Taught and emphasized right from childhood, this type of seniority order, Matondo (2012) posited, lays the foundation for the culture of a "sequential hierarchy of nominal importance of persons" within the same family group that is so common in almost all African societies.

However, that tradition of respect for elders, while relevant within an African cultural setting, presents some challenges when dealing with a workplace culture that transcends the local environment. Aviation is one example. Unquestioned respect or obeisance to captains can lead to a sense of indispensability or what Capt. XPG referred to as the "the Jehovah mentality" within a pilot group. Capt. XPG explained that in the defunct Nigeria Airways, where the first generation of Nigerian pilots started their careers, "Jehovah" culture was prevalent.

At the height of the airline's "glorious days" from the mid-1970s through the early 1990s, Capt. XPG posited, there was a steep rise in the "Jehovah culture" within its pilot rank and file: The airline's director of flight operations became so powerful that he was often referred to as "Jehovah," the Hebrew word for God, due to his unquestioned authority and autocratic style of leadership. The Chief Pilot was the "Assistant Jehovah" or simply "Ay-Jay."

This type of "uncontrolled power" in the hands of flight operation administrators in Nigeria Airways was replicated down the rank and file, leading to a pyramid structure of power stratification within the organization. The training captains are next in line, followed by line captains, in the long line of bureaucratic power-holders. First Officer XPY argued that such a boss-servant structure created a system of "over-dependence on the captain as if he is the only one needed to operate a flight." That system, he added, has led to "extreme arrogance" on the part of some captains, who, most often, started believing their own hype of "out-of-this-world" sense of "ingenuity and indispensability" in the industry. First Officer XPV has an extended definition for such captains; he read his statement without missing a word as if reading from a prepared paper or teleprompter:

> The worst thing about arrogance is that it creates a distorted image of a person's ability. Because of that distorted image of his importance, an arrogant captain thinks he knows more than he really does. So, he elevates himself while looking down on others. He knows more than everybody. Everything about him is perfect and everyone else is an idiot! He longs to be admired and respected even when he does not deserve it. Arrogance compensates for his incompetence and the attendant insecurity.

However, as is most often the case, there are two sides to every story. Captains in this study have as much problem with an arrogant first officer as much as the first officers do. XPV's description of what an arrogant captain looks like fits into some captains' description of an equivalent first officer. Many captains in this study expressed as much indignation about arrogance as did first officers. Capt. XPF, for example, was livid with anger when he described the case of "an arrogant and disrespectful ####" that he flew with some time ago. "I can understand a captain being arrogant," he explained. "At least, if he is a captain, he can say that he has achieved something in his career to make him feel superior to other people," he said, raising his voice in anger. He continued:

> But tell me, what has a f*****g co-pilot achieved that he is arrogant about? What? Because they put him in the front seat to flip gear handles for me and all of a sudden, he thinks he is important? The only reason they put him there is to satisfy those stupid insurance people and the government with whom they are conniving to deceive the public. Otherwise, tell me why I need a f*****g idiot like him sitting in the cockpit with

> me? Tell me, what does he know about flying an airplane? And don't get me wrong, there are some good co-pilots I have flown with, but this idiot is not one of them.

When the researcher prodded him regarding his flight with the first officer in question and how the disagreement between them was eventually resolved, Capt. XPF responded that he was not interested in any resolution. All he had to do was to "put the idiot in his place," and he did. He was with that first officer for "three long days!" He flew the two legs on the first and second days. On the third day, he gave him the airplane to fly. In his words, he did it "the old crafty way," the same way white European captains used to treat their Nigerian first officers:

> No, I was not going to leave the whole airplane for him. No way! This is how it's done: I do the take-off. When I level off at altitude, I call for the autopilot. After that, I tell him to take control of the aircraft. Officially, he is the one flying, but he can't touch anything besides rotating the heading knob. At destination, I tell him that the wind forecast is too strong; so, I have to make the landing. That's it! He just flew a leg! That's the way the white captains we flew with when we were young used to treat us. It is a cat and mouse game and we all know how to play it!

After a long silence, he raised his face and said to the researcher: "You are a captain, too; you know what I mean." It was neither a question nor a statement. He was looking for validation. When he did not get the type of response he was looking for from the researcher, he shifted his attention to other topics. On many occasions, he reverted to the same validation question he had asked earlier: "If you are in my shoes, how would you handle such an arrogant first officer?" At times, this was followed by, "Don't you think I was too lenient on him? Many captains would have dealt with him for pulling such a stunt! Don't you think so?"

Capt. XPB asked similar validation questions during his interview. He recalled a "cocky" first officer he flew with some years back. "He is the most disrespectful co-pilot I have ever flown with in my life!" He went further: "That clown thinks he knows everything whereas he knows nothing! I ask for a checklist and he is reading something else!" According to XPB, that first officer has been in trouble with many other captains in the past, and one of the captains had told him about it. He described him in expletive terms: “That #### thinks he has some authority as co-pilot. He has nothing! It is my cockpit, period! I tried to be nice to him, but he is beyond redemption. So, I dealt with him! Yes, I did! He will not forget about me anytime soon!”

He continued: “That boy has no cockpit etiquette. He has no home training at all. He was not well brought up.” He went further to say that when he called for a checklist, the first officer continued talking to the flight engineer about the flight attendant he had a relationship with the previous night. When he called for landing gear to be extended on the approach to land as a way of slowing down the aircraft speed to meet ATC instructions, the first officer dared to tell him that he was going to extend the flaps first. “Can you imagine that! I wonder if he was sent by someone to undermine me. That is very possible, don’t you think so?”

Like XPB, two other captains in this study believe that there is the “possibility of a deliberate plan” by management to use first officers to undermine the authority of captains in the industry. Capt. XPF related an incident that happened between him and a certain first officer as an example of the management turning a blind eye in cases of first officer insubordination:

> He (first officer) was flying. ATC gave us a descend instruction and they wanted us to start the descend right away because of conflicting traffic. Instead of pulling the power, grab the speed brake and barrel down, the idiot was busy fiddling with VNAV (Vertical Navigation). I grabbed the controls from him. As soon as I did that, he folded his two hands on his chest as if saying that he doesn’t care! After I descended and stabilized the airplane, I called for the autopilot so that I can give the controls back to him. Instead of complying, he looked at me with a smirk on his face. He ignored my instructions and kept doing whatever he was doing! As if I don’t *matter*…”

He was furious as he recounted this encounter. First, he leaned backwards and then moved his seat to get closer to the camera. To emphasize his point while repeating the sentence “as if I don’t matter,” he removed his eye glasses, looked straight into the camera and raised his eyebrows so wide for the researcher to see his eyeballs. He tightened his lips and his nostrils widened as if struggling for more air. He stayed frozen like that for a few seconds.

Instead of putting the autopilot back on and allowing the automation to do its job as he had requested, the first officer took the controls and started flying manually. At that moment, he claimed, his heart "was pumping hot blood." He slapped the first officer's hand with his fist, "grabbed the controls back," and put it on autopilot. "I took over the flying and asked him not to touch anything again!" For the remaining part of the descent, approach and landing, it was a one-person cockpit: they did not talk to each other. After landing, he headed straight to the chief pilot's office and filed a crew report on the unruly first officer. They have not been paired together ever since, but in his words, "nothing, absolutely nothing," has been done to punish that first officer. "Well," he said as if suddenly regaining his memory, "the company gave him a query. No punishment! Nothing!"

Capt. XPB had a similar experience at his previous job. In his case, the first officer not only disobeyed him, he also insulted him. He claimed that the way he was disrespected in that incident contributed to his decision to resign from the company. The company had hired him as a direct captain based on his previous experience as a captain at another airline. Some of the first officers he met there were not happy with the appointment; they felt they should have been promoted to captain instead. "They ganged up against me!" he claimed. To support his claim of "a grand conspiracy" to undermine his authority as a captain, he claimed that the first officer told him that "nothing will happen" even if he (XPB) reports to the chief executive of the airline. He linked that statement to the fact that the first officer was never disciplined as an indication that "it was a management thing." The first officer involved in his case, he argued, was "left off, with a handshake. He is a captain now!" The lack of any disciplinary action against the first officer, even after he threatened to resign over the issue, indicates to him that the company, and indeed the industry, "have no *respect* for good captains."

These comments and others from the participants in this study on the importance of respect or "showing honor and esteem" towards older or senior people reflects a societal view on the issue. They are considerable enough for the topic to earn its prominent place in this study. Those comments also reflect the growing distrust between pilots and airline management in the country. Public and employee distrust of management and government institutions in Africa, Alkali (2000) posited, is "an ongoing challenge." Some are caused by misinformation.

Vinck et al. (2019), in their roles as research doctors during the Ebola outbreak in eastern Congo a year earlier, posited that "belief in disinformation" was widespread among the people, such that more than 25% of respondents in their research believe that "Ebola was not real." They associated the low institutional trust and belief in misinformation by the people with a "decreased likelihood of adopting preventive behaviors," including acceptance of Ebola vaccines for treating the disease. Such distrust of "institutions of power" and government agencies is prevalent in Nigeria (Kainuwa & Yusuf, 2013).

Elsbach et al. (2011), also studied the effect of employee distrust of management at Hewlett-Packard Company in the U.S. They surmised that the "downward spiral" that the company experienced in the 1990s was not due, "primarily, to a reduction in trust" by the company's employees, but to an "increase in distrust by employees." The implication is that the element of distrust is a "built-in product" of every organization. Thus, for many organizations worldwide, the difference lies in how the lack of transparency, misinformation, and "other driving forces behind distrust" in that organization is mitigated.

Trust deficiencies in African public institutions remains, mainly, because those agencies "have not done enough" to rein in on the driving forces behind misinformation (Alkali, 2000).

Ogunbado (2012) also posited that widespread “distrust of, and disengagement from” institutional policies and programs has an effect on how people receive programs that “could probably have some positive impact” on them. In the Nigerian aviation industry, the distrust and general cynicism by pilots of their airline management and other government agencies in the industry can potentially hamper its safety regimen, and by implication, its growth.

Fear

Many of the first officers in this study used the word ‘fear’ to express the negative feelings of fright or impending danger that they had to deal with. It is an emotional feeling of unease that can be expressed in different ways, including “crying, screaming, sweating, silence, running, and hiding” (U.S. Department of Health and Human Services, 2020). Fredrickson (2001) described fear as that moment when someone expects something negative to happen, but “not knowing what it is that is going to happen or how it is going to happen.” Fear, Bantinaki (2012) argued, can also be a positive emotion because it “heightens human anticipation or awareness of danger.” That awareness, she added, helps human beings in “planning, making safety choices, and avoiding things or activities that are not beneficial” to them. Fear, thus, can be described as a defense thermostat inside a living being. It wakes people to the dangers ahead of them and prepares their mind and body to pick a fight for defense or take a flight in defense.

In many African cultures however, fear is frowned upon as the height of cowardice in a man. Westermayr (1915), in his study on the psychology of fear, argued that “to be afraid,” is considered “the earmark of cowardice” since “the beginning of human thought.” Soyinka (1972), in his treatise on human perseverance, posited that inside a fearful soul, “the man died.” African folklore is full of heroic praises for the brave and negative stereotypes of a coward. Because fear is associated with cowardice or what Matondo (2012) termed “the dearth of manhood” among

Africans, it is largely viewed with grave contempt within the society. To avoid societal shaming from that, many African men typically do not want to publicly associate themselves with fear to avoid being tagged as a coward. Cowardice is seen as so repugnant that people use code words such as "the missing item" or "the man who was not home" to describe it (Matondo, 2012). Doing that is the African way of "not giving prominence to what they despise."

Similarly, some of the participants in this research used different words to express the fear that they experienced in the aviation industry. Such words include scared, trauma, horror, panic, anxiety, dread, worry, nervous, and unease. Using the inductive coding process, the researcher determined that the code "fear" can be used to represent the negative emotional state that the participants were trying to convey with those words.

The cause of their fear ranges from their perception or actual behavior of the captains they work with, to fears about their career advancement, including the prospect of becoming a captain. Participant XPW's fears arose from a juxtaposition of seniority, and gender inequality rolled into one. She related her experiences, viewed from those perspectives:

> Being a woman is hard. First, I have to worry about an insecure captain whose job is nothing but to instill fear in you every time you fly with him. Then, there is sexism. The truth is that it is a man's world. Our society belongs to the men. So is the flying profession. The men control everything! Many of them think that the only reason you are in the cockpit is because you have slept with someone up in the office. They don't think that you are as capable as they are. They see you as a piece of meat, meant for their pleasure as they like. As soon as they realize that they can't have you at will, they become even more angry at you. They will do anything to embarrass you, denigrate you, and make you feel worthless. I don't want to give up, but I am *afraid*…

She claimed that when she joined the airline industry, some male pilots were attracted to her and wanted to date her. However, as soon as they realized that she was in a serious relationship, they started making negative insinuations about her. One example was when she found a note inside her mailbox within the airline's operations office, asking her to describe the chief pilot's genitals. The insinuation is that she had slept with the chief pilot. There were anonymous messages to her fiancé. "My fiancé tried to discourage me from flying, but I refused. My parents spent so much money on me, and I *fear* what their reaction will be." Eventually, she and the fiancé broke up, "because he started believing all the rubbish that he hears about me."

For another female participant, XPO, the fear is about her future in the industry. She wanted to seek employment with an international airline in the Middle East, but *feared* that they would not consider her because of her lack of experience. Though she has been flying for some time now, she has very few hours to show for it. She explains the reasons for her low flying hours as a pilot:

> I came straight from flying school. Because I came with low hours, many of the captains will not allow me to fly. I need three takeoffs and landings in three months in order to stay current as a pilot. Sometimes they pair me with very difficult captains. Some of them are just too difficult to get along with. They don't like me at all. The captains only care about themselves. They don't want first officers to grow. Most times, I am *afraid* of them and I call in sick to avoid flying with some of them. Then, I am no more current to fly, and I spent months waiting for recurrent training. One time, I sat at home for more than one year without flying!

Aviation regulations worldwide typically require pilots to maintain at least three take-offs and three landings in 90 days. Where such is not possible for whatever reason, the pilot is considered non-current. A non-current pilot is typically sent to the flight simulator to fly three take-offs and three landings. That will reset their currency status, after which they are allowed back into the cockpit. Because most of the airlines operating in Nigeria have few airplanes, they cannot afford a training department with flight simulators. So, the simulator portion of their training is typically contracted to a third party, usually a training center in Europe or North America. The complications of securing travel visas and foreign exchange to undergo such training twice a year can be challenging for many small operators. In many cases, such airlines will prioritize their training needs, giving priority to the captains.

With such challenges, First Officer XPO *feared* that she might not become a captain anytime soon. Asked if she thinks her male colleagues have it easier because of their gender, she hesitated before responding, “No, I don’t think so.” She looked down for a while and added: “I think the main difference is that men can handle failures and disgrace better than women. So, they can ignore the behavior of some captains. But for us women, we are very emotional and cannot handle such things. Most often, we end up crying.”

In almost every part of Nigeria, the responsibility for raising male and female children is shared by both parents, the extended family, and the community. However, the type of upbringing the male and female child gets is often “separate and different” (Sanda & Garba, 2007). Kainuwa and Yusuf (2013) reported that “by the time of puberty,” boys are generally in the care of their fathers, uncles, and other male members of the extended family. Most often, the upbringing happens outdoors where they engage in “manly activities,” such as hunting and contact sport. Through words, proverbs, and songs, young boys are taught the primary duty of a man in a household: protecting, providing for, and looking after his mother, sisters, future wife or wives, and children. They are taught that emotions are a sign of weakness; so, they should never cry or “show any weakness.” They are expected to “be a man” - an emotionless, stern man that can stand up in defense of “his family and the women and children.” (Eboiyehi, 2015).

Girls, on the other hand, are raised predominantly by their mothers and female relatives. They are given extensive education on household chores, especially cooking and childcare. Girls, Sanda and Garba (2007) posited, receive profound affection from their mothers, and are taught how to serve and “be submissive to their fathers, brothers, and their future husband and in-laws.” They are equipped with the kind of skills thought necessary to make one a good wife and mother, such as “being diligent and productive” (Eboiyehi, 2015). Kainuwa and Yusuf (2013) submitted that unlike boys, girls are allowed and "encouraged" to show "sensitivity and emotions" in preparation for their future roles as mothers and care-givers. Both boys and girls are expected to carry these early life lessons into their adulthood. It translates into how they show emotions at school, work, and in their day-to-day experiences, as demonstrated by First Officer XPO.

First Officer XPM's case is quite different: He has been in the industry for some time, "in fact, a long time," he emphasized. "A couple of times," he tried to upgrade from first officer to captain, but did not pass the training. "The only reason" for his failures, he insisted, was the animosity between him and "one training captain." Because of that, he *fears* he "may never become a captain" in that airline. So, he left. However, he has not made captain in his new job after four years; he is still "waiting for an opportunity" to prove he is captain material. He talked of the open hostility between himself and some captains in his previous job. He argued that there was no way he could have continued in that job without someone "eventually getting into serious trouble." So, he decided to resign to avoid further conflict and save his "sanity."

While XPM agreed that culture is a factor in the many cases of open hostility between captains and first officers, he insisted that personal ego and greed are the real causes. "Respect," he argues, "is mutual." "Why should I respect you just because you are a captain? How can I respect you when you don't deserve it"? As mentioned earlier about the overlap in the themes, the conversation quickly digressed into crew compensation and condition of service. The rest is a fusion of his views on captain authority and first officer insubordination or arrogance.

Such overlaps abound in the topics that the participants in this study talked about. This is especially so in the case of captains. As stated in the literature review, elders in Africa are typically given the freedom to speak on any issue that "come across their minds" (Matondo, 2012). This is based on the premise that an elder can see better the "totality of a problem" and so should be free to tackle it without constraint. Chen (2013) compared similar beliefs in China to a surgeon who found a different tumor or tumors on a patient during surgery. Such a surgeon is given the freedom to "do the needful" in order to achieve a good outcome for the patient. As in the case of the surgeon and the African elders, the captains in this study felt that they have "earned the right" to speak their minds on every topic without any constraint.

Research Observations and Notes

Age and Seniority

Age and seniority permeate every aspect of the conversation in this study. The influence of seniority on almost every statement and the emphasis on the speaker's age indicate the critical role those two issues play in societal order and hierarchy. Younger pilots would start their conversations with "I know that I am still young in this industry, but…," while the senior captains would typically say, "I have been in this industry long enough to know that…" This type of strategy was used even by the younger captains to gain some advantages in their arguments. For example, when Capt. XPK was expressing his opinions, he started with, "I am *still* in my forties and have been flying for *only* two decades. I am *young* and *still* learning. So, I am sure that I will be forgiven if I make any mistake here."

On issues that Capt. XPK considers too controversial to comment on, he would respond: "Maybe you should talk to the more senior captains like (mentioning Capt. XPG's name). I am too young and not supposed to talk when more senior people like him are still in the industry." On issues that he commented on, he typically starts the conversation with: "I know my level. I am still very young compared to the other captains, so I hope no one takes my comments as a form of *disrespect*…"

Meanwhile, when the more elderly Capt. XPF was interviewed, he started with "I have been flying for over 40 years now, and believe me, I *know* what I am talking about…" He ended each conversation by telling the researcher that younger captains (he derogatorily referred to them as "YouTube pilots") should not be allowed to be part of this "important conversation" (referring to this research). He recommended two other captains (mainly his age or course mates), all of whom he claimed are "capable" and "experienced enough" to be part of the research. Of the two captains he recommended, one was a participant in the study while the other declined the invitation to be part of it, citing his busy schedule and declining health. Referring to one of them, he said: "Both of us are experienced and capable pilots. We were trained as real pilots with stick and rudder feelings, long before the advent of computer and YouTube." He never missed any chance to link his age with his piloting skills.

This researcher was invited to an event in late-May 2020, where a retired captain was celebrating his 70^{th} birthday. Because of the lock-down in Nigeria and the requirement for social distancing as part of the regimen to slow the spread of COVID-19 worldwide, the party could not be held as planned. Instead, an online celebration was organized and streamed live for all invitees in the first week of June. The researcher participated in the online event.

Six professional colleagues of the celebrant were engaged in the event. All of them are participants in this study and the researcher sought their approval individually to take notes. While there were mixtures of different age groups at the event, only two older pilots (Capts. XPG and XPF), were allowed to make a speech. Each of them used the opportunity to remind the audience of how things used to be during their times, "the glorious old days when captains were worth their names…when captains were captains" and those times when "younger people really respected those with gray hairs." Capt. XPF introduced the celebrant thus:

> Nowadays, we hear of so many young men going around with the title of captain. The man I am about to introduce here tonight represents the last of what can be termed as the generation of the captains' captain! During their time, the title captain had a *meaning*, it represents something! Where his generation are gathered, people of my age has nothing to say. Their words are laws. That's the way it was, and that's the way it should be! No amount of money, position, or academic qualification can replace the wisdom, experience, and knowledge that comes with an old man's grey hair…

Capt. XPF continued his speech by admonishing "the younger generation of pilots" to always "give respect to whom respect is due. Respect is important in our culture. He who respects his seniors can expect to grow old and get the same respect." He cleared his throat and continued: "Even if you don't like someone, you still have to respect him! Why? Because that is your foundation. Elders are the foundation of our society. They represent the past and the present." He paused and continued: "Nobody can do well in life if you can't account for your past and present. That is a fact!" He waited for the message to sink in before continuing: "It is the past that gave birth to the present, and it is the present that links the future." He went further: "That is the way life is. Life is interconnected, and every little part has a role to play in the outcome. You have to connect all together, else the journey will not be a good one."

When it was his turn to talk, Capt. XPG started slowly. Several times, he referred to the celebrant as his "mentor." He claimed that the success he has recorded in his aviation career is because he had followed the footsteps of his mentor, "the man we are all celebrating today." Throughout his aviation journey, Capt. XPG explained, he has "respected and honored" those ahead of him in the profession; he has listened to "advice and directives" from his mentors and superiors, and in return, he has been "extremely successful as a professional pilot." Capt. XPF expressed the same sentiments during his presentation. He talked at length about how three of them (himself, Capt. XPG, and a deceased colleague), which he termed Nigerian aviation's "original three musketeers," became successful in the industry through hard-work and "following the footsteps and guidance of our respected seniors."

Capt. XPG offered the closing remarks and prayers. Again, he reiterated the importance of "respect for *old age* and *seniority*, loyalty and commitment to our traditions, and the fear of God." These three things, he believes, "are what saw our elder and mentor here through his 45-year accident-free career" in the aviation industry. At every opportunity he had during his closing prayers, he made it known that the celebrant is 70 years old, "a senior citizen who has paid his dues to society" and because he has served the aviation industry for "45 plus years, more than the age of some of you here tonight," he deserves some respect from everyone.

This researcher observed, from the advertorial, that while the celebrant's age was 70 as stated in the document, his years in the industry were less than what was advertised. Counting from the month he started flying school to his retirement, he had spent 42 years and seven months in the industry, less than the 45 years he was claiming. This inconsistency, First Officer XPM observed, is neither an error nor unusual; it is a typical way of enhancing one's "age and seniority qualifications in the eyes of the general public." For Capt. XPC, it is a normal thing; "many people do it! That's how you earn respect in the community."

From these discussions, it is evident that the Nigerian society places a high value on age and seniority as the primary source of gaining power, recognition, and respect within its institutions. That influence goes beyond people's words to include their pattern of reaction. For example, the following morning after the party, this researcher emailed 4 participants who were attendees at the online celebration (Capt. XPL, Capt. XPC, F/O XPV, and F/O XPY), asking them if they have anything to say about the comments made by Capts. XPG and XPF at the event on the need for younger pilots to place obeisance above everything else. Specifically, the researcher wanted to know if these participants concur that respect for seniority and age should take priority over safety concerns. The 4 respondents stated that while they may not like “a few lines” in those comments, they have no choice than to agree with them because the speakers are much *older* and *senior* to them, and they do not want to *disrespect* them.

This over-riding desire to avoid disrespecting people because of their age or seniority in the society has a continuous presence throughout the research. From infancy, children in Africa are taught to defer to older siblings and the extended family (Eboiyehi, 2015). In schools, they are under the mentorship of “senior” students who take on the quasi-parental responsibility of guiding them through the system and punishing them when they step out of their boundaries (Maluleke, 2012). Because of the value that society attaches to age and seniority, those issues continue to take on an aura of righteousness in their consciousness. As adults, they continue with the same practice of respecting and deferring to those older or senior to them (Elendu, 2012). They take that culture to their different professions, including aviation.

Threat and Error Management

Capt. XPL claimed he has been in the industry “for so long” that he has “seen it all,” including the infamous pre-2006 days, during which time a lot of aviation accidents were recorded in the country. He recalled that when he entered the industry, questioning one’s captain was the equivalent of committing career suicide. “Your progression in the industry, including the chance to become a captain, depends on how much respect you give to the senior captains.” Any negative comment about you by one captain can quickly become a report card that other captains use in evaluating you when you fly with them. They have the power to “make and unmake your career!” It was a captain’s world where first officers “will gleefully carry their captain’s flight bag for them as a way of pleasing them!”

Doing all that was not enough to please some captains. First Officer XPT recounted the case of a particular captain, an ex-military pilot. Because he was a line check airman, he was given the responsibility of training young pilots hired by the company. Unfortunately, he had no respect for civilian-trained pilots and "was fond of making derogatory comments about us." He taunted one young first officer so much, "constantly reminding him that he has no business in the cockpit." Eventually, the young man broke down and wept uncontrollably. Capt. XPK was a first officer then, and he too remembered an uncomfortable experience he had flying with the same captain, who is now retired:

> It was a domestic flight. Before leaving the operations room, I wanted to verify the flight plan route because of an experience I had with the same operations officer the previous day. My captain berated me because of that. His argument was that as the captain, he has the final authority on everything and wondered where I got my powers from to cross-check what he had already checked. This created a tense atmosphere between us. On the climb out of Lagos, I suggested a heading change to avoid weather build up ahead of us. He responded by striking me with a physical blow on my left shoulder saying, "Do you think I am blind." For the rest of the flight, I recoiled into myself and we did not talk to each other except when he called for the checklist.

While this encounter by Capt. XPK as a first officer was exceptional, similar cases have been reported and collaborated by other pilots. Most times, even with reports by multiple first officers against a captain, nothing was ever done to sanction the captain. In some instances, Capt. XPK and First Officer XPT emphasized, the reporting first officers usually ended up being punished for insubordination. Pressed to comment on these allegations against captains, Capt. XPF took a strong exception to what he described as "this ugly and general categorization" of captains as villains and first officers as victims in what has become a "cultural war of annihilation against Africa and Africans." That war, he claimed, is being waged by foreign powers with the "strong collaboration" of "corrupt and dubious people in our aviation industry."

When asked to give his thoughts on the communication pattern between captains and first officers in Nigeria, Capt. XPB claimed that he does not see any problem, "except for a few first officers who think they are smarter than their captains." He went further to state that the few times he had personally engaged a first officer in the cockpit are when he felt that the first officer was "not up to speed" on the flight. To address the situation, he said he could do anything from talking, to taking over the airplane's control from the non-performing first officer. His worst anger, he said, is typically reserved for "an arrogant first officer" or one who tries to negotiate or claim power parity with him. He feels no sympathy either when he sees such first officers being "corrected" by other captains. Capt. XPF, shared the same views, claiming further that he would not spare anything in "setting straight" some of "our hot-headed first officers."

Two of the first officers reported such experiences in the hands of their captains. First Officers XPW and XPV separately talked about a certain captain, now retired, who is notorious for ignoring and insulting his subordinates. "He comes into the cockpit, do his paperwork, and that's it! When you say hello to him, he does not respond. He does not do any briefing either. It's like I am too small for him to talk to!" First Officer ZPW remembers the first time she flew with him: "He called for engine start without a checklist. So, I brought out the paper check-list as a way of reminding him. I started reading the check-list, but he turned his back at me, looking at the window. It's like I was annoying him. I thought maybe it's because I am a woman."

First Officer XPV also had a rough time with the same captain, but he knew that it has nothing to do with his gender: "He does that to all first officers. He thinks that because we are below him, he does not need to talk to us!" "Meanwhile," he continued, "as soon as you become a captain, he will start relating well with you." He also related how he had written a report to the chief pilot's office about another captain who over-heated an engine during start. It turned out that the chief pilot's secretary was a girlfriend to the said captain. "He got the report instead of the chief pilot!" First Officer XPV claimed that the same captain called him after the incident and threatened that he would never be a captain for as long as he (captain) works for that airline. “Thank God,” he added, “He is gone now! I survived him!”

XPO, another first officer, had a different experience. Even though she almost lost her job because of that, she claimed she has “no regrets” about it. She referred to it as “the defining moment” in her career because “as unpleasant as it was, I learned a lot from it.” It went thus:

> It was a bad day for flying. The weather was terrible at our destination and we could hear many other flights headed for the same destination diverting to other airports. While waiting for the bad weather to clear, we went into a holding pattern overhead a fix along our route. After a considerable time on the hold, I asked the captain if it is okay to contact dispatch for weather condition at our alternate airport. I was trying to be proactive in getting him all the information he needed for a possible diversion. But he did not like the fact that I took that initiative without him directing me. He told me that my only job in the cockpit was to do whatever he commanded me to do and nothing more. He told me that he does not need my opinion or ideas on how to fly the airplane. At that point, we had only 1 hour 54 minutes of fuel left. We needed at least 1 hour 20 minutes of fuel to divert to our alternate airport and be able to execute one missed approach to a full stop.

So, 30 minutes into the hold and with the captain yet to communicate his next course of action, First Officer XPO did the unthinkable: she called the captain's name, looked him in the eyes, and defiantly told him that they were diverting to the alternate airport. Without a directive from the captain, she called the air traffic controller and requested a heading to the alternate airport. The captain was too angry to say a word. She continued her story:

> We landed at our alternate airport and had to wait for 2 hours and 35 minutes for the weather at our original destination to clear up. I had been right all along. After we finally landed at our original destination and set the parking brake, the captain turned towards me. His fury was unimaginable. He chastised me like I was his little child. He told me that I was not yet born when he started his flying career. "How dare you, a mere co-pilot, make decisions for me," he screamed through his lungs. He never acknowledged the fact that we achieved the most important thing – safe landing. All his focus was on my audacity to counter his authority. Nevertheless, I apologized to him. I told him what he wanted to hear. Apology is a necessary evil that I have adopted as a survival kit inside Nigeria's toxic environment.

Hofstede (2001) posited that while inequality exists within all cultures, the highest manifestation of power distance lies in the degree to which members of each society are willing to *accept* the inequality. Shavitt et al. (2006) shared the same view, arguing further that the central difference between a high- and low-power distance culture is not in the actual power disparity, but people's attitudes toward power disparity. In this case, XPO's action was heroic, but in many other cases, the junior pilots involved accepted and justified their relegation by the power-holders in the society on the basis of their position, thus validating Hofstede's theory. Most often, they accept the disparity because they have no option.

Also, hidden in the reactions of the first officers are what can be considered as indications of insecurity or what Ellis and Maoz (2011) referred to as "low-context communication culture." Many of the first officers sounded unprepared or scared of assuming leadership or decision-making role in the cockpit: "I am not the captain! I do whatever he asks me to do," one said contemptuously. The fear of making a wrong call is probably one reason for the observed insecurity among some of the junior pilots. So is the complacence of being a follower. "The captain makes all the decision. He is in charge," another commented. While this 'conformist follower' mentality might be as a result of long-term power-inequality in the system, the need to further invest in these first officers' human capital and confidence level in order to transform them into future captain materials is one consequence of the power-disparity culture in Nigeria.

In a high power-distance society, inequality is typically seen and accepted as the basis of societal order (Hofstede, 2001). Because social order is supposed to benefit every member of the society, maintaining it is seen as something that should be of interest to every citizen. It requires that everyone play their parts by staying within their defined roles and positions. This belief is reflected in the way many of the first officers see themselves in the aviation safety structure. For example, when asked if they will do something if they observe the captain doing a wrong thing that can jeopardize flight safety, 50% of the first officers were non-committal in their responses:

“It depends! You know, he is the captain, and maybe he knows what he is doing.”

This acquiescence to inequality, especially among a large segment of a country’s population confirms the assertion by Brockner et al. (2001) that individuals in a high power-distance environment are less likely to react negatively to not having a voice in their safety process than those in low power-distance society. They are more likely to respect, defer to, and trust their supervisors (Kirkman et al., 2009), and are less likely to react adversely to injustices from supervisors than people in a low power-distance culture (Lee et al., 2000).

While 50% of the first officers were non-committal in their willingness to take on their captains, the remaining 50% argued that their inability to do so was because of their respect for the culture of deference to seniority in the society. One explained: “It is like showing your middle finger to your manager! In our culture, that is considered disrespectful. The whole society will rise against you for doing that!” Mimicking the voice of one of the captains with a reputation for high-handedness, First Officer XPV added: “You will never get a landing again!” Another first officer quipped: “You can also kiss goodbye to your dream of becoming a captain here. You may have to quit and go to another airline or another country!”

When asked if fear of reprisal is the main reason in their decision not to question their captains’ actions, 67% of the first officers nodded to the affirmative. One first officer helplessly raised his eyebrows and commented: “The cockpit belongs to the captain. He is the boss, with all the power!” He continued: “It is a captain’s industry. All you can do is wait for your time!” These statements confirm the findings by Bourdieu (1984) and Miller et al. (1993) which suggests that rather than be seen as responsible for altering the social order, lower-level people from high power-distance cultures would always accept, and where necessary, try to own the society’s instruments of inequality by participating in enforcing its tenets. In doing so, they achieve two things: on the short term, “any potential conflict with the superior” is diffused; on the long term, they are accepted and trusted “as committed members of the tribe,” thus securing their own and, possibly, families’ future (Bourdieu, 1984).

McLaughlin (2013) suggested that breaking the social order in a tribal group, especially by a lower member of the group, is often seen as an act of disloyalty to the entire tribe and, in worst cases, as treason. In the case of the aviation industry, the captain is already a trusted member of the tribe - a power-holder. He has nothing to gain by disrupting a system that favors him. Thus, when the same question was put to one of the captains in the study, his response was swift and predictable: “If a first officer wants to be the decision-maker inside the cockpit, he will have to wait until he becomes a captain!” One of the younger captains responded that while he acknowledges that captains are human and do make mistakes, “it is not part of our culture for a junior person to correct or question his superiors.” This cultural attitude, he agrees, “definitely” has a negative impact on aviation safety. “It is not a good thing for aviation safety when a first officer is afraid to correct a captain when he makes a mistake.” He chuckled and added: “but, unfortunately, that’s the way it is!”

Another captain noted that while CRM is a commendable venture that is good for safety, he does not believe that equality has a place in the cockpit in Africa. “Our culture,” he was eager to point out, “does not recognize equality even in a family.” Yet another one supported his position by quoting the Bible in his assertion that God recognizes the husband as “the head of the family, the same way Jesus is recognized as the head of the church.” He argued further that while two pairs of eyes are better than one, having two captains in a single ship is not good for safety either, “it can also lead to disaster.” For these reasons, they both argued, hierarchy should be part of the CRM process because “that is the order of everything in nature.” Another one added:

"That's what we believe in Africa and that's our way of life."

Winterich and Zhang (2014), in their work on the motivating factors behind charitable acts or behavior, posited that people with high power-distance belief (PDB) tend to demonstrate a lower perceived responsibility to aid others, thereby decreasing their participation in charitable giving. Contrary to that finding, however, the respondents in this study view high power-distance as a fundamental part of charitable giving. One captain put it this way: "It is our responsibility to groom our young first officers. We are willingly transferring our knowledge and experiences to them, without any condition. They just have to listen to us and respect us as their captains and stop fighting over space with us." Two of the first officers agreed, as exemplified by First Officer XPW's comments: "they (captains) went through the same tutelage to get to where they are today. If they had been rude to their superiors, they will never have got to where they are now."

Thus, from the perspective of these respondents, the high power-distance between captains and first officers in the industry is a manifestation of captains' role as mentors to their younger and less experienced colleagues. In their view, the captains are "freely giving their time and abundant experience" to help the first officers "to grow like them." Most often, such 'giving' comes with tough love that may include verbal, and in some cases, physical assaults. That is the nature of things. Every good thing comes with a price. As one of the captains proudly explained, "bringing a baby to life is an amazing thing, but a mother cannot give birth without shedding blood." Suffering and sacrifices are part of a success story.

This type of rationalization can also be deduced from the African perspective of success. Within many African cultures, sacrifice or the act of enduring pain to achieve success is accepted and hailed as a necessary ritual towards human accomplishment (Soetan, 2001). A mother has to shed blood to bring forth a new life. A male child has to go through circumcision to become a man, the same way a girl has to experience menstruation in order to be called a woman. All these processes involve some pain, discomfort, or suffering, but they are geared towards a successful outcome.

Furthermore, the process of a young African boy becoming a man "traditionally involves some form of stringent initiation rites," the lack of which, Obuh (1989) argues, can derail the boy's attempt at becoming a full-fledged member of the community's adult population. It is a cultural belief and way of life that have been transmitted from generation to generation. With such cultural and historical background, it is understandable why many of the respondents believe that some form of power-distance between the captain and the first officer is "okay for the good" of the first officers themselves. As one of the captains said, quoting a famous African proverb: "The road may be rough, the journey may be tough, and the experience may be bitter, but they are stepping stones to our future thrones."

Power-Distance: Right or Wrong?

Despite this general belief system that favors power disparity, a few of the respondents were quick to repudiate it as "not right," especially when they are themselves victims of it. For example, throughout the interview process, Capt. XPK continued to bemoan the "oppression" that he experienced in the hands of a particular captain when he was a first officer a few years earlier. He recalled how, as a first officer, that captain mentally and verbally abused him on several occasions, eventually culminating in a physical assault on at least one occasion, a fact that was corroborated by another pilot who witnessed the encounter.

While he views his travails in the hands of that captain as "wrong," now that he is himself a captain, XPK nevertheless sees CRM as "a perversion of African culture" for the main reason that it sought to turn “a whole aircraft commander into a nobody” by requiring him to seek the permission or consensus of “a mere first officer” before making a decision. While he believes that CRM can “contribute something” to aviation safety, he does not believe that the best way to go about it is by “castrating” the captain. In his opinion, such a system will never “fully work” anywhere in Africa. “Why then am I wearing these four bars?” he queried, and answered simultaneously: “Maybe they don’t mean anything anymore, even though I struggled to get here!” Like an afterthought, he added: “I have paid my dues in this industry and I deserve the gains that come with the success!” Many of the respondents shared the same belief, with particular emphasis on the need to “reap the fruits of one’s sweat.”

One of the questions in the study was about respondents’ understanding of power-distance and CRM. Many of the pilots seem to have a good understanding of CRM, with statements such as “making use of all available human and other resources to promote safety” and “resolving communication failures and improving situational awareness” repeatedly featuring in their responses. When it comes to power-distance, however, their descriptions of it points more towards validation. One of the first officers described power-distance as the “normal relationship between parents and children” or a boss and the workers “under his supervision.” Another one likened it to the relationship between “a military commander and his troops in the war front.” Or between “a football coach and his players in a world cup tournament.”

This unending desire to seek justification for society’s disparity in power by highlighting its positive values as a way of normalizing it further confirms Hofstede’s assertion on the eagerness of lower-ranking members of a high power-distance society in accepting their unequal status (Hofstede, 2001). From safety perspective, power-distance is an anomaly inside the cockpit; it disturbs the whole concept of CRM. The aviation industry ranked the captain at the top of its ladder; societal culture in Africa further saddled him with unquestioned authority. The role of CRM in the equation is to strike a balance between his powers as the aircraft commander and his physical and mental limitations as a human being. In Africa, the ability to strike that balance can be limited if the cultural perspective of the major players, including the junior crew members, is not aligned with the program's objective.

An example of that cultural misalignment surfaced when the pilots were asked if they will consider taking control of the aircraft from the flying pilot if the standard operating procedures are not being followed and the flying pilot is not responding appropriately to advise or queries from the monitoring pilot. All the captains were unanimous in stating that they would, and all the first officers agreed that they expect the captain to take control of the aircraft from them under such a scenario. However, when asked if they would do the same if the roles were reversed, 50% of the first officers stated that the only time they "will consider" taking control of the airplane from the captain is if he (the captain) is incapacitated "in any form or manner."

A follow-up question, thought to be a critical safety one, was asked of the first officers: what would they do if the captain showed up for flight drunk? They all agreed that they would not condone such a behavior, but are divided on how they would handle the situation. The majority of the first officers (67%) claimed that they would not only refuse the flight but will also let the chief pilot or someone holding a near-equivalent rank in flight operations know about it. The remaining first officers stated that their responses would depend on "the level of drunkenness" of the captain. They answered that while they will not fly with a captain who is "completely drunk," they will first "watch him closely" to determine the level of alcohol in him. However, they will not report him. One will counsel him to "call in sick and go home." Another will pray for him, "counsel him to go for treatment immediately," and further advise him to "accept Jesus in his life."

This overall concept of captain's command authority and its inviolability, except in the case of incapacitation, is not only a tenet within the aviation industry in Nigeria, it is part of the country's overall culture of deference to a higher authority. That culture, and its justification, rewards those who play by it and punishes those who defy it. For example, up till twenty years ago, a first officer's progression to captain rank required the approval of a certain percentage of the number of captains in that airline. That was the case in many countries and most airlines. First Officers would typically carry with them "upgrade forms" for their captains to sign. A "good" first officer could garner as many signatures as he needs in a short time to apply for the upgrade; on the other hand, first officers with the image of "a bad boy or bad girl" could find it hard to get enough sponsoring captains.

While the requirement for captain signatures in upgrade form is no longer popular or applicable, there are still other ways to punish "recalcitrant first officers" in the industry. Capt. XPL argued that all a vengeful captain needs to do is spread "some rumors" about a first officer's flying skills, enough to scare many captains. "No captain will want to fly with an incompetent and arrogant first officer." If that happens, "that first officer's career is over. There is no way of recovering from that!" When asked if it is possible for everyone to believe a single captain's word against another crewmember without any investigation, he smiled and responded: "Remember, this is a small industry, and almost everyone knows everyone!" "Besides," he continued, "it is the captain's word versus a first officer's defense, especially if it is from a captain with a good reputation in the industry. Who do you think people are going to believe?"

CRM: A Cure or A Curse?

A recurring pattern in this study is the notion among some of the pilots that CRM equates crew equality or is an attempt to make the first officer equal to the captain in the cockpit. To support that notion, Capt. XPG related an experience he once had while in the US for training. One of his simulator sessions was canceled because the airline that owns the training center needed the slot to train one of its captains. On further inquiry, he discovered that the captain was sent for re-training because his first officer reported to the company that he (the captain) was not following the company's standard operating procedures (SOP) on the flight line.

Another captain, XPB, told the story of an expatriate captain at his previous airline. The expatriate captain was fired from his previous job in the U.S. because he flew with a first officer who "snitched on him." That, in his view, exemplifies the "over-application of CRM." He believes that if an airline "does not like a captain," the management can "easily use CRM" to get rid of him. That and many other stories that he has heard about CRM made him to distrust it. That, he argued, can get worse in a place like Africa where "there is so much impunity" and where airline owners can use their powers "to punish any captain they don't like."

Capt. XPL also related an experience he once had with an expatriate first officer at one of his previous jobs. He had, for several years, been on medication for high blood pressure. Because of the implications for his job security, he had not disclosed his ailment to the airline or the regulatory authority. A day before going for his biannual aviation medical examination, he took some medication to lower his blood pressure. When the expatriate first officer saw him taking those medications inside the airplane, he became apprehensive of his intentions. Unable to draw a reasonable explanation from him to justify the need for those pills, the first officer filed a report to the chief pilot's office.

As a result of that report, Capt. XPL was suspended from flying and asked to see a company-appointed physician for evaluation. He refused, calling the company's directive "a witch-hunt." That led to his separation from that employer after many years of employment there. He blamed the "embarrassment" from that incident on the "vast powers" granted to first officers through the CRM program.

This perception of CRM as a potential instrument for pilot vengeance pervades among a segment of the pilots, especially the captains, in this study. They do not trust that the outcome will be used only for safety. While most of the pilots see CRM as "good for aviation safety," they disagree with its process, which they think is not in alignment with their cultural beliefs. This lack of trust in the process presents broader implications than a mere case of policy distrust. Tyler (2005), in a study of minority perceptions of police work in the U.S., posited that when people form their opinions about a system "based on their interactions with actors in that system," they tend to focus more on the process than the outcome. In this case, the participants' distrust of the CRM process is due to its cultural underlings, based on their interaction, and which they perceive to be disrespectful or not in consonance with their ways.

Also, when people distrust something, it creates a sense of insecurity or fear in them (Kirby, 1997). In fear, there is the element of "impending loss or the potential for it" (Zastrow, 2001). These pilots see an impending loss of some of the privileges they enjoy as captains, and dismissing CRM as "anti-African" is one way of fighting back against it. Pressed as to why they think that CRM is aimed at creating equality between captains and first officers in the cockpit, their responses ranged from "what else is the intention, except to encourage co-pilots to snitch on their captains?" and "I can tell that is the direction we are heading," to "that's what I think" and "I don't know, but I just feel that way!"

These responses also align with Mazonde's findings on the link between low education success rate in Africa and the observation that its process lacks congruence with the beliefs and cultural ways of the African people (Mazonde, 1998). As in education, these pilots can see the immense benefits of CRM, but they have problems with its process because it does not follow the dictates of their culture or "ways of doing things." African societies, Matondo (2012) noted, have for a long time, "functioned on the doctrines of hierarchy, fixed roles, authoritarian decision-making, and conformity/commitment" to group values and interests. The participants in this study have spent most of their lives adhering to those values even though such values might be antitheses to those championed by CRM. As shown in their responses, any attempt at changing those ways, especially from outside, is bound to be met with stiff opposition.

Personal Ego and Communication

From the start of this study, the researcher insisted on a first-name relationship with all the participants as a way of enhancing low power-distance with them. Despite that, two of the first officers were uncomfortable with addressing the researcher by his first name. "I am sorry, *sir*; I am not used to calling captains by their first names," one of them said. "Is it okay if I just call you skipper?" another asked, after several admonitions. First Officer XPT tried to explain why it is difficult for him to relate on a first-name basis with "some" senior captains. He narrated his experience with another senior captain on the issue a few years earlier:

> I had asked a ramp agent to get me a particular brand of soft drink. When the agent brought it, the captain and I were busy programming the FMS. To draw my attention, the agent said: "Captain, I have your drink here." The captain looked back and responded: "Who? I did not order any drink." At that point, I responded that I asked him to bring the drink for me and reached out to take possession of it. From that point on, it was hell for me. He started screaming on top of his voice: "Who made you a captain? When did you become a captain? If you are the captain, what am I? Is that the lie you have been telling people everywhere?"

XPT claimed that the passengers who were boarding the flight heard his captain screaming at him. All his efforts at explaining the misunderstanding fell on deaf ears. "In fact, the more I tried to explain, the angrier he gets." XPK explained further that "it is not unusual in our part of the world for airport workers to address every pilot they see as captain. They don't know any better." Despite XPT's pleadings, "my captain screamed and balked the whole flight."

Capt. XPK related a similar experience he once had with another captain. He and that captain were at London Heathrow airport on their way back home. The ticketing agent asked for their names as they appeared on their traveling documents to process their tickets. XPK did that for both of them. When the agent handed over the tickets to them, their names were prefixed with "Mr." He was okay with it, but his partner was not. The other captain looked at the ticket, tossed it on the desk counter, and went into a fury:

> He was screaming on top of his voice! "Who told you that I am a Mister? Mister what? I am an airline captain, a real one! I worked hard to earn that position!" He wrote the word "Captain" in capital letters on the ticket and insisted that he will not accept it until the agent make the change. Meanwhile, he continued shouting obscenities. When I tried to tell him to ignore the error because it does not affect our flight or ticket class, he turned his anger on me. He created a big scene, accusing me of being the one who made the agent to disrespect him! The agent refused to change the ticket. So, after we boarded the flight, he went ahead and wrote "Capt." on top of the space where he had put a line across the "Mr." before his name. He sulked through the whole flight and for a long time after.

Thus, it can be argued that ego is part of the challenges of personal interaction among crewmembers in Nigeria. As Ritter et al. (2013) posited, ego comes with "delusions of grandeur and the desire to be constantly noticed, flattered, and admired." Holiday (2016) further describes this need to make one's presence felt on the individual personality and upon others as "the cause of many negative human traits, including that of being critical and judgmental of others, being manipulative, and constantly worrying over trivialities." Many of those characteristics were on display with some of the participants in this study.

Analysis of Power-Distance Behaviors

One of the advantages of the qualitative research methodology employed in this study is the ability it affords the researcher to take cultural, historical, and societal influences into account when analyzing the data and telling the participants' stories. The context of the culture, time, and place, both geographically and historically, creates a frame of reference from which the research question can be explained and understood. That frame of reference was used in connecting and explaining the four stages of participant reaction or what Williams (2003, p. 273) referred to as "discrete transitions" of their feelings toward the offending superior crewmember as reveled in this study. They include the offending act or behavior, the attendant shock and confusion, the withdrawal stage, and the final shut-down (Figure 5).

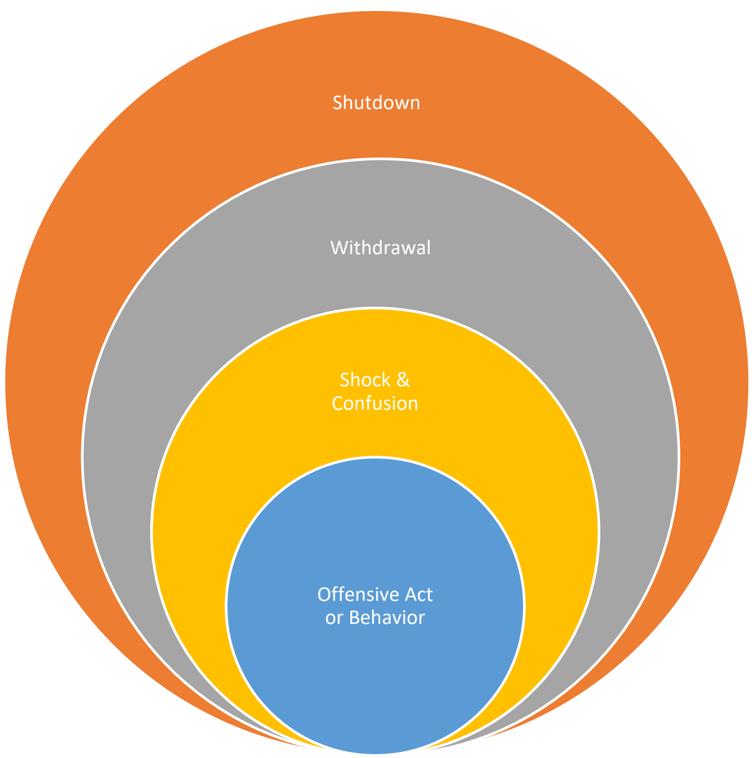

Figure 5: The four stages of the PDB reaction process.

However, unlike most processes where the stages take some time to metamorphose from one to the other, the steps in this power-distance behavior (PDB) analysis happens quickly, with some overlapping the other. For example, First Officer XPM recalled that from the time the captain he was flying with assaulted him for moving the radar controls to tilt it downward for a better view of the weather ahead of them, his thoughts went from pain to fear, anger, and withdrawal in a few seconds. The shock and confusion stage took much longer because the captain's action happened so fast, and he was "confused" on what his course of action should be. In such cases, the withdrawal process was instantaneous: "I went straight into a withdrawal. I went into deep shock and never recovered." For another pilot, "My whole body shut down immediately!"

The Offensive Act or Behavior

The first stage of the process can be defined as the offending act or behavior that triggered the power disparity by the senior person. The participants define that moment as "when you know that you are going to have a very bad day." They can vary from a seemingly insignificant act of the captain ignoring the first officer when they met for the first time, or the use of actual words of abuse and dismissal, to the extreme case of using profane words and physical assault on them. In some cases, the junior crewmembers are aware of what to expect when they show up for work. First Officer XPV related his experience thus:

> You know, it's a small industry here. Everybody knows almost everybody. People talk to each other. So, long before I flew with him, I heard stories about him. I was told that he is a difficult person to get along with. I met him with fear, my heart was beating very fast. I don't know what I did wrong to offend him. But I know that it was 100 degrees, so I opened one of my shirt buttons to loosen my tie a little. I don't know if that was the problem, but he did not respond to my greetings. Instead, he took a look at me in a somewhat condescending way, you know, the kind of look that said everything. He never said one friendly word towards me throughout the flight. When he wants something, he calls for it in a very angry tone. It's like he was mad at me, but I couldn't figure out why.

From XPV's account above, the moment he said "hello" to his captain and there was no verbal response, he knew that the day was not going to be a good one. But, as in many cases where there is a clash between high- and low-power individuals, the low-power people are typically the ones who make changes to themselves because, as Kraus et al. (2009) posited, having low power means "always having to adjust and adapt to fit into the world of the high-power person." In this case, XPV felt that it was probably not the captain's fault for not warming up to him on their first contact. "Maybe he was having a bad day," or "maybe I greeted him wrongly." Or, "maybe someone who does not like me said some uncomplimentary things about me to him! Maybe…." XPV felt that the onus was on him to reproach the captain in a better way: "I have to lower my head. I am the one who needs acceptance, not him."

The same thought went through First Officer XPY's mind when his training captain physically assaulted him inside the cockpit. He did not feel that what the captain did was right, but he felt that he was partially responsible for what had happened to him. Like XPV, he experienced a moment of confusion that culminated in expressions of doubt about himself. He claimed to be "so dazed" and, as such, was unable to fathom how best to react to the assault.

Cravens et al. (2015), in their study of why abused women stayed in the relationship with their abusers, posited that "self-blame, damaged self-worth, and fear of retribution" are some of the main reasons why such women do not leave. In the case of these first officers, blaming themselves for the abuse or violence visited on them by someone else is "a typical symptom of abused women's syndrome" (Johnson, 2008). Related to self-blame is the damage to the self that results from "degrading treatment." Like the abused woman, many of the first officers in this study "felt beaten down," and of little value. That, combined with the fear of retribution that can jeopardize their career advancement keeps them in a trapped situation (Cravens et al., 2015).

Shock and Confusion

In general, those who found themselves at the receiving end of the precipitating behavior or acts of abuse tend to experience momentary confusion about how to react to it. Based on these crewmembers' accounts, the movement from the first stage (offending act or behavior) to this stage tends to take longer due to the initial confusion. First Officer XPV, for example, recalled that it took him "a very long time, probably up to two minutes" before he could think, or "come to terms with what had just happened." His colleague, First Officer XPT, claimed that it took him about 3 to 5 minutes to get over the shock of being shouted on and called a "moron" by the captain he was flying with because he missed an ATC radio call.

> First, there was a feeling of shock, followed by shame and worthlessness. My situation was compounded by the fact that he (captain) would not stop talking. He kept screaming at me and calling me horrible names. So, it was hard for me to get out of that despair and confusion. I felt so worthless, almost to the point of killing myself at that point. I was totally lost! I could not think immediately or react in any tangible way. It was bad, very bad. Nobody should be treated that way.

Every participant in the study who has been through that experience relates that it was hard to get used to the shock and confusion, irrespective of the number of times it has happened to them. "Every experience feels like the first time!" One participant claimed that even though he had flown with a certain captain so many times in the past and "knew him like the back of my hand," he still feels "scared" every time he flew with him and "shocked and confused" whenever he chooses to "belittle" him. Many participants reported that after the "devastating" shock or confusion, they seamlessly transitioned into the next stage, the withdrawal phase. "The transition was very sudden. I guess I was hurt so much that I did not know when or how the transition happened." The most painful part of this experience, XPY said, is the fact that "I still have to sit in the same cockpit with my abuser for the rest of the flight, and other flights!"

Withdrawal

Many of the participants in this study see the withdrawal stage as the cooling moment that connects the anger or confusion to the complete shutdown. First Officer XPW recalled that her transition to the withdrawal stage was very sudden: “I was seething with anger. Of course, I cannot talk back. So, I kept my anger bottled inside me. Keeping quiet was my only way of responding.” Another participant described the withdrawal process as a “melting down” period: “It’s like an ice buildup. With exposure to a higher temperature, it starts melting until the complete transition to liquid water.” In some cases, the process can be delayed or stopped from transforming to a complete shutdown if the captain made “a reconciliatory move or statement to defuse the situation.” First Officer XPV claimed that while such moves can “help” in reducing the tension, it is “difficult to completely reverse the damage” that has already been done. As he relates it,

> When someone has belittled you that much, it creates a scar in your heart. It’s like being stabbed in the heart with a big knife. It never heals completely. You carry the scar in your heart for the rest of your life. It creates fear in you and it affects your confidence level. You are even scared of interacting with other captains irrespective of how nice they might be towards you. It’s like a woman who has been jilted. It takes a long time for her to be able to trust another man again. That’s how it feels.

While withdrawal is a temporary stage that can potentially be reversed, many of the respondents claimed that their minds were already “outside the airplane” by the time they get to that stage. The implication is that those pilots were no longer thinking about the safety of their flight at that moment; their minds were pre-occupied with hurt and fear from the low self-esteem occasioned by “negative communication” or lack of communication inside the cockpit. At that time, any remedial effort, argued First Officer XPV, is “almost like trying to force a dead horse into a race.” Many other research participants in similar situations felt the same way.

Shut Down

The last stage of the PDB process is that in which the people involved completely shut themselves out or disengage from their immediate environment. It typically results when a listener or participant "withdraws from an ongoing interaction or event" (Van Der Hart et al., 2004). Tartakovsky (2016) describes it as "stone-walling," something that happens when a person "refuses to interact actively, engage, communicate, or participate" in a process.

People often go into the shutdown phase because they are trying to avoid or escape a conflict (Neville, 2006). In doing that, Schalinski et al. (2015) posited, they may "turn away, stop making eye contact, cross their arms, or do anything to escape" the environment they are in. That was precisely the experience that First Officer XPW had with a certain captain she flew with:

> We could not get along at all. He found fault in everything with me. My radio phraseology was wrong. He said I don't know anything and that I have no business being in the cockpit. He accused me of possessing a fake pilot license from a fake flying school. He said he has been flying long before I knew how to crawl. Who am I to tell him that he is flying below the glideslope? He chastised me for so long that I could not take it anymore. I just went into a shutdown. I was overwhelmed and I did not want to be part of anything with him anymore. In fact, if I had seen anything bad happening to the flight at that time, I would have maintained my silence. *I don't care anymore*….

This shutdown stage represents the point where interpersonal relationships and effective communication between the two pilots inside the cockpit have entirely broken down. As mentioned earlier, effective communication between flight crewmembers is essential to flight safety. It is through it that other safety factors such as "information sharing, planning, leadership, decision-making, and identification and management of errors and problems are realized or made possible" (Neville, 2006). Communication is thus a very crucial part of safety, so much that in describing it, Monan (1988) noted that "perhaps no other essential activity is as vulnerable to failure through human error and performance limitations as spoken communication."

Thus, arriving at the shutdown phase of minimum to zero communication without mitigating efforts to stop or reverse it can result in a tragic end for the team and the mission-objective. Verderber & Verderber (1992) had argued that one distinctive aspect of communication relationships, especially in a hierarchical setting, is “how people interact with each other in the course of upholding their team mandate.” They noted that because “conflict exists in all relationships,” communication serves primarily to diffuse it. Such conflict may go unresolved when communication is “difficult or impossible.” From a humanistic perspective, Tartakovsky (2016) added, effective communication relationships typically involve “openness, empathy, supportive behavior, engagement, and commonality.” That usually happens with people “after a solid and clear sociological connection” has been established between them (Verderber & Verderber, 1992).

Where that connection is eroded or lost, as exemplified by an “I don’t care anymore” mentality, the overall objective of a working relationship between the people involved in that process is destroyed. When that happens in an aviation context, open communication, and, thus, the safety objective of CRM in the cockpit can easily be compromised. That is the biggest threat posed by a shutdown or withdrawal syndrome because of power-distance, occasioned by age or seniority, in a flight environment. While the act of communication shutdown or withdrawal from the safety process by a crewmember is potentially dangerous, the circumstances leading to it are in themselves, signs of danger. Noelle-Newman (1993) posited that individuals have a fear of isolation by their social groups or the power-holders in their society. It is that fear that leads oppressed people to either maintain their silence or toe the majority line of silence instead of voicing their opinions where and when they need to do so.

The circumstances leading to silence or communication shutdown among some junior crew members in this study emanate from similar fear of isolation by the power-holders in their profession. Because of the way power is distributed in the Nigerian society, the junior crewmembers (first officers) typically bear the brunt of the immediate damage caused by the shutdown. In reality, though, the long-term and most damaging effect of it is borne by the whole society, by virtue of the consequences on its aviation safety management process.

Summary

The objective of this study was to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots. Beglin (2016) described seniority within the Chinese society as “the lubricant used to establish a harmonious atmosphere” amongst its members. This is mainly due to its ability to soften any conflict within or between the component groups in the society. In Nigeria, power-distance plays a similar role. Across society, age and seniority are the primary tools for exercising power and authority within a household, clan, or national space. That has been the African continent’s method of maintaining peace, discipline, and law and order within and among the citizens long before the arrival of Western law enforcement infrastructure.

However, as shown in this study, the power embedded in age and seniority is not always used for societal or professional good. In many cases, they have been severely abused by those who wield them to preserve and promote their interests or boost their egos. This study used participant data to explain how Nigeria’s culture of deference to age and seniority was used to promote personal interests and egos, and how such behaviors affect crew communication, thereby distorting the application process of CRM in the aviation industry.

The process of explaining the effect of age and seniority as power-distance factors on the communication aspect of CRM among Nigerian pilots started with identifying the precipitating behavior, attitude, or action of the senior crewmember through the different but related stages of shock or confusion and withdrawal, and ended with a partial or complete crew shutdown. The receiving crew members moved through each of the stages in temporal order, except for the shutdown phase. While every stage is crucial and has some debilitating effects on cockpit communication if not reversed, the shutdown phase poses the greatest danger for the CRM process and aviation safety.

Data provided by the participants in this study points to several adverse effects of power-distance inside the cockpit. As in most prior literature on the subject (Ekiyor, 2004; Frank & Ukpere, 2012; Peretomode, 2012; Ejimabo, 2013), findings from this study supports the belief that age and seniority are two of the most prominent drivers of power-distance in the Nigerian society, and by extension, its aviation industry. Within African societies and institutions, leaders are typically given uncontrolled powers so that they can adequately deal with all situations or threats as they emerge. Excessive power in the hands of one individual can lead to abuses. This study revealed the negative effect of the uncontrolled exercise of those powers in a modern jetliner cockpit and the potential consequences on safety and threat and error management for a global industry such as aviation.

CHAPTER 5: DISCUSSIONS AND CONCLUSION

"The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn and relearn" – Alvin Toffler (1990).

Introduction

The previous four chapters have outlined the nature and depth of age and seniority as power-distance factors within African societies, reviewed the existing literature on the topic, and identified 12 codes related to how those factors effect pilot communication. Those codes were further collapsed into three broad themes that are related to the subject of power-distance among Nigerian pilots. The choice of a qualitative case study methodology to study the effects of age and seniority on the communication aspect of Crew Resource Management among Nigerian pilots was justified in Chapter 3. In Chapter 4, the researcher submitted and analyzed the data emanating from the study and tied it to the topic of power-distance among Nigerian pilots.

This chapter, thus, is aimed at connecting the research findings with the research questions, analyze the findings in the context of existing literature or what is already known, and justify the relevance of the research. The purpose of relevance in a qualitative study, Glaser (1998) argued, is to provide an indication that the research data explains "how what is going on is continually resolved," especially regarding the research questions. To achieve that objective, the chapter will start with an analysis of the research findings and the usefulness of the findings in answering the research questions. That will be followed by discussions on the possible limitations of the study. After that, the policy and operational implications of the study for the Nigerian aviation industry and suggestions for any future research will be addressed.

Analysis of Research Findings

Result Discussion

Data from this study indicates that age and seniority have tremendous impact or relevance on the scope and flow of communication between a captain (senior) and first officer (junior) in the Nigerian aviation industry. The researcher discovered from the data that power-distance caused by age and seniority between the two pilots inside a cockpit can have a debilitating effect on how they relate and communicate with each other, thus potentially jeopardizing the safety objectives of CRM. The data showed that the junior pilots, who are typically the ones on the receiving end of the power-distance spectrum, go through some emotional stages and processes that, most often, overlap each other.

The data from the study also shows that majority of the participants have at one point or the other in their career suffered the humiliating process of "being talked down or walked over" by someone senior to them inside the cockpit. Many of the first officers have stories to tell, in varying degrees, of the "intimidation, fear, and belittlement" that have been meted to them by their captains. The captains shared similar stories that portrayed their "concerns" of what they went through when they were first officers. While the actions or behaviors that were used to display power-distance between them and their senior colleagues varies, depending on the time and circumstances, the fear and powerlessness induced by those behaviors remain the same, as did the emotions of withdrawal and the silence or shutdown that followed. So are the impact of such emotions on the communication aspect of the CRM process among the pilot group.

Data from the study showed that there is a continuous conflict between those crewmembers who want strict adherence to that cultural way of behavior and others who want changes. Many of the captains want their first officers to be "quite and attentive" when they (captains) are talking, the same way junior people defer to their elders within the larger society. They want their first officers to be attentive and learn from their wisdom, and not spend their time questioning their authority as the pilot in command of the flight.

As demonstrated with the four stages of the victim reaction process towards power-distance behavior, research data reveals that communication breakdown between a junior and senior pilot is typically a major sign of power-distance behavior. The "I don't care anymore" and other statements from First Officer XPW exemplifies a state of finality, indicating complete shutdown in the communication channel between a junior crewmember and the captain. Because CRM is about communication, any shutdown in communication between the two crewmembers in the cockpit can have a devastating effect on the implementation of the CRM process, and thus aviation safety in Nigeria.

The first research question in this study refers to the effects of age and seniority as power-distance factors on the communication pattern between junior and senior pilots in Nigeria. Data indicates that power-distance occasioned by age and seniority is prevalent in the Nigerian society, and it has tremendous influence on the communication pattern between junior and senior crewmembers in the country's aviation industry.

The second research question is about the effect of the communication pattern between a junior and senior pilot in Nigeria on the implementation of CRM process in the country. Findings from this research shows that the misaligned communication pattern between a junior and senior pilot in Nigeria has a negative effect on the CRM implementation process in the country. The discovery from this study, thus, answers the research questions on the effects of age and seniority as power-distance factors on the communication aspect of the CRM implementation process among Nigerian pilots.

Analysis of the Results

The data from this research shows how Nigerian pilots, of different ages and seniority, communicate with each other in the flight line. It shows *what*, *how*, and *when* they share critical safety information amongst themselves and the relevance of the ensuring interactive process in advancing or stagnating aviation safety in the country. The data also testifies to the relevance of communication to the CRM process. In terms of communication within the cockpit, three significant themes that highlight the major concerns of the captains and first officers in Nigeria emerged from this study. They are seniority, respect, and fear.

Among Africans, seniority and respect are intertwined. Without respect for the elders and seniors, individuals, whatever other positive qualities they may possess, will find it hard to go far in many African cultures (Nwankwo, 2015). Many captains in this study expressed utter disdain for a first officer who does not "show respect" for their seniors. One way of showing disrespect is for a person to meet someone senior or older for the first time and greet them in a casual manner. With the entrance of young millennials into the aviation industry, there is the possibility that many of them will bring along their 'laid-back' behavior or what psychologist Goali Bocci (2017) referred to as "digital greeting," into the cockpit.

For many people, especially in Western societies, the image of their young wards greeting them with a hand wave while busy on their phones or other digital devices is no longer uncommon (Loh et al., 2020). Most in the West have made peace with the fact that their children may see them and use a slang word instead of a formal greeting or talk to them while their eyes are glued to their gadgets. In Africa, such behaviors are still frowned upon as very disrespectful. For a first officer to meet his captain for the first time and not show the basic gestures of respect such as smile, eye contact, and acknowledgment can trigger an unpleasant reaction that has the potential of marring their day together. When such happens, as in most relationships between a superior person and a junior one, the outcome is hardly ever in favor of the later.

Among the participants in this study, the first officers know their positions relative to that of the captains. Because they grew up in the same traditional society, they cannot escape their immediate environment's cultural ways. So, they understand that they have to defer to the captains, irrespective of whether they agree with them or not. As they are accustomed to doing at home and in the society, they know that they have to “warm up to” the captains by greeting them respectfully on their first contact.

Respect for the captain, thus, starts with a warm formal greeting. As in other instances where a junior person has to interact with an elder or senior person in the Nigerian society, the next thing is for the first officer to stay a step behind the captain on their way to the airplane. “Walking ahead of your captain is a sign of disrespect for his position and person,” commented Capt. XPK, drawing on his experiences from when he was a first officer. “You can offer your services to the captain and he will tell you if he needs you or not,” he insisted. “The rest of the journey,” he added, is as easy as it can get: “Just sit down and shut up!”

While this narrative shows the usual format of interaction between a first officer and the captain, not everyone agrees with it. A few of the first officers, including one captain, have started questioning the necessity for such a rigid power-distance structure in the society. One first officer’s critical question started the conversation: “How do you define respect?” Should a person blindly respect his seniors or elders even if they are not behaving in a way that deserves respect? What if the senior or older person takes advantage of his position to oppress those below him? In other words, should their position as pilot-in-command confer on captains the right to demand and expect respect from their first officers irrespective of the circumstances?

A captain’s lawful instructions must, and need to, be obeyed by subordinates in order to maintain a disciplined and safe operation. But, does that extend to respect? Does one have to respect a boss in order to follow his or her operational orders? Do a boss and people with power who have no respect for others deserve respect themselves? Flaxington (2018) described respect as “a feeling of deep admiration for someone or something” based on or elicited by “their abilities, qualities, or achievements." On the other hand, to obey someone is to simply comply with the command, direction, or request of that person or his authority.

The difference between obeying someone with authority and respecting that person can also be viewed in the context of defining a boss versus a leader: While a boss gives orders to his employees, a leader influences his followers by setting an example. Employees will obey the boss because of his seniority or authority; they will follow a leader because they *respect* his ability and character. A leader is recognized because he values and respects those working under him; a boss is identified by his penchant for dominating the space and administering rules on those beneath him. These observations about respect will need to be explored further to fully understand its dimensions, and determine its rightful balance within the Nigerian society.

One prominent topic in this study is arrogance. While respect is desirable, arrogance is considered its distasteful opposite within the Nigerian culture. From the perspective of many first officers in the study, an arrogant captain is a problem. For captains, an arrogant first officer has no place in their flight deck. From their statements in the study, it is evident that an arrogant first officer can easily get into trouble with his captain. However, what if the arrogance is from the captain? Can the first officer do anything to chastise a captain who is misbehaving?

Because the locus of cockpit power lies with the captain, it can be surmised that the bulk of the work aimed at leveling the power dynamic within the cockpit should be directed at the captain. However, since most first officers will eventually become captains, there is enough reason to believe that an arrogant first officer may likely carry the same arrogance with him to his command post. Thus, it is evident that both captains and first officers need more culturally-targeted training that will help in mitigating the over-bearing effects of power-distance.

Another topic that "stands out" from this research data is interpersonal connections among the crewmembers. The first officers reported that a prior personal relationship with the captain assures a cordial relationship between them. Takaki (1993) posited that personal relationships are, often, the glue that binds people together, “especially during times of stressful situations and other difficulties.” Data shows that person-to-person relationships create trust, while competence or capability leads to mutual respect among the pilot group. Captains admitted trusting and relying on first officers who are competent just as first officers confessed to having respect for captains who value good relationships with their junior colleagues.

Data from this study indicate that many captains show friendship, trust, and camaraderie to first officers who reach out to them for friendship and those they consider to be competent and skillful as pilots. Captains report that they often share jokes and talk about family with such first officers. Some of the first officers also expressed their respect and admiration for captains whom they consider to be competent or “on top of their game.” Thus, competence and relationship are two shared values that can potentially serve as connecting bridges between the two crew members and lay the foundation for an effective CRM process in the country.

Personal relationships can also be mirrors that show us how to manage our fears: It is not unusual for first officers to spend some valuable time before their flights gathering intelligence information on their captains. They want to know the likes and dislikes of the captains they will be flying with, especially if they are going to be together for some time. Any information can be helpful, but getting first-hand information from another first officer who has flown with that captain in the past can be more valuable. As one of the first officers explained it, “if you are going to be locked up for a couple of hours in a small tube, alone with a lion, you might as well know what type of food that lion likes to eat.”

Last but not the least is the theme of fear. Ohman (2000) posited that fear can either be rational and appropriate, or irrational and inappropriate, depending on the circumstances. How we react to fear is based on our perception of the level of danger or threat. For some of the first officers in this study, their perception of fear is mainly related to its impact on their present and future career objectives. However, irrespective of the causal factors or implications, one fact is obvious: Flying is a safety-critical profession. Having to fly an airplane filled with innocent, and fee-paying passengers, while also dealing with the looming fear of one's senior colleague at the back of one's mind can never be considered a normality; it should not have to be.

Implications for Aviation Safety

The damages occasioned by shutdown or withdrawal, as presented in this study, can be applied to other situations in life where a person is denied access to a level playing field. Aside from age or seniority, other areas in which such denial can happen include nationality, religion, race, gender, or sexual orientation. In almost all of those situations, the usual human tendency is for the disadvantaged party to withdraw onto themselves and stop participating in the process (Mazonde, 1998). The same applies to pilots in this study.

Most people typically want to be a part of any process they are involved in (Spencer-Oatey, 2000). That is what gives them a sense of belonging. Where that is denied to them for whatever reason without any avenue for redress, they either fight back or where that is not possible for fear of the repercussions on their life or career as in this study, they tactically withdraw their participation (Shonhiwa, 2008). Thus, even though the disadvantaged first officers may still be sitting on their seats, they are no longer part of the team. That applies to many similar situations in life.

This study depended on the subjective views of 12 participants who are themselves part of the "confluence of interest" of the research topic (Bernard, 2002), either as a power-holder, victim, or both. While the discoveries from the study are crucial in answering the research questions, especially from the injured person's perspectives, it is important that they predict the reaction and path that most regular people will follow if and when they find themselves in similar situations in life.

More important is that, in identifying those stages of the power-distance phenomenon and how they collectively affect the communication aspect of the CRM process among Nigerian pilots, the study may help in advancing public knowledge on the subject. The findings may also serve as a safety framework for human resources personnel, human factors researchers, flight operations specialists, and aviation safety regulators that are tasked with the responsibility of ensuring safe and efficient flight operations in Nigeria.

Furthermore, this study provides perspective for both captains and first officers to have a better understanding of the damage that can potentially be done to aviation safety, including their own career prospects. Its results may enable flight operation managers to be better prepared in handling human factor issues in the flight line through more culture-sensitive training and publications for their employees. Its process, as presented in this study, may also guide future researchers in undertaking further studies on the role of age and seniority in communication lapses inside the cockpit in Nigeria and Africa at large. Its findings may also have a wider application across other safety-related industries in the country and across Africa.

Evaluating the Study

This study used a case study strategy to uncover and explain the effects of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots. The development of the processes and stages discovered in the study is derived from the real-world stories of men and women who had experienced power-distance from their senior colleagues in the Nigerian aviation industry. To assure credible research and good match of the research questions with the results, Yin (2014) recommends that the four systemic criteria of credibility, transferability, dependability, and confirmability should be used to evaluate the trustworthiness of the study and its findings.

Credibility refers to how believable and appropriate a research account is, with particular reference to the level of agreement between the researcher and the participants. In this study, the data generated from the interviews were analyzed through constant comparison to arrive at an outcome that provided an explanation of the problem. The evidence from the research subjects was “compelling, plausible, and persuasive” (Yin, 2014), especially when judged for their simplicity and clarity. That is further aided by the collaborating data from other research sources provided in the literature.

Transferability is established by providing readers with evidence that the research study’s findings “could be applicable to other contexts, situations, times, or populations” (Denscombe, 2014). It is synonymous with generalizability, or external validity, in quantitative research. Denzin and Lincoln (2005) argued that it is not really the qualitative researcher’s job to prove that the study’s finding “is applicable” to other similar situations. The researcher has an obligation, however, to provide evidence that the study “could be applicable,” by providing “the database that makes transferability judgments possible on the part of potential appliers” (Lincoln & Guba, 1985). In this study, the damages to individuals on the receiving end of power-distance can be applied to many similar situations in life where people are denied a voice in a process. In most cases, as in the case of the pilots in this study, those people will react in a similar way by restricting further participation in the process.

Dependability in qualitative research refers to the stability of the data over time and conditions. It is an evaluation of "the quality of the researcher's integrated processes of data collection and analysis" (Merriam & Tisdell, 2016). This study used direct words and quotes from frontline participants in the field to explain how power-distance inside the cockpit caused by age and seniority affects the communication pattern between senior and junior crewmembers in Nigeria, in a way that has never been previously presented.

The new insights presented in the discovery offers a better understanding of how a disconnection in communication between two unequal pilots inside a cockpit can distort the basic principles behind the establishment of CRM – that of unhinged and unrestricted sharing of information among the crewmembers to enhance flight safety. These insights are useful tools for both senior and junior flight crewmembers in Nigeria because it provides them with a better understanding of how a societal behavior that they import into the flight deck can potentially become a formidable obstacle to flight safety.

Confirmability is a measure of the level of confidence that the study's findings are based on the participants' narratives and words rather than potential researcher biases. Confirmability is a verification that the findings are "shaped by participants" and not the qualitative researcher (Yin, 2014). It is, thus, "a judgment of the investigator's level of objectivity" and "the degree to which he confesses and adheres to" his own predispositions (Lincoln & Guba, 1985).

In this study, the researcher's emphasis is on the participants' concerns, not on his. Thus, in Chapter 1, the researcher confessed to his ancestral origins and social and professional relationship with the research subjects. He also discussed the implications of such relationships for the research, the potential for bias, and the procedures for mitigating it. The researcher has made every good-faith effort to adhere to those declarations.

Limitations and Delimitations

The emergence of the COVID-19 epidemic and its global spread, starting from late January through the summer of 2020, presented one of the greatest challenges for this research. The closure of national airspaces and land borders worldwide in response to the pandemic made it impossible for any physical contact between the researcher and the participants. While a video-interview model eventually proved successful in conducting the research, the researcher's inability to observe the participants in their normal day-to-day activities and social behavior left some void in the collected data.

Another limitation is the spread of the participants across different airlines and aviation companies. From the participants' responses to the initial research survey, it is easily discernable that different corporate cultures exist across the industry. For example, there is a noticeable difference in the experiences and perspectives of Capts. XPC and XPG, whose career backgrounds are from multi-national corporations compared to the crewmembers whose flying careers had been with wholly Nigerian-owned domestic operations and crews.

The data showed that Capts XPC and XPG, because of their international operations background, are more exposed to multi-cultural perspectives on safety. Thus, they are more receptive to CRM and SMS applications, compared to those who did not have the same career path. They are also more likely to volunteer for a study of this nature, and they tend to have a more strident approach to flight safety procedures and processes than their domestic counterparts.

Another observed discrepancy is in the recruitment response. As detailed in Chapter 3, an advertisement was placed in the Telegram social media platform used by many Nigerian pilots soliciting for captain and first officer volunteers. There was no shortage of captain volunteers:

More than 50 captains applied within 48 hours of the online advertisement. The challenge was that of getting enough number of first officers to volunteer for the research. It took another advertisement, specifically soliciting for first officers to get a total of 14 respondents.

Such a low response from first officers raises the question: Why are first officers not keen on participating in this research the way captains are? One answer may be that first officers are afraid of the consequences of speaking their minds. It may also be because, as one first officer submitted, "first officers are hardly ever invited to participate in any of the research" that have taken place in the industry. "Nobody listens to a first officer when it comes to serious discussions," First Officer XPO added. That line of thinking was reinforced during the research when some of the captain participants wondered why the researcher was talking to first officers. One of the captains submitted the names of those he termed "top-notch captains" to the researcher. Those are captains who, in his estimate, are "eminently qualified" to be part of the research. First officers were not included in his list.

Another limitation is the size of the study pool. This study examined the perceptions of 12 pilots (six captains and six first officers) out of a pilot population of over 2,500 in Nigeria. While this number of in-depth personal interviews can provide a generous data source for the research, it does not guarantee transferability to the broader pilot population. Aside from transferability, there is the usually limited capacity for event-recall by most people. Human beings can, and do, alter their perceptions of past events in order to explain them or to aid in fitting the present reality with their idealized version of the past. In other words, perceptions of event and human memory can sometimes be skewed, either intentionally or unintentionally, to fit any set of scenarios and times.

Thus, it is possible that some participants may have experienced more effects of power-distance as under-dogs, or have been more engaged in the role of power-holders than they led the researcher to believe. Whether it is a captain who has tormented juniors and caused them great anguish, but now wants to present himself in a better light to avoid being judged negatively or a first officer who has been a victim of such display of power but chooses not to be perceived as weak and timid, there could have been some participants who told a story that is entirely different from what they are. There are no fool-proof ways of verifying them; that is not what this study was designed to achieve either.

Also, while the aforementioned themes of seniority, respect, and fear are the major ones discovered in this study, they are by no means the only ones that can possibly be discovered from a study of the effect of age and seniority on the power-distance spectrum in Nigeria. There may be others that are beyond the scope of this study. Finding mitigation for the 3 discovered themes in this study may help in resolving them and thus narrow the cultural gap in age and seniority between captains and first officers in Nigeria. That may help in softening the communication glitches between them, smoothen their cockpit relationships, and improve the CRM process in the country's aviation industry.

One of the consequences of the COVID-19 lockdown and the associated effect on a mobile group such as pilots is that they found solace in continuously talking to each other on the phone. The aviation industry in Nigeria is relatively small. Almost all the professionals in the industry know each other, and they talk to each other regularly. In the course of doing that, they get to know that some of their colleagues are participants in this research. So, as much as the researcher tried to keep the identities of the participants confidential, it was impossible to do so with such a knit-tight group of people in a period of pandemic during which they are regularly calling to check on each other's well-being.

Finally, there is a potential limitation in the participant discussion model used in collecting data for this study. While participant discussion is essential in collecting in-depth data for a study of this nature, it can also jeopardize the credibility of the data. For example, during a discussion on how captains can systematically punish disrespectful first officers during flight, Capt. XPB said to the researcher: “You are a captain too, and you know what I am talking about! We copied these things from you guys in the US, and white expatriate pilots are very good at it. So, it is not something new. If you are in my shoes and you have such a disrespectful co-pilot, what will you do?”

Sensing the trap in the question, the researcher politely declined to be drawn into a specific “what if” scenario and instead told the participant that because every situation is different, it is not appropriate to assume that a single answer will fit them. Such validation questions were rampant with some of the participants in this research. This type of hidden self-reproach or what Chapman (2013) referred to as “troubled-consciousness” will continue to surface in social science studies of this nature where the participants are made to recount a not-so-glorious past that needed to be imposed into a present reality that is most often contradictory because of the changing times.

Directions for Future Study

This research looked at how age and seniority in the cockpit affect how senior pilots communicate with their junior colleagues in Nigeria and its impact on the CRM process. While the use of 12 participants is appropriate for the case study strategy employed in this study, the need to expand the research pool and increase its transferability may justify the need for another study. Thus, one potential area for future research is to increase the participant pool in order to understand how the study findings will extend or transfer to a much larger pilot group.

Another area of potential research benefit is a cross-industry examination, especially between multi-national corporate flight departments and wholly Nigerian operators. The data from this study showed that pilots flying for multi-national corporations have the advantage of exposure to CRM procedures from other regions of the world; a more lateral communication pattern emerged when compared to pilots flying for a Nigerian operator with wholly Nigerian pilots. Thus, a study of the difference between these two pilot groups in Nigeria that considers the impact of corporate culture and cross-cultural operation on one group as against the other will be an important addition to the body of knowledge.

More research can also be done in identifying those characteristics that encourage low power-distance. For example, since fear and disrespect are themes that featured prominently in this research, a study to find out how fear alone impact a junior crewmember's behavior in the cockpit or what influence a feeling of subordinate disrespect has on the way a captain relates with his first officer could provide more insight on the subject of power-distance. Lin et al. (2019), in a recent study, found that employees are more inclined to speak up under leaders deemed to be humble. Thus, a study of the human characteristics that encourages subordinate participation in the cockpit safety regimen will add to the knowledge base on the topic.

Also, the fears expressed by one of the two female participants, First Officer XPW, regarding what she considers to be unfair treatment, mainly because of her gender, deserves to be investigated. For example, could having to rebuff male advances and dealing with the aftermath influence how she deals with conflict in the cockpit? Do female pilots, generally, face increased career-defining harassments because of their gender? Such an exploration of the nature of misogynism in the Nigerian aviation industry will be a valuable addition to the literature; it will also offer some explanations to the questions raised by First Officer XPW.

One unintended revelation from this study is the cultural evolution that is in progress across Nigeria. For example, while there is no doubt that age and seniority still command wide respect within all segments of the Nigerian society, including the aviation industry, statements by older participants such as “the days when captains *were* captains” are indications that such respectabilities are gradually being eroded. Those participants, like many older people within the larger society, are gradually coming to the realization that the world is changing, and so are the level of adherence to certain aspects of peoples’ culture globally.

The fact that some younger first officers are openly questioning their captains is a sign of the changing times. Questions emanating from first officers such as “why should I respect someone just because he is a captain?” or “I cannot respect someone who is not deserving of it” are generally not heard of within the larger Nigerian society. That puts the pilots in this study a step ahead of the larger society in terms of their willingness to break the cultural barriers that fosters strict power-distance amongst people. It is also apparent, judging from the statements from the older captains, that if this study had been conducted twenty-five years ago when age- and seniority-power were more strictly revered (when “captains *were* captains”), the emerging data might have shown a more authoritarian cockpit culture. Thus, as societal changes, diversification of power sources, and interactions with outside cultures increases, the utility and thus locus standing of age and seniority as power-holders within the Nigerian society are systematically declining.

However, as evidenced by the results of this study, they are still alive and active. Thus, there is need for a continuous study to appraise their impact on societal and cockpit culture. Having up to date data on how the society deals with age and seniority is important because, along with the other cultural markers in the society, they are the enablers of the power-distance phenomenon inside Nigerian cockpits and the society. They are the biggest threat to CRM.

Suggestions for Safety Improvement

Nigeria has not experienced a major air disaster in 8 years. The last major air accident in the country happened in June of 2012 when Dana Air Flight 992, an MD-83 aircraft, crashed into a populated area of Lagos, killing all the 153 people on board and another six people on the ground (AIB, 2013). Being accident-free for that period in Nigeria is an indication that the industry is doing something right compared to the past, and most of the emerging errors are being mitigated. They should be encouraged to double their efforts by ensuring that any weak link within the system is strengthened, and any avenue for potential error is plugged.

One of the areas that needs strengthening is crew reporting system. As detailed in Chapter 2, anonymous safety reporting systems are prominent features of the 'just culture' process within Western aviation establishments. The focus of the Aviation Safety Action Program (ASAP), for example, is "to encourage voluntary reporting of safety issues and events that come to the attention of employees of certain certificate holders" (FAA, 2002a). The program, which is a partnership between the FAA, the certificate holder, and the employee's labor group, is designed to "encourage employees to voluntarily report safety issues even though they may involve an alleged violation of Title 14 of the Code of Federal Regulations (14 CFR)," which governs all aviation activities in the U.S.

Under the ASAP program, airline employees can submit "anonymous, voluntary reports without fear of being reprimanded by their employer," and "without fear of being legally implicated by the FAA through their report" (FAA, 2010a). Such reports "remain anonymous" and can be paired with data from flight recorders to analyze the entire scope of the situation. Because most of the reports are single-source, and would probably not be publicly available or discoverable if not for the report, it is a win-win for the FAA, the airline, and the individual employee involved.

In Nigeria, the only option available to any aviation employee, especially a crewmember, who witnesses or is a party to a safety event, is to report it to the chief pilot or airline safety officer. That official follows up with a report to the Nigeria Civil Aviation Authority (NCAA) on behalf of the employee. There is no guarantee of privacy and protection for the employee involved. Without the guarantee of privacy and legal protection, employees may be reluctant to report safety events, especially when there are no other independent means of discovering them. To mitigate that problem and truly make aviation mistakes and incidents in the country a learning experience rather than a punitive one, there is the need to adopt a formal safety reporting program similar to ASAP that will help in alerting the NCAA and the airline industry to safety situations that need to be changed or improved upon.

The report may include other safety information about events which can be valuable to the regulators, the airlines, and other pilots in fixing identified gaps within their safety framework. For example, if the data shows many unstable approaches to a particular airport, the airline can issue warnings or guidance to its pilots and change their policies regarding approach procedures to that airport. Such information may also afford the authorities of that airport the opportunity to modify or fix any identified lapse in the airport infrastructure or facility for safer operations.

Another area that needs improvement is CRM training. Data from this study shows that age and seniority represent how power-distance is expressed in Nigeria. A society's culture or ways of doing things are highly entrenched among its people; they will not go away simply because pilots take a few classes on how to 'get along with others' in their profession. It will be unrealistic to expect every Nigerian pilot to completely change the ways of life they have learned since childhood simply because of a few CRM lessons. However, there are operational and policy changes that can help them in the process. Such changes can include legislation to support a broader and more comprehensive CRM training that will account for the cultural differences between the Western countries where the program originated from and its African users.

These steps are necessary because, as Li et al. (2007) pointed out, while CRM has been and is continuously being influenced by culture, "CRM training does not include cultural awareness." To resolve that problem, Powell and Hill (2006) have suggested that CRM training can be culturally calibrated to take into account the pilots' societal attitudes, norms, and beliefs. Helmreich (1999) also argued that a well-designed and culturally-tailored CRM training program is "a recipe for overcoming the many cultural barriers in different parts of the world." Such a tailored program will take into account the power-distance that exists in some regions of the world. It will start by emphasizing the point to all crewmembers that correcting or questioning the captain is not about disrespecting that captain or making him "lose face;" it is about "watching his back" and preventing catastrophic outcomes down the line.

Lastly, while the focus of CRM is in using open communication between the two crew members in the cockpit to achieve operational safety, its objective cannot be achieved if the foundation for open interaction is not in existence. The culture in Nigeria and most African countries do not support a younger or junior person challenging an older or senior person as is prevalent in Western societies. Changing that culture effectively among the Nigerian pilot group will involve some tangible investment in social acculturation. It will require a holistic approach that involves integrating the major concerns or cultural ways of the captains and first officers in Nigeria, as identified in Chapter 4, with the core principles of the CRM process.

Conclusion

Pilots are human. Because they are human, they are susceptible to making mistakes the same way other humans do. Thus, for pilots, including the best of them, if presented with the right alignment of circumstances, they are susceptible to making an occasional poor decision or wrong judgment as other human beings in equally demanding professions. Krivonos (2007) has suggested that safety in any field of human endeavor does not imply that errors or mistakes will never arise. In most cases of error, the difference lies in how the error is managed (The Royal Aeronautical Society [RAeS], 1999). For pilots therefore, most often, the difference lies in how they, as a crew, work together to recognize the emerging threats, catch the inherent errors, share the information amongst themselves, and mitigate it, using all the resources available to them. That is the definition of Crew Resource Management.

CRM is all about communication (Stolzer et al., 2008). However, because of the differences in the content, format, and direction of communication flow from one culture to another, the sharing aspect is not always the same across all societies (Harris & Li, 2008). That difference in the style of information-sharing, based on cultural variations, is one of the challenges militating against the uniform application of the program globally.

Effective communication, Krivonos (2007) also argued, is not just about what is said or heard, but the *openness* of the process: It starts with an understanding that because pilots are human, mistakes can and do happen under their watch. The openness of the process is essential because while the overall objective of CRM is communication, it is usually the combination of *what* is said, *how* it is said, and *when* it is said, that determines the level and effectiveness of the communicate on. Thus, in a good CRM environment, it is a sign of strength, and not weakness, for a crewmember to admit to a mistake or error, communicate the same to colleagues, and together, initiate a plan of action to resolve the issue. That, Wiegmann and Shappell (2003) admitted, goes beyond effective communication: it indicates sound aeronautical decision making.

In this research, a connection was established between what is said, how it is said, and when it is said, between a captain and first officer inside the cockpit, and how they affect the communication aspect of the CRM process in Nigeria. As is common in most joint ventures, the professional relationship between a captain and first officer involves some trade-offs and compromises. Van Vugt (2006) posited that globally, "the nature of leadership" in a society typically implies a trade-off among its members that can have profound implications for that society. During emergencies or crises, society has typically looked to their leaders to guide them toward stability or desirable outcomes. The main job of the leader is to guide and coordinate member thoughts and actions, establish and prioritize their goals, and lead them towards those goals that are important to the group's success. How a leader and the people under his leadership negotiate that trade-off and what each side gets from it defines the nature of that society.

The aviation industry is not different. To achieve its safety objectives, the industry appoints and confers on captains the powers of a leader. While it is the prerogative of the industry to confer such powers on the captain, how the captain exercises it has a lot to do with the culture or "ways of doing things" predominant in that society. As documented in this study, the Nigerian society is one that confers absolute power on its leaders with the expectation of an equivalent amount of "successful outcomes" from them. Airline captains are no exception. In

Nigeria, the societal expectation is for captains to lead the way for their first officers to follow. The first officers are expected to follow their captain's directions without question.

Nigeria is ranked among the countries that Hofstede (1980) identified as high power-distance societies. Daniels and Greguras (2014) identifies power-distance as the relationship between those in power and the subordinates in a society where lower-ranking individuals depend on those in higher positions for guidance on most of their day-to-day thoughts and actions. In Nigeria and most African countries, people with a great extent of power, including captains, are respected and looked up to for daily guidance. In most of those places, age and seniority are the primary loci of that power. Because age and seniority are essential ingredients of the society's menu, the fear that such cultural behaviors can easily be imported into an airplane cockpit is real. That fear informs the need for this research, the objective of which is to uncover and explain how age and seniority affect the communication aspect of the CRM process among Nigerian pilots.

The case study strategy adopted for this study used online surveys, video interviews, documents review, and other data collection tools to gather information. The major findings are the outcome of the data collection process and analysis by the researcher. The findings revealed four stages of power-distance behavior: the offending act or behavior, the attendant shock and confusion, the withdrawal process, and the final shut-down. These stages of "discrete transitions" provide a rich insight into the minds and perceptions of those who have been, at one point or the other in their careers, on the receiving end of Nigeria's power-distance spectrum.

Findings from this research also show that building good relationships alongside professional competence can work as bridges connecting the two crew members in the cockpit. Over time, those assets can be transformed into a bonding glue that attracts and holds the other themes together to achieve a formidable CRM success. Bridging and bonding are essential elements of a power-distance mitigating theory that can benefit the aviation industry in Nigeria. This power-distance mitigating theory can be a potential panacea not only for resolving the conflict inherent in age and seniority differences within the aviation industry, but one that can have a significant influence in addressing other enablers of the power-distance phenomenon in the Nigeria society.

This is necessary, because, as in most societies with high power-distance, class also plays a prominent role in every aspect of the Nigerian life. Nigerian pilots are among the workers regularly referred to as “white-collar” professionals. In terms of economic status, they are among the highest-paid in the country, and thus, fall within the Mapungubwe Institute of Strategic Reflection (MISTRA) classification of middle-class (Ndletyana, 2014). While the Nigerian middle-class, as in most other places, does not necessarily own any “means of production,” it derives its middle-class status and high income from “the specialized skills and expertise that it provides the society” (Seekings, 2008). That applies to professional pilots in Nigeria, especially captains. Also, because of the economic and social privileges attached to it, climbing the ladder, especially to the status of a captain, is very important to Nigerian pilots; it signifies the height of professional accomplishment for them.

Besides the higher income related to the position, captains are respected society-wide for their professional competence, experience, and achievement. Their opinions and judgments are widely respected in the industry. The younger pilots rely on them for professional guidance, while the traveling public depends on them for their safety. They are perceived as the custodians of aviation knowledge and safety protocols, the same way elders of the society are looked-up to as the custodians of society’s history, culture, and values. Because of that immense societal goodwill and leadership expectation from airline captains, much power is vested in them.

Like every power-holder in other professions, Nigeria's airline captains are trusted to use their unquestioned powers as they see fit to ensure flight safety and for the overall good of the industry. The godfatherly role of the captain in the aviation industry in Nigeria can be viewed from that traditional social structure. By contrast, Western societies have a less formal cultural structure that allows captains and first officers to interact as equals outside the cockpit. Because that informal relationship or low power-distance already exists outside the work environment, it is much easier to transfer the same behavior into the cockpit without hindrance.

In terms of the regulatory framework, the law defines the duties of a captain and first officer in separate and complementary terms. The US Federal Aviation Regulation (FAR 91.3) defines a captain's role as follows: "The pilot in command of an aircraft is directly responsible for, and is the final authority as to, the operation of that aircraft." The first officer must be able to function as an assertive individual when safety goals calls for it, and a loyal subordinate under a teamwork atmosphere.

The FAR is a delicate balance that, alongside the low power-distance already in existence within the U.S. society, is expected to be sustained by the two crew members to achieve an even communication pattern. Beaman (2002) argued that to have a well-established system of co-operation between two unequal institutions or individuals, there should be a fairly reasonable division of power between the actors. In the alternative, he posited, there should exist a system of "checks and balances" that diminishes power differential between the individuals so that there can be a reasonable level of co-operation and trust. Such a "cultural equalizer" is needed in the Nigerian aviation industry.

To achieve that goal, there is a need for industry-led legislation and codes of CRM training and practice for pilots that will take into account the culture of the Nigerian people. After all, every culture is local, and by virtue of that, every CRM can be deemed local too. So, to make it successful, consideration must be given to local people whose knowledge of their surroundings, language, and "ways of doing things" comes from the shared life experiences that they have imbibed from family, friends, and neighbors from childhood. It is such cultural background and experiences that shape and defines the *what*, *when*, and *how* of the things that they do, say, or believe in, including their communication choices and perspectives on aviation safety. It is the foundation of their CRM, which, like culture, is nothing more than "the way we do things around here."

APPENDICES

(Appendix A)

SAINT LOUIS UNIVERSITY

Institutional Review Board (IRB) Research Approvals:

SAINT LOUIS UNIVERSITY

Institutional Review Board
3556 Caroline Street, Room C110
St.Louis, MO 63104
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FAX: 314 977 7730
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NOTICE OF INSTITUTIONAL REVIEW BOARD APPROVAL

Date:	May 11, 2020
To:	Allu, Abdul, Aviation Science-General
	Kelly, Terence, Aviation Science-General
From:	Kisselev, Oleg, Chairperson, Professor, Minimal Risk #2
Protocol Number:	30870
Protocol Title:	Power Distance in the Cockpit: A Study of the Effect of Age and Seniority on the Communication Aspect of Crew Resource Management Among Nigerian Pilots.

Sponsor Protocol Version Number and Version Date: Not Applicable

The above-listed protocol was reviewed and approved by the Saint Louis University Institutional Review Board.
Assurance No: FWA00005304

Below are specifics of approval:

Form Type:	AMENDMENT
Level of Review:	EXPEDITED #6, #7
Form Approval Date:	May 07, 2020
Protocol Expiry Date:	December 18, 2020
HIPAA Compliance:	Not Applicable
Waiver of Consent:	Waiver of Written Consent

The Saint Louis University Institutional Review Board complies with the regulations outlined in 45 CFR 46, 45 CFR 164, 21 CFR 50 and 21 CFR 56 and has determined the specific components above to be in compliance with these regulations, as applicable.

Approved Study Documents Include: CITI Program IRB Trg Certificate.pdf; CITI Program IRB Trg Report.pdf; 1 - SLU - PhD Dissertation (ABSTRACT).docx; Re_IRB #_30870.pdf; 1 - SLU - PhD Dissertation (Appendix C - Research Document).docx; Approved_1 - SLU - PhD Dissertation (Appendix F - Interview Protocol).pdf; Approved_1 - SLU - PhD Dissertation (Appendix D - Online Survey).pdf; Approved_1 - SLU - PhD Dissertation (Appendix E - Participant Invitation Letter).pdf; Approved_1 - SLU - PhD Dissertation (Appendix G - Reflective Letter).pdf; Approved_1 - SLU - PhD Dissertation (Appendix B - Recruitment Statement)-1.pdf; Approved_1 - SLU - PhD Dissertation (Appendix B - Recruitment Statement).pdf

(**Appendix B**)

SAINT LOUIS UNIVERSITY

<u>Recruitment Statement</u>

Please answer these 3 questions:

1. ARE YOU A NIGERIAN-BORN NATIONAL?
2. ARE YOU A PILOT?
3. DO YOU FLY FOR AN AIRLINE IN NIGERIA?

If you answer "YES" to all the three questions, please read on:

My name is Abdul Alliu, and I am a doctoral student in aviation at St. Louis University in Missouri, United States of America. I am inviting you to participate in this study.

The title of this study is: Power Distance in the Cockpit: A Study of the Effect of Age and Seniority on the Communication Aspect of Crew Resource Management Among Nigerian Pilots. The purpose of the research is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of the CRM process among Nigerian pilots.

Your participation in this study will include filling surveys, answering research questions by video and giving your insight about power-distance. A single video interview session may last between two and three hours. If there is need for a follow-up interview, you will be so informed and you have a choice to continue to participate in it or refuse to. The research study is planned to be completed within 6 months from start to finish.

The risks to you as a participant are minimal. These include your time, and dealing with any psychological pain you may have suffered from past negative power distance experience(s).

The results of this study may be published in scientific research journals or presented at professional conferences. However, your name and identity will not be revealed and your record will remain confidential. Your personal identifying information will be coded, and the codes will be kept in a separate location; its contents will be known to the researcher and his research committee members only. At the end of the study, those codes will be erased, and the whole data will be completely destroyed.

Participation in this research may not benefit you immediately, but it may help in making CRM more productive, and thus help in advancing aviation safety in Nigeria.

You can choose not to participate in this study, and you can participate and choose to withdraw from it at any time. Doing either of that will not result in any penalty to you or loss of any benefits to which you are otherwise entitled.

If you have any questions or concerns about this research, you may contact the researcher, Abdul Alliu, at 214-417-8100 or abdul.alliu@slu.com. If you have questions, concerns or complaints about your rights as a research participant and would like to talk to someone not on the research team, please contact the Saint Louis University (SLU) Institutional Review Board (IRB) at 314-977-7744 or irb@slu.edu and reference IRB Protocol # 30870.

(Appendix C)

SAINT LOUIS UNIVERSITY

Research Document

STUDY TITLE:	**Power-Distance in the Cockpit: A Study of the Effect of Age and Seniority on the Communication Aspect of Crew Resource Management Among Nigerian Pilots.**

This consent form contains important information to help you decide whether to participate in a research study.

The researcher will explain everything about this study to you. Ask questions about anything that is not clear to you at any time, either before or during the research. You may choose to go home and think about it and discuss with family or friends before making a decision to participate or not.

- **Being in a study is voluntary – <u>your choice</u>.**
- **If you join this study, you can still <u>stop at any time</u>.**
- **Do not join this study unless all of your <u>questions</u> are <u>answered</u>.**

After reading and discussing the information in this consent form you should know:

- Why this research study is being done;
- What will happen during the study;
- Any possible benefits to you;
- The possible risks to you;
- Other options you could choose instead of being in this study;
- Whether being in this study could involve any cost to you; and
- What to do if you have problems or questions about this study.

<u>Please read this consent form carefully.</u>

"You" refers to the person who takes part in the research study.

You are being asked to take part in a research study conducted by Abdul Alliu because:

(a) You are a Nigerian-born citizen,

(b) You are a pilot,

(c) You fly for an airline or aviation company in Nigeria, and,

(d) You are at least 18 years old.

This consent document may contain words that you do not understand. Please ask the researcher to explain anything that you do not understand.

<u>Key Information for You to Consider</u>
• **Purpose. The purpose of this research is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of the crew resource management (CRM) process among Nigerian pilots.** • **Duration. It is expected that your participation will last approximately one week.** • **Study Procedures. You will be asked to recall and discuss instances of power-distance in your career and how it affected the communication relationship between you and your superior or junior colleague.** • **Risks. Some of the foreseeable risks or discomforts of your participation include recalling unpleasant memories from your past that you will rather not want to discuss.** • **Benefits. There are no direct benefits accruable to you from this research. However, the knowledge and understanding gained from the study can potentially lead to the adoption or strengthening of better safety processes that can improve the aviation industry in Nigeria for the benefit of everyone.** • **Alternatives. You may choose not to be in this research study. Participation is voluntary and the alternative is to not participate in the study.**

1. WHY IS THIS RESEARCH STUDY BEING DONE?

The population of Africa is equal to 13 percent of the world population. That is about the same size as Europe and North America put together. Yet, Africa controls only 3 percent of world aviation activities while North America and Europe controls 55 percent of it. While only 3 percent of worldwide aviation takes place in Africa, in 2016, about 22 percent of worldwide commercial aviation accidents happened in Africa. These figures are from the International Civil Aviation Organization (ICAO).

This low share of world commercial aviation activities by Africa has an effect on the cost of airline tickets, availability of flights, and the overall economy of Africa, and Nigeria in particular. Across the world, the performance of the aviation industry is directly related to the safety standard in that country or region. Less safety means less aviation activity. Fifty years ago, aviation accidents were blamed on the condition of the aircraft and its engines. But because of improvement in technology, the cause of accidents has shifted from machine to human behaviors or "human factors." And those behaviors are different from one country to the other, depending on the culture of the place.

While there are many studies on aviation safety in Nigeria, there are not many that are aimed at learning and understanding how Nigeria's culture is reflected in the way a Captain and First Officer communicate with each other inside the cockpit. There is none about how their communication pattern can affect the implementation of crew resource management (CRM). That is why this research study is very important. And because the study is about understanding the effect of Nigerian culture on pilots, the research purpose is better served by doing it with Nigerians. 6 Captains and 6 First Officers from Nigeria will be needed for the study.

If you agree to take part in this research study, you may be asked to recollect and tell any experiences you may have had about power distance. Some of those experiences, if any, may be unpleasant to recollect. This may cause you some emotional discomfort. Also, taking the time to answer the survey questions and taking part in a video interview may make you feel unease. Other than that, there are no known risks of physical harm to you for taking part in this study.

2. WHAT AM I BEING ASKED TO DO?

After you read this document and agree to take part in the research by contacting the researcher, a preliminary research survey will be emailed to you. The purpose of the survey is for you to tell the researcher who you are, and if you meet the requirements to be included in the study or not. After the decision is made to include you in the study and you agreed to take part in it, you will be asked to do the following:

(a) You will be asked to take part in an online survey or questionnaires. As part of the survey, you will be asked about where and when you graduated from flying school, your years as a pilot and years in your present job.

(b) You will be asked to take part in an online video interview using Zoom or Skype, that may last about two to three hours. You will be asked questions about your experience on power distance from senior or junior colleagues. You will also be asked follow-up questions based on your response to the online survey.

(c) The researcher may contact you again by phone or email to verify some information or statement you may have made, either in the online survey or during the video interview.

(d) At the end of the study, the researcher will email you a copy of the transcript of all information that was collected from you. This is for you to read and be sure that your words and statements as recorded by the researcher are correct and not misunderstood. If there is any misrepresentation of your words, please let the researcher know immediately.

(e) It is important that you tell the researcher if you are currently in a similar research study as this one. There are reasons such as potential conflict of interest that will let the researcher know if you can take part in this research study and a similar one at the same time.

(f) Also, as part of the research study, the researcher will record your voice during the video interview session with a digital audio recorder. This is to make sure that the researcher does not miss or misunderstand anything you said during the interview. While the recording will include a sound of your voice, the researcher will make sure that your name, photo, or other identifying information about you is not revealed; it will not be played for the hearing of anyone beside the researcher. All data will be kept with coding, meaning that all direct identifiers like your name will be removed from the data and replaced with a number or alphabet or a combination of both. A listing of that code alongside your name will be kept separately for privacy protection and confidentiality.

(g) The recorder disk and other research data will be stored in a box that is double-locked and stored in a secure location by the researcher for the duration of the research; only the researcher, his research supervisor and dissertation committee members will have access to it. The recorded data and other data from this study will not be used for any other research besides this one. At the end of the research period, all the collected data and information will be erased and the recorder disk physically destroyed.

3. HOW LONG WILL I BE IN THE RESEARCH STUDY?

Your overall participation may last about 6 hours. This include filing the research survey and consent documents online that may last about one hour and a video interview session that may last between two and three hours. If there is need for a follow-up interview, you will be so informed and you will have a choice to continue to participate in it or refuse to. The whole study itself is planned to be completed no later than 6 months from start to finish.

4. WHAT ARE THE RISKS?

There are certain risks and discomforts that may occur if you take part in this research study. They include the time you will spend on this research. Also, some of the questions in the interview, especially those that are associated with recalling past unpleasant experiences of power distance from senior or older colleagues, may make you feel uncomfortable. You do not have to answer any question or questions that make you feel uncomfortable. There may also be risks that are unforeseen or unknown at this time.

To try to prevent these risks, the researcher will do everything within his power to schedule the interview at a time that is convenient for you. He will stop the interview session if at any time you are not comfortable with continuing with it. If discomforts occur, the researcher will try to get any available help for you, at no cost to you.

As this study involves the use of your personal information, there is a chance that a loss of confidentiality will occur. The researcher has procedures in place to lessen the possibility of this happening, as described in section 7 of this form.

The researcher is willing to discuss any questions you might have about these risks and discomforts. Feel free to discuss any risk concerns or questions you may have about these risks and discomforts with the researcher.

5. ARE THERE BENEFITS TO BEING IN THIS RESEARCH STUDY?

You will not benefit from this research study. Even though you will not receive any direct or immediate benefit, the society as a whole may benefit in the future because of what the researchers, safety regulators, and the industry as a whole may learn from this research study. The objective of the study is to get a better understanding of the effect of age and seniority as power distance factors on the communication aspect of the crew resource management (CRM) in Nigeria. It is hoped that gaining this understanding may ultimately help in improving aviation safety in the country. As an aviator, you stand to benefit in the future from a safer and more productive aviation industry in Nigeria.

6. WHAT OTHER OPTIONS ARE THERE?

You may choose not to be in this research study. Participation is voluntary and you may choose not to participate in the study at all or withdraw at any time of your choice. If you choose to withdraw half-way, all your data will be destroyed and excluded from all stages of the research.

7. WILL MY INFORMATION BE KEPT PRIVATE?

The results of this research study may be published, but your name or identity will not be revealed and your information will remain private. In order to protect your information, the researcher will make sure that any information that can be used to identify you in the data is replaced with a code or codes. Such codes will be kept in a secure and different location. Only the researcher will have access to it. None of the data or your personal information will be sent to anyone outside of SLU. However, information collected for this research study may be shared with other researchers and academic staff of SLU. If any information about you is so shared, it will not include names, addresses, or any other identifying information. At the completion of the research project (no later than the expiration of the federally-mandated period to keep research materials), all the data and the codes related to the study will be completely destroyed.

A digital voice recorder will be used for audio recording during the video and phone interviews. A separate flash disk will be used for each subject interview, and coded as such. Each of those disks will be kept in a sealed security envelope, and will be kept separate inside a doubled-locked and fire-proof box in a safe place. Upon completion of the project (no later than the expiration of the federally-mandated period to keep research materials) or immediately after notifying the researcher of your intention to voluntarily withdraw from the research, the audio disks will first be erased and then physically destroyed.

The Saint Louis University Institutional Review Board (the Board that is responsible for protecting the welfare of persons who take part in research studies), or other University officials may review this research study records including your data. State or federal laws or court orders may also require that information obtained from you for this research study be released.

8. WHAT ARE THE COSTS AND PAYMENTS?

In this study you will not be paid any monetary compensation for taking part in it. Also, there will be no any costs to you for taking part in it. All research study materials including hard copies of the survey (if needed) will be provided to you at no cost by the researcher.

9. WHAT HAPPENS IF I AM INJURED BECAUSE I TOOK PART IN THIS RESEARCH STUDY?

If you believe that you are injured as a result of your participation in the research study, please contact the researcher and/or the Chairperson of the Institutional Review Board as stated in section 10.

10. WHO CAN I CALL IF I HAVE QUESTIONS?

If you have any questions or concerns about this research study, or if you have any problems that occur from taking part in this research study, you may call the researcher (Abdul Alliu) at +1(214)417-8100 or email him at: abdul.alliu@slu.edu

If you have questions, concerns or complaints about your rights as a research participant and would like to talk to someone not on the research team, please contact the Saint Louis University (SLU) Institutional Review Board (IRB) at 314-977-7744 or irb@slu.edu.

11. WHAT ARE MY RIGHTS AND WHAT ELSE SHOULD I KNOW AS A RESEARCH PARTICIPANT?

Your participation in this research study is voluntary. You may choose not to be a part of this research study. There will be no penalty to you if you choose not to take part. You may leave the research study at any time. The researcher will let you know of any new information that may affect whether you want to continue to take part in the research study. Also, the researcher may take you out of the research study if something happens to make this necessary. This early withdrawal can happen if, in the researcher's judgment, it is in your best interest to do so under certain circumstances. If that happens, your data will be immediately destroyed and excluded from all stages of the research.

This study is being sponsored by the researcher. There is no any financial support from an outside source. There is presently no any economic or financial value attached to the study. But, a valuable product such as a published book may be developed from it in the future. Should such a product be developed resulting from the data obtained from this research, there are no plans to share with you any monies or economic benefit from the commercial sale of such a product.

12. AM I SURE THAT I UNDERSTAND?

I have read this consent document and have been able to ask questions and state any concerns. The researcher has responded to my questions and concerns. I believe I understand the research study and the potential benefits and risks that are involved.

SAINT LOUIS UNIVERSITY – INSTITUTIONAL REVIEW BOARD – APPROVAL STAMP

This document is valid only if the IRB's approval stamp is shown below.

SAINT LOUIS UNIVERSITY

Institutional Review Board
3556 Caroline Street, Room C110
St.Louis, MO 63104
TEL: 314 977 7744
FAX: 314 977 7730
www.slu.edu

NOTICE OF INSTITUTIONAL REVIEW BOARD APPROVAL

Date:	May 11, 2020
To:	Allu, Abdul, Aviation Science-General
	Kelly, Terrence, Aviation Science-General
From:	Kisselev, Oleg, Chairperson, Professor, Minimal Risk #2
Protocol Number:	30870
Protocol Title:	Power Distance in the Cockpit: A Study of the Effect of Age and Seniority on the Communication Aspect of Crew Resource Management Among Nigerian Pilots.

Sponsor Protocol Version Number and Version Date: Not Applicable

The above-listed protocol was reviewed and approved by the Saint Louis University Institutional Review Board.
Assurance No: FWA00005304

Below are specifics of approval:

Form Type:	AMENDMENT
Level of Review:	EXPEDITED #6, #7
Form Approval Date:	May 07, 2020
Protocol Expiry Date:	December 18, 2020
HIPAA Compliance:	Not Applicable
Waiver of Consent:	Waiver of Written Consent

The Saint Louis University Institutional Review Board complies with the regulations outlined in 45 CFR 46, 45 CFR 164, 21 CFR 50 and 21 CFR 56 and has determined the specific components above to be in compliance with these regulations, as applicable.

Approved Study Documents Include: CITI Program IRB Trg Certificate.pdf; CITI Program IRB Trg Report.pdf; 1 - SLU - PhD Dissertation (ABSTRACT).docx; Re_IRB #_30870.pdf; 1 - SLU - PhD Dissertation (Appendix C - Research Document).docx; Approved_1 - SLU - PhD Dissertation (Appendix F - Interview Protocol).pdf; Approved_1 - SLU - PhD Dissertation (Appendix D - Online Survey).pdf; Approved_1 - SLU - PhD Dissertation (Appendix E - Participant Invitation Letter).pdf; Approved_1 - SLU - PhD Dissertation (Appendix G - Reflective Letter).pdf; Approved_1 - SLU - PhD Dissertation (Appendix B - Recruitment Statement)-1.pdf; Approved_1 - SLU - PhD Dissertation (Appendix B - Recruitment Statement).pdf

Page: 1

Signature of Principal Investigator	**Date**

First Name / Last Name	*Credentials*
Printed Name	**Credentials**

(Appendix D)

SAINT LOUIS UNIVERSITY

ONLINE SURVEY - INFORMATION SHEET

You have been invited to participate in this research, with the title: Power Distance in the Cockpit: A Study of the Effect of Age and Seniority on the Communication Aspect of Crew Resource Management Among Nigerian Pilots.

Being in this study is optional. If you choose to be in the study, you will complete a survey. The survey will help me learn more about you, your background, and qualification to take part in the research. The purpose of the research is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of the crew resource management (CRM) process among Nigerian pilots. The survey will take about 10 minutes to complete.

You can skip questions that you do not want to answer or stop the survey at any time. Your answers will be kept confidential and your personal information will not be shared with anyone outside the research team.

If you have any questions or concerns about this survey, you may contact the researcher at abdul.alliu@slu.edu. If you have questions, concerns or complaints about your rights as a research participant and would like to talk to someone not on the research team, please contact the Saint Louis University (SLU) Institutional Review Board (IRB) at 314-977-7744 or irb@slu.edu.

If you choose to participate in this study, click the ***Next*** button to start the survey. If not, click the ***Exit*** button to exit the survey.

RESEARCH SURVEY

Title of Research: Power-distance in the cockpit: A study of the effect of age and seniority on the communication aspect of crew resource management among Nigerian pilots.

IRB Protocol ID: 30870

Nationality:

Country of birth:

Country where you grew up (elementary and high school period or ages 6 – 18):

Have you ever lived for 5 years or more continuous in any country aside from Nigeria?

If yes to the previous question, where, when, and for how long?

Have you lived continuously in Nigeria for the past 10 years (do not count outside trainings or travels of less than 6 months duration): Yes or No (Circle One)

Your current Flight deck position: Captain or First Officer (Circle One)

Length of years as a professional pilot (since qualified with a Commercial Pilot Licence/Instrument Rating/Multi-Engine Rating):

Length of years since first job as a professional pilot:

Length of years in present position (Capt. or F/O):

Pilot certificate possessed: Private, Commercial, or Airline Transport Pilot (Circle One)

Gender: Male or Female (Circle One)

Age:

Country of initial pilot training:

Have you ever worked as a pilot in any country other than Nigeria? Yes or No (Circle One)

If yes to the previous question, which country, when and for how long?

How many companies or airlines have you worked for as a pilot before your present job?

In which of the jobs did you stayed the longest and for how long (N/A if Not Applicable):

In which of the jobs did you stayed the shorted and for how long (N/A if Not Applicable):

Think of the best Captain (no names) you ever flew with (N/A if Not Applicable):

What is about that Captain that make him or her your best?

Think of the best First Officer (no names) you ever flew with (N/A if Not Applicable):

What is about that First Officer that make him or her your best?

Think of the worst Captain (no names) you ever flew with (N/A if Not Applicable):

What is about that Captain that make him or her your worst?

Think of the worst First Officer (no names) you ever flew with (N/A if Not Applicable):

What is about that First Officer that make him or her your worst?

This survey is for a research only. The purpose of the research is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of the crew resource management (CRM) process among Nigerian pilots.

Thank you for your time.

(**Appendix E**)

SAINT LOUIS UNIVERSITY

INVITATION TO PARTICIPATE IN AN ACADEMIC RESEARCH

Date: ………………………

Dear ……………………..,

Sometime ago, a Research Document was read and discussed with you. It sought your implied consent to take part in a proposed research on "Power-distance in the cockpit: A study of the effect of age and seniority on the communication aspect of crew resource management among Nigerian pilots." This was followed with an online survey that sort your willingness, and qualification to participate in that research.

Following your response to the Research Document and the Online Survey, and your agreement to take part in the research, I am hereby informing you that you are one of the pilots selected to participate in it. As indicated in the said research document, the process will include surveys, questionnaires, and video or phone interviews.

I am very grateful, and sincerely appreciate your willingness to spare your time and effort in accepting to participate in this research; I am greatly honored. If you have any questions or concerns about the research or the process and procedures, please do not hesitate to contact me immediately.

With warm regards,

…………………………………………….

(PI).

Parks College of Engineering, Aviation and Technology,

Saint Louis University,

St. Louis, MO 63103.

Phone:

Email:

(**Appendix F**)

SAINT LOUIS UNIVERSITY

INTERVIEW PROTOCOL

Research title: Power-distance in the cockpit: A study of the effect of age and seniority on the communication aspect of crew resource management among Nigerian pilots.

Date of Interview:

Time of Interview (Saint Louis Time):

Participant ID code:

Introduction:

Thank you for agreeing to speak with me today. As you are aware, the purpose of this study is to uncover and explain the effect of age and seniority as power-distance factors on the communication aspect of the crew resource management (CRM) process among Nigerian pilots. We will try to talk about the nature of the interaction between Captains and First Officers inside and outside the cockpits, especially on flight safety issues. Please feel free to elaborate on any questions and ask for clarification as needed. Again, you do not need to answer any question or touch on any particular incident that make you feel uncomfortable or that you do not want to answer or talk about.

Ice breaker or opening questions:

Tell me about your flying career.

What led you into aviation?

Do you enjoy your career as a professional pilot?

Could you say that you've had a great career so far?

Probes:

What are the challenges that you have gone through in your flying career?

What are the major events, or safety benchmarks that you can remember?

What is your thought about the communication pattern between a captain and first officer inside the cockpit?

Getting at the central category:

How do you define crew resource management (CRM)? Why do you think CRM is such an important part of safety management?

How do you understand power-distance? How would you define the relationship between power-distance and CRM?

Probes:

Can you remember any incident or conflict between you and your captain or first officer in the cockpit that you think is not good for safety? What, in the setting, contributed to it? (context, intervening conditions).

Probing randomly:

Ego? Power-distance? Safety concerns? CRM issues? What was your role/power in the CRM equation? How did you handle your role? What was the role of the other pilot? What issues or actions, in your opinion, could have contributed to it? What, if any, strategies or actions do you believe can be used to strengthen the communication pattern between crew members?

Consequences:

What are the consequences of power-distance in the cockpit?

Can the relationship between the captain and the first officer be strengthened? If so, how?

How do you help one another overcome the challenges you (or any other pilot) face as a junior first officer inside the cockpit with a very senior captain or check airman as the other pilot?

Reflection:

Is there anything else you will like to share with me on the issue of power-distance between a junior crew member and a senior one inside the cockpit? Will you be interested in a follow-up interview? Maybe you will remember something new by that time! Or maybe you may remember another pilot who may have had the same experience and insight as yours?

End of Interview:

Thank you very much for your time today. As we have already discussed, your response will be kept completely private and confidential. It is possible that I will contact you again for clarification on certain points, or to check back with you to make sure I am accurately reporting what you have told me. I don't want to misquote you on anything! Thank you again.

(**Appendix G**)

SAINT LOUIS UNIVERSITY

THANK YOU/REFLECTIVE LETTER

Date: ………………………

Dear …………………….

Re: Power-distance in the cockpit: A study of the effect of age and seniority on the communication aspect of CRM among Nigerian pilots

I want to thank you abundantly for sparing your time and effort to participate in the above research. I greatly appreciate your willingness to fill out my surveys, for talking with me for an extended video interview, and for sharing your thoughts about your experiences, which were extremely informative and useful for this study.

Based on the transcripts of our video interview and conversations, I am hereby attaching a textural-structural description of both what and how you experienced power-distance in the cockpit for your review and verification. Please feel free to respond with any necessary corrections or additions. Doing that will help in guaranteeing that I accurately understood and have correctly summarized the experiences that you have shared with me.

I am very grateful, and sincerely appreciate your willingness to participate in this research; I am greatly honored. If you have any questions or concerns about the research or the process and procedures, please do not hesitate to contact me immediately. Again, thank you so much for your time and effort that made this research study possible.

With warm regards,

…………………………………………….

(PI)

Parks College of Engineering, Aviation and Technology,

Saint Louis University,

St. Louis, MO 63103.

Phone:

Email:

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VITA AUCTORIS

Abdul Ateiza Alliu was born in Nigeria on October 15, 1966. In 1991, he moved to the United States of America to pursue an aviation career. He obtained his commercial pilot certificate including the instrument and multi-engine ratings at Bolivar Aviation in Bolivar, Tennessee, in July of 1992.

Ever since, he has worked as a professional pilot for many airlines, flying across the length and breadth of the world. Among the airplanes he has flown in his career are the following: B707, B727, B757, B767, and B747-400/-8. He has accumulated over 15,000 hours of flight time as a pilot and he is currently a B747-400/-8 captain with Atlas Air in New York, United States.

Between 2009 and 2011, Abdul combined his job as a professional pilot with a graduate program, thereafter earning a Master of Business Administration (MBA) with emphasis in aviation business management from Embry-Riddle Aeronautical University, Daytona Beach, Florida, United States.

In the fall of 2014, he started his PhD program in aviation at Saint Louis University, Missouri, United States. His dissertation is titled "Power-distance in the cockpit: A study of the effect of age and seniority on the communication aspect of crew resource management among Nigerian pilots." He aims to major in aviation safety and human factors and is looking forward to finish his dissertation and defend it in the Fall of 2020.

Dissertation Example 2

THE EFFECT OF AIR TRAFFIC CONTROL INTERVENTION ON REPORTED ALTITUDE DEVIATIONS DURING OPTIMIZED PROFILE DESCENT ARRIVAL PROCEDURES

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A Dissertation Presented to the Graduate Faculty of Saint Louis University

in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

2020

COMMITTEE IN CHARGE OF CANDIDACY:

Professor Terrence Kelly,
Chairperson and Advisor

Professor Stephen Belt

Professor William Irwin

To my Mother, Norma W. Lyle

Breast Cancer Survivor

ACKNOWLEDGEMENTS

I would like to thank my doctoral committee for their insight, encouragement, and wisdom navigating a project of this magnitude. Special thanks to Dr. Terrence Kelly for encouraging me to pursue the idea for this study, and his time and effort serving as my Advisor and Committee Chair. Thank you to all those who contributed materials and data to this effort; without you, this project would not have been possible. To the operational users of the U.S. National Airspace System for whom this study is intended, I hope I have made your jobs safer.

To my wife Cindy, words cannot express my gratitude for your support during this process. Counselor, sounding board, cheerleader, and motivational coach were just a few of the many roles you took on to help me see this idea to fruition. I literally could not have done it without you.

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LIST OF KEY TERMS

Altitude Deviation: Departure from assigned altitude greater than or equal to 300 feet.

ATC: Air Traffic Control.

FMC: Flight Management Computer, computational component of FMS.

FMS: Flight Management System, coordinated group of components for navigation and control.

GPS: Global Positioning System, satellite navigation.

Idle Path Descent: FMC calculation where altitude is decreased with engine thrust at idle.

NextGen: Next Generation Air Transportation System.

OPD: Optimized Profile Descent, combines lateral and vertical navigation components.

RNAV: Area navigation, lateral component of OPD.

RTA: Required Time of Arrival, navigation capability to a specified waypoint using time.

STAR: Standard Terminal Arrival Route.

VNAV: Vertical navigation, vertical component of OPD.

Waypoint: A navigation point in space defined by latitude and longitude.

CHAPTER 1: INTRODUCTION

Modernization of the United States and European airspace systems is needed to accommodate the projected increase in demand for air travel while simultaneously meeting increased societal demands for environmental sustainability. With these two seemingly contradictory goals at the forefront, the United States Next Generation Air Transportation System (NextGen) and European Union Single European Sky (SES) airspace modernization initiatives became concrete proposals in 2004 (European Commission [EC], 2017; Houston, 2017; U.S. Department of Transportation [U.S. DOT], 2004). The objectives set forth in these plans aim to update the aging air traffic management infrastructure of the United States, coordinate the separate functions of thirty-seven separate air navigation service providers within the nations of the European Union, and reduce delays within both systems through efficiency and automation improvements that reduce fuel consumption and emissions by more efficient use of existing airports and airspace (EC, 2017; U.S. DOT, 2004). One of the key components of NextGen and SES is the increased use of automation both on the ground and in flight, leveraging the increased accuracy of the Global Positioning System (GPS) with advanced aircraft avionics to precisely manage the flow of air traffic, increase the predictability of flight paths within the terminal environment, thus reducing separation requirements between aircraft (General Electric, 2010; U.S. DOT, 2004). Viewed through the lens of a relatively finite ground infrastructure, reduced separation criteria and capacity enhancements are able to positively affect the reduction in congestion at U.S. airports that is projected to "…cost consumers up to $20 billion a year by 2025" (U.S. DOT, 2004, p. 3), a figure found to be conservative even when direct airline delay costs are factored out (Airlines for America, 2019; Peterson, Neels, Barczi & Graham, 2013).

As with any discussion of aviation and air traffic, safety is the overriding consideration and needs to be the cornerstone of any system of the present or future. According to McCartney (2018), 2017 was the safest year on record for air travel from the standpoint of zero airline fatal accidents worldwide, with accident rates in the developing world decreasing with that of more developed, regulated countries. Improved avionics and automated systems, advances in aircraft design and construction, and rigorous maintenance practices have all been contributors to this impressive achievement (McCartney, 2018). However, there are factors that run counter to the world-wide safety-improvement trajectory, particularly, the aging infrastructure of the U.S. air traffic control system (Economist, 2016). The *Next Generation Air Transportation System Integrated Plan* (2004) hereafter referred to as the *Integrated Plan*, blends safety planning, design, and management into its implementation and transitional scheme, proposing NextGen as an integrated plan with complementary components. The lack of integration and seamless implementation results in the present manual air traffic management system intersecting with automated NextGen procedures, and has the potential to compromise aviation safety. The purpose of this research is to determine the effect of air traffic control intervention on altitude deviations reported during optimized profile descent arrival procedures in the U.S. National Airspace System from January 1, 2012 to January 1, 2018, adding to the literature with respect to negative unintended consequences resulting from the non-integrated deployment of NextGen procedures.

Background

The FAA has outlined a "roadmap" for NextGen concept development and implementation in the *Integrated Plan* that has been divided into three phases: short-term (2004-2012), mid-term (2012-2020), and long-term (2020-2030+) (Houston, 2017). The short-term phase was primarily focused on concept definition, and research and development, resulting in demonstration and selection of system components. The mid-term phase began the introduction of NextGen capabilities and procedures into the National Airspace System as well as supporting foundational infrastructure and marked the transition from tactical to strategic flow management philosophy in air traffic management. The long-term phase, 2020 and beyond, proposes the introduction of technologies and procedures, with review and improvement of existing capabilities (U.S. DOT, 2004).

In the most recent government report detailing the progress of NextGen implementation, it is clear that the milestones contained in the *Integrated Plan* are behind schedule (Federal Aviation Administration, 2016; Halsey, 2018; U.S. DOT, 2017). One of the reasons cited for this is the unpredictable U.S. Congressional budget cycle that funds the FAA, which has been a driving force behind efforts to privatize the U.S. air traffic control system (Economist, 2016). Proponents of this public-private partnership state that privatization would allow a more predictable, stable source of funding for long-range projects like NextGen, and prevent the ad hoc implementation of various components that create a patchwork air traffic management system (Economist, 2016). “The International Civil Aviation Organization (ICAO) … has urged all 191 of its member countries to extricate their air-traffic control from government bureaucracy and political micromanagement—so they can manage the explosive growth in air travel with greater safety and effectiveness” (Economist, 2016, p. 2). While this organizational structure is not specifically addressed in the *Integrated Plan*, it becomes clear in the following paragraphs that another source of funding is required to complete it in an integrated fashion. There is opposition to privatization from some users of the National Airspace System, most notably the National Business Aviation Association and the Aircraft Owners and Pilots Association, who are wary of the user fees which would fund the new corporation and the perceived influence airlines would exercise in its operation (Aviation Today, 2018; Wall Street Journal, 2018). Marc Scribner of the Competitive Enterprise Institute (Wall Street Journal, 2018) notes that under the current system, "the business jet industry pays 0.6% of aviation user taxes but accounts for 11-13% of controlled traffic" (p. A16). Canada is frequently used for comparison with the United States since it has a privatized air traffic control system, NavCanada, similar to the one being proposed for the United States. In a comparison of Canadian user fees with current U.S. aviation taxes, The Eno Center for Transportation reported a 43% reduction in cost for an Airbus A320 flight from New York to Fort Myers, Florida, with some other segments reporting a 60% reduction (Wall Street Journal, 2018). A privatized air traffic control system may accrue cost savings to the government as well as the industry. NavCanada enjoys a 25% cost advantage over the FAA for air traffic services; $340 per flight hour to $450 per flight hour respectively (Economist, 2016).

One of the principal arguments for privatization is a stable source of funding for the air traffic control system, and predictable long-range funding for multi-year projects such as NextGen (Economist, 2016). As of 2018, the Facilities and Equipment account that funds improvements to the air traffic control system is one of four FAA accounts funded by revenues from the Airport and Airways Trust Fund (AATF) through a variety of taxes and fees (FAA, 2017). When examining AATF expenditures, the Facilities and Equipment account spending that funds NextGen has remained relatively flat at roughly 20% of AATF revenues from FY 2013 to FY 2017, while FAA Operations account spending has risen from approximately 25% to 50% of AATF revenues for the same period (FAA, 2018). Air traffic control (ATC) privatization aims to preserve user fee revenues collected from users of the system for reinvestment and system operation, and prevent funds being diverted for use by competing interests in the FAA budgeting process (Economist, 2016). With the total price tag for NextGen at roughly $37 billion through

2030 (Houston, 2017) and $7 billion already spent (Halsey, 2018), the current AATF balance of $14.77 billion beginning FY 2017 (FAA, 2017) suggests that another source of funding will be necessary to implement NextGen, as the FAA Operations budget consumes an increasing portion of AATF revenues.

NextGen was initially proposed as an integrated system to fully realize its objectives of safety, airspace modernization, efficiency, and environmental sustainability (U.S. DOT, 2004). Inadequate funding has proven an obstacle to this integrated approach resulting in partial deployment of some NextGen components and delays in others, and the inability to fund a long-term strategy under the present mechanism. Leftwich and Legan (2016) document this lack of integration stating, “the ground systems haven’t kept up with the aircraft systems, or avionics, with which they must interface. Modern avionics capabilities could enable additional efficiency, safety, and environmental benefits to aviation stakeholders, but delays in systems integration with NextGen ATC capabilities and infrastructure constrains these potential benefits while adding to the cost of implementation” (p. 1). One such technology is Automatic Dependent Surveillance-Broadcast (ADS-B) which would replace ground-based air traffic control radar with satellite communications and GPS to allow air traffic management providers to precisely track aircraft position in real time. This technology would allow ADS-B equipped aircraft to communicate with each other via data link on their respective flight decks much like the view of air traffic controllers on the ground (ADS-B Technologies, 2018). One feature of ADS-B is that its satellite-based framework eliminates gaps in radar coverage and allows precise tracking of an aircraft's position anywhere in real time. This precision has the potential to safely reduce the separation required between aircraft by increasing the capacity of the National Airspace System and facilitate more direct flight paths due to the accuracy of satellite navigation, reducing fuel consumption and emissions (FAA, 2018). These benefits speak directly to goals outlined in the *Integrated Plan* to "transition to a system with less dependence on ground infrastructure and facilities..." (FAA, 2018, p. 27), "provide sufficient capacity to satisfy demand" (FAA, 2018, p. 25), "provide sufficient resources to ensure that the development of new technology remains on track" (FAA, 2018, p. 25), and "allow expansion of the NextGen Air Transportation System while ensuring environmental protection measures are met" (FAA, 2018, p. 30). The concept of ADS-B was first proposed in the mid-1990s and prototype testing was conducted in the early 2000s with the goal of using this new air traffic management technology by 2015 (Economist, 2016). The FAA has mandated that aircraft operating in ADS-B airspace must be equipped with ADS-B transponders by January 1, 2020 (FAA, 2018) and the NextGen infrastructure to support it in place by 2016. In addition, the mandate states that ADS-B will be the principal means of aircraft surveillance and increased surveillance accuracy and update rates from ADS-B will improve safety and efficiency in the NAS (FAA, 2016). A report later in 2016 indicated that deployment of ADS-B has possibly been delayed until 2025, and with advances in satellite technology since it was first proposed, the ground infrastructure associated with it may prove obsolete (Economist, 2016).

One of the priorities of the *Integrated Plan* is the establishment of a "… comprehensive proactive safety management approach" and to "improve the level of safety in the U.S. air transportation system while *accommodating future growth and changes in system operations* (U.S. DOT, 2004, p. 29). In the short-term phase of the *Integrated Plan*, 2004-2012, where research was underway on early NextGen concepts and applications, several studies highlighted the importance of maintaining the integrated approach for which NextGen was designed, and identified possible unintended consequences of not following the integrated approach. In one of the earliest simulator studies evaluating the importance of inter-aircraft spacing with regard to the Continuous Descent Arrival (OPD), Murdoch, Barmore, Baxley, Abbott and Capron (2009) observed that a combination of traditional manual air traffic control techniques and automated NextGen procedures may actually reduce an airport's arrival rate due to the use of different arrival trajectories. This study was one of the first to include non-normal events in simulation that required air traffic control (ATC) intervention and a manual response from the flight crew and reported issues related to the return to automated flight (Murdoch et al., 2009). Dao et al. (2010) investigated spacing accuracy on OPD procedures when the required airspeed was entered automatically or manually by the pilots and concluded that current interval management systems perform better at higher levels of automation where there is low human intervention. Chiappe, Vu and Strybel (2012) addressed the role of situational awareness in the NextGen system and highlighted incompatibility between manual air traffic control methods and the increasingly automated methods employed by NextGen. Within the context of situational awareness, the authors addressed workload and the use of automation by pilots and air traffic controllers, the friction created between manual and automated methods and the effect on workloads, and this incompatibility being a possible source of deviations (Billings, 1997; Chiappe et al., 2012). More recently, EUROCONTROL, the European Union air traffic management entity, confirmed this issue as part of its safety assessment of OPD procedures of "cockpit workload, in particular where radar vectoring and profile management can impact onto a phase of flight that is already subjected to increased workload" (EUROCONTROL, 2017, p. 3). These early studies highlight the importance of NextGen as an integrated system and identify possible sources of conflict if it is not employed in this manner.

Problem Statement

The purpose of this research is to determine the effect of air traffic control intervention on altitude deviations reported during optimized profile descent arrival procedures in the U.S. National Airspace System from January 1, 2012, to January 1, 2018. The results of this research will contribute to a better understanding of this phenomenon in aviation science and safety literature. This study analyzed the U.S. National Airspace System in its present form with its combination of manual and automated air traffic management techniques through the examination of aviation safety reports.

Research Question

RQ1: How are air traffic control interventions and altitude deviations related on an Optimized Profile Descent?

Hypotheses

$H1_0$: There is no relationship between altitude deviations and air traffic control intervention on an OPD.

H1a: There is a positive relationship between altitude deviations and air traffic control intervention on an OPD and air traffic control intervention will display the largest number of frequencies and largest effect sizes related to altitude deviations.

Professional Significance of this Study

While the majority of studies related to NextGen deal with concepts and procedures to be integrated into the system, there is a notable absence of literature reporting findings related to the actual use of the system with its non-integrated deployment of NextGen components. While NextGen is designed to be an integrated system, according to the *Integrated Plan*, the FAA's own progress reporting documents that the implementation of this integrated framework is behind schedule (FAA, 2016) and over budget (Economist, 2016). Within this fragmented environment, studies by Murdoch et al. (2009) and Chiappe et al. (2012) have reported the incompatibility of manual air traffic management techniques with automated NextGen procedures. There is a notable deficiency in the literature reporting findings that have documented the outcomes of these incompatibilities and their potential to affect aviation safety.

The primary mandate of the air traffic management system (ATC) in the United States is "… to prevent a collision between aircraft operating in the system and to provide a safe, orderly and expeditious flow of traffic" and "give first priority to separating aircraft and issuing safety alerts …" (FAA, 2015, p. 2-1-1). An altitude deviation is defined as a departure "… from the assigned altitude (or flight level) equal to or greater than 300 feet. Altitude deviations may result in substantial loss of aircraft vertical or horizontal separation, which could cause a mid-air collision" (Flight Safety Foundation, 2000, p. 65). Analysis by the International Air Transport Association (IATA) in 2014 showed that 60% of reported altitude deviations worldwide occurred in the descent and approach phases of flight, and a threefold increase in the number of altitude deviations was reported from 2011 to 2012 (Margison, 2014). According to Houston (2017), 2012 marked the beginning of the NextGen mid-phase in the United States. While this increase was not solely attributable to ATC, flight management by the aircrew and ATC were the two largest contributing factors for altitude deviations (Margison, 2014), which would be consistent with both pilots and controllers becoming familiar with the new OPD procedures. By comparison, 28% of the aircrew reports cited errors in aircraft automation use, while 40% of the reports citing ATC listed confusing clearances and late changes to clearances as contributing factors (Margison, 2014). Margison did not specifically separate these two leading contributing factors and some overlap may exist. For example, a late change to an ATC clearance leads to an error in the use of aircraft automation; it may also indicate some degree of incompatibility where manual air traffic management techniques intersect with the more automated methods of NextGen and SES.

Importantly, the analysis and identification of these types of events have the potential to improve aviation safety. As stated in the 2014 IATA study, a meaningful increase in reported altitude deviations between 2011 and 2012 was observed, and it is notable that reported altitude deviations continued to increase in 2013 but at a slower rate. Additional factors may have led to the increase in altitude deviations from 2012 to 2013 and caused the altitude deviation rate to climb from 0.10 deviations per 1000 flights in 2011 to 0.45 deviations per 1000 flights in 2013 worldwide (Margison, 2014). In the context of the potentially catastrophic result of an altitude deviation, it is incumbent upon both the ATC and flight operations communities to understand the reasons for these unintended consequences and take steps to design policies and procedures for their minimization or reduction. Within this spirit of collaborative understanding and problem-solving, the National Air Traffic Controllers Association (the union representing air traffic controllers in the United States) was invited to participate in this study but declined.

Overview of the Methodology

The current study was a mixed-methods study with a quantitative emphasis that used the exploratory sequential strategy of qualitative-quantitative-interpretation (Creswell, 2014). The qualitative portion of the analysis coded information from the narratives contained in aviation safety reports to assign cases to groups, creating independent variables. These de-identified safety reports were obtained from the NASA Aviation Safety Reporting System (ASRS), and the Aviation Safety Action Program (ASAP) of a U.S. major airline, referred to as Airline A. The independent variables were then subject to quantitative analysis using the correlation analysis method to determine the underlying relationships present in the data, and whether ATC was a primary factor in altitude deviations reported on an OPD. This method was chosen for its ability to determine the effect size of each independent variable on altitude deviations and the strength of interactions between variables (Field, 2013).

Individual cases were assigned to groups consistent with the literature regarding factors contributing to altitude deviations. Each report was initially screened to determine if it was related to an OPD. If it was, it was assigned to one of eight groups: air traffic control intervention, aircrew error, collision avoidance, communication error, equipment malfunction or limitation, other, terrain avoidance, and weather (Buono, 2014; Flight Safety Foundation, 2000; IATA, 2016; Margison, 2014). In cases where multiple factors were stated in a narrative, a single contributing factor was determined by the researcher from the narrative context as being primary. Both data samples were for the period January 1, 2012, to January 1, 2018, which corresponded to the beginning of the transition to strategic traffic flow management in the *Integrated Plan*, and the beginning of the NextGen mid-phase to the present (Houston, 2017; U.S. DOT, 2004).

Limits and Delimits of the Study

The voluntary nature of NASA ASRS data limits the generalizability of findings to the entire U.S. National Airspace System, which is clearly stated by NASA when searching the database. These limits derive from two major features of the data: (1) this is a voluntary reporting system and not all occurrences are included for the specified time period, and (2) cases may be combined to enhance continuity of the event for the reader so multiple reports may be present in a single case (NASA, 2018). NASA ASRS data represents a sample of occurrences, not the entire population. In contrast, the airline ASAP data does not have these limitations. Although it is also a confidential aviation safety reporting system, the nature of ASAP reporting contains events that are not combined even though there may be two reports for a single event and assigned a single event number (FAA, 2014). This is due to the fact that both pilots are required to submit a report for a single event if they are to be covered by the protections of the ASAP program (FAA, 2014). An advantage is that two differing perspectives to the same event may provide additional insight into the factors involved. ASAP reports may be present in the ASRS sample, but ASRS reports will not be present in the ASAP sample.

The inclusion of the airline data presented an opportunity to minimize some of these limitations and potentially increase the generalizability of the findings. The presence of a second sample allowed for comparison between the two groups and investigating for consistent frequency and effect size characteristics present in both samples. A comparison of this type may increase the ability to generalize the findings with respect to the National Airspace System, thus increasing the importance of the study.

CHAPTER 2: REVIEW OF THE LITERATURE

Previous modernization efforts of the National Airspace System have been limited to changes in existing procedures. A recent report showed that the FAA has only recently started to collect data to establish a baseline on how the U.S. National Airspace System currently functions and makes no mention of increasing the use of automated capabilities to achieve NextGen goals (FAA, 2020). NextGen represents a clear departure from ground-based infrastructure and leverages the technological capabilities of modern aircraft to increase system capacity and efficiency (U.S. DOT, 2004). Entrenched political interests have resisted the changes related to NextGen, and the funding inconsistencies mentioned in Chapter 1 for NextGen implementation have prevented meaningful modernization and allowed these interests to maintain control. For instance, the European Union's SES produced a less than 1% increase in capacity from 2008 to 2017 (Swierstra & Garcia-Avello, 2019). The U.S. economy incurs substantial costs associated with the delays produced by the outdated air traffic management system, projected to reach $40 billion annually by 2020 if no action is taken to increase capacity (Vasigh, Fleming & Tacker, 2013). The components that make up this cost include "...direct effects of increased airline cost and the indirect effects of lost labor productivity for business travelers, an opportunity cost of time for leisure travelers, and changes to consumer spending on travel and tourism goods and services" (Peterson et al., 2013, p. 107). Domestic flight delays cost the U.S. economy $31.2 billion in 2007 (Airlines for America, 2019) and $26.6 billion in 2017 (FAA, 2019). The key concept to take away from these costs is that they were absorbed within the economy as a whole, and not returned to the National Airspace System for its improvement, as would be the case with a user fee (Vasigh et al., 2013).

The existing research and corresponding literature mainly followed the NextGen short phase (2004-2011) and mid-phase (2012-2020) time periods along five central themes: safety, patterns and predictability, human factors, automation and efficiency, and air traffic flow management. Research in the short phase was predominantly conceptual with the majority of seminal and foundational theoretical works found here. Studies consisted of primarily simulator studies which examined ideas that address the fundamental objectives of the NextGen program and tested the viability of these ideas in a simulated operational setting. Mid-phase studies were concerned with the testing of deployed concepts and operational scenarios utilizing simulations with actual traffic data and real-time evaluations conducted in the National Airspace System to validate and evaluate procedures in operational use. The literature review is presented in a hybrid thematic-chronological format illustrated in Figure 1. This format allows the reader to follow the development and operational deployment of NextGen components chronologically within each theme.

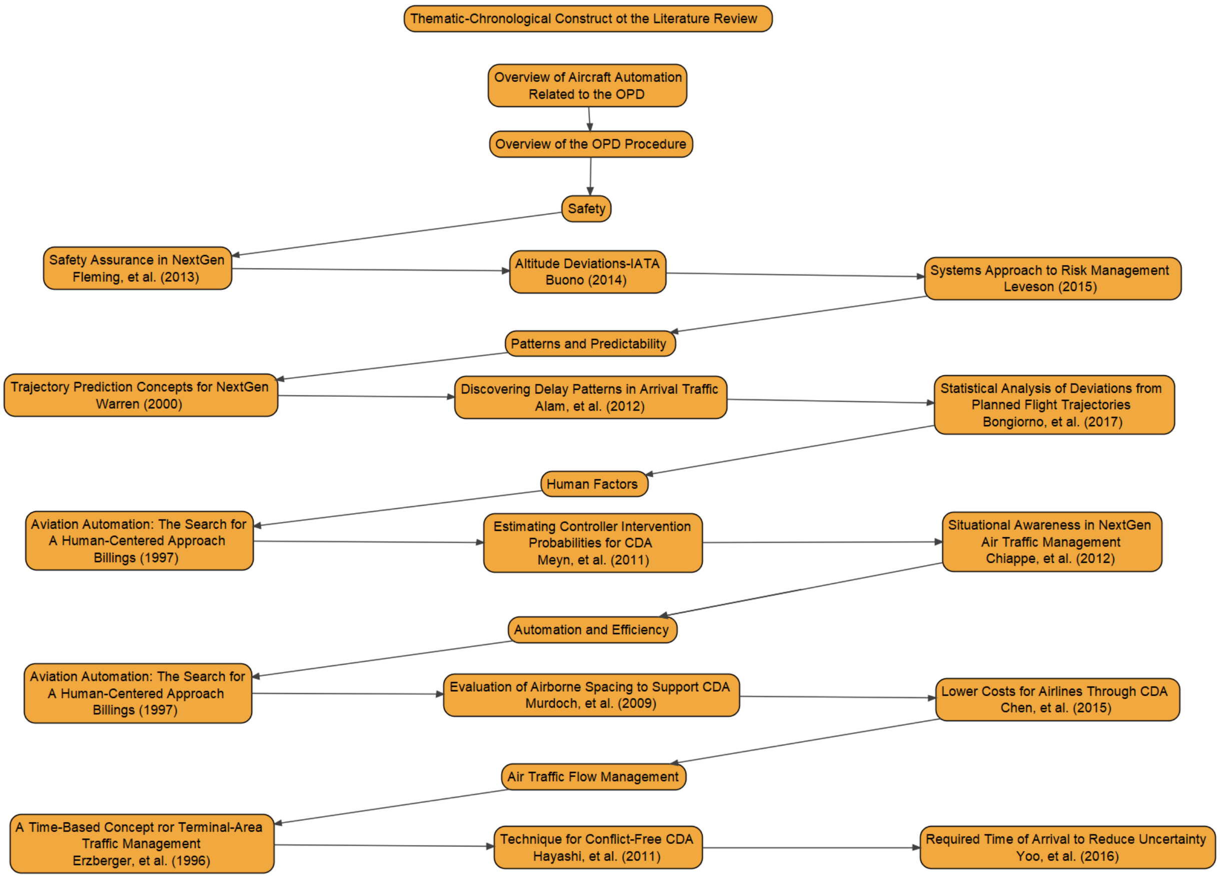

Figure 1. Literature Review Map

Aircraft Automation

The airborne system responsible for the execution of the OPD procedure is known as the flight management system [FMS] (General Electric, 2010). The principal component in this system, the flight management computer (FMC), performs the horizontal and vertical flight path calculations using inputs from various aircraft sources that provide the control inputs to the other integrated elements of the FMS (General Electric, 2010). This integrated system is "…capable of providing continuous automatic navigation, guidance, and performance management" from initial climb to glide path intercept on the destination approach when used with "…lateral and --longitudinal autopilot coupling and automatic thrust control" (General Electric, 2010, p. 1-23).

Furthermore, the FMC optimizes these functions in response to system inputs and manually entered performance parameters to maximize efficiency (General Electric, 2010). One such optimization capability is Required Time of Arrival (RTA), which uses the input of a specific arrival time at a specific navigation point to calculate an optimized speed schedule within the performance limits of the aircraft to comply with the arrival schedule in the most efficient manner. The FMC calculates arrival parameters at the fix using manually input time tolerances and adjusts aircraft performance accordingly when it appears that these tolerances will not be met (General Electric, 2010). While RTA is a capability available on most FMS systems installed on transport category aircraft and available for use at little or no cost to the U.S. air traffic control system, it is not presently being used in the U.S. National Airspace System. RTA will be discussed more in-depth later in this dissertation but is important to mention here because of its potential to relieve some of the sequencing and separation issues experienced by air traffic management in the transition from the en route to the terminal phase of flight.

FMC flight path construction. As the lateral flight plan course is loaded into the FMC, it automatically begins construction of the vertical flight path using information stored in internal navigation databases and calculates an idle path descent from the lowest charted altitude on the arrival procedure upward to the aircraft en route cruise altitude entered in the FMC (General Electric, 2010). If the OPD design is such that an idle path descent is not possible throughout the entire procedure, or the descent rate on a segment is not steep enough to support an idle path descent, the FMC builds a vertical flight path angle known as the gradient path between the two waypoints and manipulates the speed via the auto throttle to safely fly that segment (General Electric, 2010). This descent mode is called VNAV PATH (vertical navigation path), where the FMC follows the calculated idle path and gradient path to comply with charted altitude and speed restrictions on an OPD arrival (Southwest, 2014). VNAV PATH is the most comprehensive descent mode used to fly an OPD because it ensures that airspeed restrictions will be complied with and that the aircraft will not descend below a charted altitude, thus increasing predictability and reducing uncertainty (Southwest, 2014).

Performance-Based navigation. Underpinning any discussion of an OPD is the concept of Performance-Based Navigation (PBN). PBN is the ability of the aircraft to navigate in compliance with the performance standards of RNAV while adding a navigation monitoring component within the flight management system known as RNP (Required Navigation Performance) to alert the flight deck crew if the applicable navigation parameters are not being met for the phase of flight (FAA, 2016). This alerting function is an important safeguard with respect to the OPD, providing navigational performance information to the crew as the RNP tolerances become more restrictive as the aircraft enters the terminal area and approaches the runway (FAA, 2016). RNP capability has also allowed a reduction in aircraft spacing requirements both horizontally and vertically due to its ability to monitor navigation tolerances (FAA, 2016).

Interruption of the calculated flight trajectory. When these calculated lateral and vertical paths are interrupted, the conditions exist to produce a deviation. One of the prerequisites for the FMC to calculate a vertical path is the presence of a waypoint "…in the descent path … with an associated altitude constraint" on which to build the vertical path, and allow the pilot to monitor deviations from that path (General Electric, 2010, pp. 1-62, 2-189). If the flight plan is modified in the FMC during descent, the FMC will continue to fly the previous flight plan for 60 seconds until the calculations are complete for the revised flight plan. VNAV PATH and the protections it provides will automatically disconnect if the new path calculations are not completed within this 60-second timeframe (General Electric, 2010). This is the type of vertical path disruption that can be caused by a vector off the arrival by air traffic control or by the insertion of a new restriction or change to an existing one that has the potential to produce deviations. The fact that the FMC does not have a known waypoint and altitude constraint on which to base its vertical path calculations introduces uncertainty into the arrival procedure. Even under conditions where the aircraft is cleared to resume the OPD rather quickly, it may take the FMC up to 60 seconds to build the new flight path and for the pilot to determine if they are in compliance with parameters. To illustrate, the navigation tolerance within the terminal area is 1.0 nm (nautical mile) for the FMC. After an interruption to the flight path where the aircraft is subsequently cleared back on the OPD, an aircraft with an airspeed of 210 knots (a common transitional speed within the terminal area) will travel 3.5 nm in the 60 seconds it could take the FMC to construct the new vertical profile (General Electric, 2010), 3.5 times the navigation error allowed for the FMC in terminal airspace. While the aircraft is not on a predictable published flight path, controller workload is increased due to the requirement to manually monitor both lateral and vertical separation. OPD arrivals provide more waypoints to "… allow Controllers the latitude to know the lateral path, speed, and altitude of anyone on the arrival at each waypoint" and "… assist in alleviating ATC workload" (Southwest, 2014, p 4-5).

Optimized Profile Descent (OPD) Arrival

NextGen was proposed and is designed to be deployed in an integrated fashion (U.S. DOT, 2004), and the Optimized Profile Descent (OPD) is a NextGen component that links the en route airspace structure to the terminal airport environment (FAA, 2017). The OPD has the potential to achieve most NextGen System goals as outlined in the *Integrated Plan*, expanding capacity through precise, predictable flight paths, ensuring safety due to accurate aircraft spacing, standardizing arrival procedures, minimizing “exposure time between controlled and uncontrolled aircraft at lower altitudes” (FAA, 2017, p. 5-4-3), and reducing noise and fuel consumption in the lower-altitude terminal operating area (U.S. DOT, 2004). Moreover, OPDs are currently in use at many of the larger U.S. airports providing airline service.

STARS (Standard Terminal Arrival Routes) were in use prior to NextGen, providing a primarily lateral arrival path. The OPD descent capability may be added to an existing STAR, or the procedure may be completely reworked to include the OPD feature. As used here, a STAR will refer to an RNAV arrival without a vertical component, and RNAV STAR (OPD) will designate a STAR with an OPD vertical capability. For this discussion, area navigation (RNAV) refers to a navigation method where GPS or ground-based signals provide navigation inputs to inertial platforms within the navigation computer onboard an aircraft. RNAV provides the ability to fly any desired flight path within “… the coverage of station-referenced navigation aids … the limits of the capability of self-contained systems … or a combination of these capabilities” (EUROCONTROL, 2014, p. 15). EUROCONTROL estimates the potential to save 150,000 tons of fuel per year and reduce CO2 emissions by nearly 500,000 tons per year within the E.U. by using the OPD procedure in a consistent manner (EUROCONTROL, 2017).

The OPD Defined

The FAA defines the OPD as a fuel-efficient descent comprised of an “uninterrupted descent … from cruising altitude to the point when level flight is necessary for the pilot to stabilize the aircraft on final approach” to “… enhance safety, minimize the impact of aircraft noise and conserve aviation fuel” and “minimizing low altitude maneuvering of arriving” aircraft (FAA, 2017, p. 5-4-3). EUROCONTROL’s definition is “an aircraft operating technique in which an arriving aircraft descends from an optimal position with minimum thrust and avoids level flight to the extent permitted by the safe operation of the aircraft and compliance with published procedures and ATC instructions" with the goal to "reduce aircraft noise, fuel burn, and emissions by means of a continuous descent" (EUROCONTROL, 2017, p. 1). This is in direct contrast to the current air traffic management practice of a stair-step type descent where arriving aircraft descend and level off at intermediate altitudes requiring multiple descent clearances and thrust settings above idle at less fuel-efficient lower altitudes (FAA, 2019). Examination of both definitions highlights the primary elements of an OPD procedure: continuous descent, minimal time in level flight, and reduced thrust which produce less noise, lower fuel consumption, and less time in the lower altitude structure (FAA, 2019). In addition to these benefits, the OPD procedure provides predictability in both the lateral and vertical planes for an arriving aircraft due to the precision and accuracy of GPS, an important safety feature in the terminal environment which contains a denser grouping of aircraft per unit of airspace.

STAR Elements

There are common features to all STAR designs and additional features incorporated into OPD procedures, safety being the overriding priority in all cases. The FAA mandates that all STARs begin at an en route navigation fix, not require use of an automated vertical navigation capability such as VNAV, use minimum thrust throughout the procedure, and transition to a charted fix on an instrument approach procedure in the terminal area (FAA, 2013). STARS should also incorporate the fewest number of navigation fixes and waypoints as possible to comply with the requirements of a specific procedure. Additionally, STARS will generally have course changes, airspeed and altitude restrictions at some points, and should consider the "… combined impact of altitude, airspeed, and course changes …" contained in the procedure and minimize them as applicable (FAA, 2016, p. 4-12). In addition to the basic STAR elements, an

OPD is constructed upward from a point in the terminal area to a point in the en route structure and may contain three segment types: en route transitions, common route, and runway transitions (FAA, 2013). In other words, consolidate arriving aircraft from various points in the en route structure, send them along a common routing to the terminal area, and distribute them to the various runways at a given airport. This concept expands the work of Favennec, Hoffman, Trzmiel, Vergne, and Zeghal (2009) and their "point-merge" arrival flow technique for arriving aircraft, taking it one step further from arrivals to a single runway to allocating arrivals to multiple runways.

OPDs are designed to be flown with automated vertical navigation equipment (VNAV) with descent gradients planned for flight at minimum or idle thrust (FAA, 2013). Airspeed and altitude restrictions may be needed at various points along the procedure to allow for obstacle clearance, de-conflict with arriving or departing traffic, or manage speed to maintain aircraft separation criteria (FAA, 2013). These OPD restrictions are consistent with Warren (2000) who identified the vertical or descent trajectory of an arrival to be the least predictable and most uncertain, and proposed that airspeed and altitude restrictions be used for "trajectory path control" to increase both the predictability and certainty of the descent component. An important consideration in STAR and especially OPD development is the FAA goal of constructing STARS to "…accommodate as many different aircraft types as possible" (FAA, 2013, p. B-2), which must take into account the different navigation computers in transport aircraft. While built to a common industry standard, these systems have differing capabilities related to the aircraft in which they are installed (EUROCONTROL, 2014).

Early OPD Development

Early OPD design work at the Georgia Institute of Technology in 2006 emphasized the elimination of level flight segments, a reduction in fuel burn, noise, and flight time, and "minimize the need for controller intervention (vectoring) at low altitudes" (Brooks, 2006). This design methodology also proposed a range of altitude restrictions at OPD waypoints (Brooks, 2006) to account for the differences in aircraft performance and navigation computer capabilities and is the forerunner of altitude windows used in some current OPD procedures. An altitude window is a range of crossing altitudes at a waypoint that allow descending aircraft to cross at any altitude between the altitude floor (lowest) and altitude ceiling (highest) when crossing a given waypoint. From the ATC perspective, adding the OPD component to existing STARs is a desirable goal for predictability, but it needs to be evaluated for compatibility and integrated in a comprehensive manner in concert with other airspace modernization initiatives, but may not be universally applicable to all flight regimes due to safety and efficiency concerns (Porter, 2006).

An analysis of traffic at Atlanta's Hartsfield International Airport during the 24 hour period of October 30, 2005, showed that applying the OPD concept and eliminating level flight segments resulted in an average fuel savings of 14.9 gallons and an average reduction in flight time of 1.7 minutes per arrival (Porter, 2006). With 26,527 average daily scheduled passenger flights in the United States (FAA, 2018) and an average price per gallon of jet fuel purchased by the airlines in North America of $1.847 on March 2, 2018 (IATA, 2018), using Porter's estimates and assuming that only half of those flights used an OPD arrival, this represents a total fuel cost savings of $365,002 per day, $27.52 per flight, and a reduction in flight time of 22,547 minutes or 376 hours per day. An airline such as Southwest that has 4000 daily departures (Southwest, 2018), if only half of these flights use an OPD procedure, a daily savings of

$55,040, and an annual savings of $20,089,600 will be observed.

Safety

A fundamental precept of the NextGen program is the maintenance and enhancement of the high safety level present in the National Airspace System (DOT, 2004). Tools and methods began to appear during the beginning of the NextGen mid-phase to facilitate measurement of safety-related factors and comply with the NextGen mandate that safety considerations be part of systems design. Safety measurement processes are congruent with a proactive approach to safety and using feedback from these measurements to take a data-driven approach to system improvement and risk reduction (DOT, 2004).

Safety Culture

As NextGen procedures and capabilities began to be deployed for operational use during the mid-phase starting in 2012, safety analysis tools were developed to produce operational data for feedback into the system (Mearns et al., 2013). Safety considerations formed part of the input to procedural design and construction as per the *Integrated Plan,* and new tools were required to assess the performance of these procedures and enable their improvement. To provide a starting point for this type of analysis with respect to NextGen, Mearns et al. (2013) proposed a model for the evaluation of the safety culture present in air traffic management. The application to air traffic management as an indicator of safety culture required the identification of relevant factors from practitioners to construct a valid model. The authors identified three main themes consistent with the safety culture literature on which to base their model: incident reporting, employee involvement, and prioritization of safety (Mearns et al., 2013). According to Mearns et al. (2013), safety climate is the status of an organization's perceptions and performance at a given point in time, and safety culture refers to an organization's attitudes and behaviors on an ongoing basis over time. The unique nature of air traffic management and the immediate nature of its environment, coupled with the high level of training present in individual controllers calls for an analytical framework that "... aims to avoid future accidents through measuring safety culture, identifying system vulnerabilities, and initiating change" (Mearns et al., 2013, p. 124).

One limitation of this model is its consistency across the national boundaries present in Europe served by EUROCONTROL, for whom it was developed (Mearns et al., 2013). This would certainly pose less of a problem in the United States with its more homogeneous cultural setting, but where minor cultural and regional differences may still be present. Due to the real time nature of air traffic management, the authors also mention the lack of an ability to isolate an experimental control group to test the effects of various safety interventions identified by the model and establish a "... baseline safety measurement through which success can be determined" (Mearns et al., 2013, p. 131). However, correlational evidence from a single European air navigation service provider using this model demonstrates a reduction in serious incidents as safety reporting increased (Mearns et al., 2013). The experimental limitation could be overcome by the use of high-fidelity simulation platforms available to both air traffic management and flight operations. In spite of these limitations, the safety culture model discussed in this dissertation is in use in some form by 25 air navigation service providers in Europe without regulatory requirement, has been endorsed by the U.S. Federal Aviation Administration, and demonstrates the scalability of the model to provide some level of safety benefit to the user (Mearns et al., 2013).

Safety Assurance

The procedures and concepts developed for NextGen represent a notable departure from current air traffic management and flight operations techniques and mindset. With the greater use of automation overall, existing tools for the evaluation and analysis of safety procedures have become questionable. NextGen's proactive approach to safety through system design and feedback for system improvement do not lend themselves to the traditional reliability theory approach of accident causation (Fleming, Spencer, Thomas, Leveson & Wilkinson, 2013). Reliability theory is primarily a reactive approach which traces the failure of physical system components as the root cause of an accident and prescribes remedial remedies after the fact. NextGen calls for a proactive approach to safety which encompasses a more robust methodology including human, physical, and automated components operating in a more tightly coupled environment (Fleming et al., 2013; U.S. DOT, 2004). The human role is changing with NextGen for both pilots and air traffic controllers, and the traditional reliability theory approach may not capture the host of interactions taking place in a more automated setting. Research indicates that automation tends to put distance between operator and system, and this distance may possibly lead to new accident causal factors (Billings, 1997; Charette, 2018; Fleming et al., 2013).

Systems Theory Approach

Systems and control theory provide a more powerful analytical tool that accounts for a greater number of interactions taking place in a tightly coupled integrated system (Fleming et al., 2013). By defining the overall desired safety performance of the system, safety specifications can be detailed for individual system components that allow each component to integrate into the system and contribute to the overall desired system safety performance (Fleming et al., 2013). This approach addresses the NextGen goal of safety as an input to system design, leading to a static assumption that the system, as designed, is safe (Fleming et al., 2013). The analytical tool proposed by Fleming and colleagues, System Theoretic Process Analysis (STPA), has two goals: "… identify potentially hazardous control actions …" and "… analyze the system to ascertain the potential scenarios that could lead to providing one of the unsafe control actions" (Fleming et al., 2013, p. 178-179). Safety assumptions and conclusions used in the original system design are documented as part of the STPA approach so that future requirements for system update or change may easily identify the safety assumptions used when the system component was constructed (Fleming et al., 2013), which is known as traceability.

The relevance of systems and control theory and the STPA concept has a direct application to the topic of this dissertation. As designed, an OPD reduces traffic conflicts by altitude and airspeed constraints through the analysis of arriving and departing traffic for a given terminal area (FAA, 2017). These conflicts cannot be fully eliminated by the design of the OPD, as there will always be an element of random traffic that cannot be 100% accounted for and will thus require some type of separation maneuver. The OPD is designed to minimize exposure to this random traffic (FAA, 2017, p. 5-4-3); however, the built-in safety features and efficiency benefits of an OPD will be invalid once the aircraft is no longer following the OPD trajectory. If there are identified waypoints or segments on an OPD that tend to result in ATC intervention, following the STPA approach would suggest an analysis of that point or segment and updating it to reduce the incidence of conflict (Bongiorno et al., 2017; Fleming et al., 2013; Meyn et al., 2011). While there is no failure of the human or system elements per se as defined by reliability theory, STPA reasoning suggests that it is the suboptimal use of the system by human operators that may be at issue, or that the confluence of two incompatible systems creates a location for potential deviation. The use of the system as designed or flying the procedure as published utilizes the greatest number of built-in safety features and is generally more successful at controlling threats than mitigating strategies by themselves (Fleming et al., 2013).

Empirical evidence suggests that the majority of altitude deviations (66%) happen in the climb (15%) and descent (51%) phases of flight, which also correspond to high pilot and controller workloads (Billings, 1997; Buono, 2014). The data included in Buono's analysis is from Q1 to Q4 2013 worldwide, the same time period marking the early stages of the NextGen mid-phase in the United States. This is the NextGen phase where the concepts developed in the short phase began to be put into operational use and were relatively new procedures for both pilots and controllers. The data used in Buono's study was a subset of the data used by Margison (2014), but Buono provides a more in-depth examination of potential causal factors during the mid-phase period. Margison included altitude deviation data beginning in 2009, well before the introduction of OPD procedures for operational use (Margison, 2014). The two studies are consistent in their findings of the climb and descent phases of flight producing the greatest occurrence of altitude deviations (60% Margison, 66% Buono), and the two leading causes of altitude deviation being ATC and Flight Management by the aircrew in both studies (Buono, 2014; Margison, 2014).

Leading Safety Indicators

Based on the systems theory approach of Fleming et al. (2013), Leveson (2015) proposed the use of leading safety indicators which transform complex conditions into hazard identification. According to Leveson, leading indicators provide system-specific signs that may be used to show the presence of factors for accident causation. Leading indicators may serve as a call to action when conditions warrant and system safety has "migrated" to a level of unacceptable risk over time (Leveson, 2015). The information provided by leading indicators supplies the requisite feedback required by the system for operators to initiate action to prevent an accident. Foundational to the concept of migration is "… that there can be significant divergence between the modeled system and the as-built system, interactions between the social and technical parts of the system may invalidate the technical assumptions underlying the probabilistic analysis, and the effectiveness of the mitigation measures may change over time" (Rae & Nicholson cited in Leveson, 2015, p.19). Following this rationale, the argument may be made that this migration may also occur when there is a difference between the designed system and the system as it is used. All relevant factors as possible inputs to a leading indicator need to be considered in its composition even if their probability of occurrence is remote to form a truly worst-case scenario for analysis (Leveson, 2015).

Within this context, an altitude deviation is considered a leading indicator for accident prevention in the National Airspace System. The documented increase in altitude deviations in the early stages of the NextGen mid-phase (circa 2012), and the lack of empirical evidence to indicate that deviation rates have declined after this introductory period suggest a difference between system design and system use (Leveson, 2015). Viewed through the lens proposed by Leveson, this suggests that while altitude deviations have increased and not returned to a historically normal level, this feedback is not being used to initiate action to reduce the risk of this potential hazard (Leveson, 2015). NextGen is designed to be deployed as an integrated system (designed), but the data may be suggesting that the deployment of NextGen in an ad hoc manner is causing the migration toward greater risk as procedures and workarounds are used to operate a non-integrated system (used). Anecdotal evidence illustrates this point. For instance, OPD arrivals into Los Angeles (LAX), San Francisco (SFO), and Chicago Midway (MDW) resulted in seven (7) airspeed changes (LAX), a combination of six (6) airspeed and altitude changes (SFO), four (4) step-down altitudes prior to the arrival and five (5) airspeed and altitude changes on the arrival (MDW) compared to the charted procedure (Lyle, personal observation, September 5, 2018 (LAX), September 19, 2018 (SFO), February 28, 2019 (MDW). Chicago Midway (MDW) is one of the leading airports in the United States for the number of level flight segments from the top-of-descent point to the airport (4), and one of the longest durations in level flight at 55 nm (FAA, 2019). These observations are for a single arrival at each location. If this is the case, the value of altitude deviation as a potential leading indicator should be considered.

Patterns and Predictability

The search for predictability and reduction of uncertainty are key contributors to the accuracy of decision support tools, arrival scheduling, and resolution of conflicts, which increase overall safety (Warren, 2000). A documented 60% of altitude deviations occur in the climb and descent phases of flight. In addition, climb and descent segments present a greater "path uncertainty" than the en route segment (Billings, 1997; Buono, 2014; Warren, 2000). These flight phases also constitute the highest workload periods for both pilots and air traffic controllers (Billings, 1997). Construction of trajectories with greater predictability of climb and descent through tighter navigation tolerances and use of aircraft automation have the potential to reduce the overall workload for both pilots and controllers and improve safety through a feedback mechanism (RNP) which monitors compliance with stricter navigation parameters (FAA, 2016; Warren, 2000). Consideration of these requirements in procedure design produces trajectories that leverage the precision of advanced navigation systems such as GPS, to reduce uncertainty in arrival trajectories "... required to avoid major safety consequences resulting in increased workload for pilots and controllers" (Warren, 2000, p. 3). One tool available to achieve this predictability in the early phases of the NextGen concept design was the inclusion of altitude windows at specified points on a descent procedure to accommodate the largest number of different aircraft FMC systems, and aircraft that did not have an FMC installed (Warren, 2000). To achieve the level of accuracy and predictability envisioned for NextGen procedures, Warren (2000) proposed a Trajectory Quality Assurance Methodology framework consisting of prediction accuracy (error sources), prediction integrity (redundancy monitoring), and prediction availability (navigation source and path control; Warren, 2000).

Reduction of Uncertainty

Some of the early conceptual metrics for the design of NextGen trajectories are currently in use in OPDs, most notably trajectory path control via altitude constraints at procedural waypoints. The increased update rate and expanded coverage of ADS-B will be a contributor to increasing accuracy and predictability in addition to its ability to precisely assess aircraft position and compliance with procedural requirements (ICAO, 2007, 2008; Warren, 2000). Another capability conspicuously absent to date is RTA and its ability to deliver a predictable arrival stream to the terminal area boundary, providing a more stable and predictable baseline from which to begin a terminal area procedure (Barmore, et al., 2005, 2008; Yoo et al., 2016).

One benefit of patterns and predictability is through their value as feedback mechanisms to monitor the operation of the National Airspace System and identify problem areas (Alam et al., 2012). This approach is used in the analysis of the interdependencies of ground and air systems and their interaction with respect to delays (Alam et al., 2012). Examination of the traffic behavior patterns present in both of these components shows how they each affect delays, and how they may be better integrated to reduce these delays. The researchers used the computational red teaming methodology to stress-test the system to its breaking point to better identify "… points of failure" (Alam, et al., 2012, p. 2). While this analytical technique is obviously used in a simulated environment, its merits lie in the ability to load up the system and apply varied traffic demand scenarios to better identify the air and ground chokepoints and correlations that may be delay sources. This also allows the testing of the network in a holistic manner and presents a more systems-oriented result accounting for the contributions of various network components (Alam et al., 2012). The computational red teaming approach proposes the concept of an arrival procedure known as the dynamic CDA which uses a set of navigation points to construct an OPD procedure based on real-time ground constraints to find the optimal solution for a given scenario in real time (Alam et al., 2012). The dynamic CDA would produce a more responsive OPD with respect to current conditions, but it requires a more flexible airspace structure for successful implementation.

Patterns as Feedback

The presence of patterns has the benefit of supplying data for analysis where problem areas may be identified, and solutions proposed. This reduces uncertainty and leads to more valid assumptions in planning and scheduling tools for the most efficient use of resources (Bongiorno et al., 2017). These plans are usually not executed as intended, as in the case of an ATC interruption of an OPD procedure; thus, the safety and efficiency benefits that are designed into these procedures are not realized, increasing uncertainty (Vaaben & Larsen, 2015). This is also true for airspace users and their planning for the most efficient use of costly equipment and personnel and having to modify those plans in response to airspace issues. The FAA's airspace modernization effort has not produced the forecast efficiencies or reduction in delays and airspace congestion, and the en route capacity constraints documented in European airspace are also becoming a source of uncertainty and delays in the United States (Carey, 2018; Vaaben et al., 2015). Vaaben and Larsen (2015) propose the use of disruption management techniques from the field of operations management to facilitate a more "… proactive handling of the kind of disruptions … which are caused by congested airspace" (p. 54). This approach includes both airspace users and airspace managers in the model to mitigate the effect of congestion on both and provide a holistic recovery solution to address disruptions in this tightly coupled system (Alam et al., 2012; Vaaben et al., 2015). Through the cooperative approach, the cascading effect of delays may be minimized while continuing to respect the increasingly relevant human limits present in the air traffic management system. Taking this view of system recovery through flexible flight planning within the context of minimal deviation from the original schedule, the authors found a potential annual savings of several million dollars (US) for a medium-sized European carrier as compared to traditional recovery methods without flexible flight planning (Vaaben et al., 2015). This methodology is directly suitable to the congested airspace of the Northeastern U.S. which has been designated for application of NextGen in a more integrated way, as it accounts for roughly half of all delays in the National Airspace System (Carey, 2018).

The value of the feedback provided by patterns lies in the ability to use them as a basis on which to construct models and develop strategies for system improvement. Recent work by Bongiorno, Micciche, Mantegna, Gurtner, Lilly and Pozzi (2015) builds on the importance of interdependence within air traffic management identified by Alam et al. (2012) and Vaaben et al. (2015) to use network science as the basis for a more flexible air traffic system structure. By analyzing statistical patterns, the authors were able to identify areas for more in-depth examination and use them to compare planned use to actual use, and argue for the establishment of a more "adaptive air traffic network" to better meet system needs (Bongiorno et al., 2015; Santos et al., 2017). The comparison of system design to its actual use offers insights into how the system is being operated and highlights points where there is a difference. Each of these points has quantitative attributes that can be measured; *degree* is the number of trajectories that use the same navigation point, *strength* is the amount of traffic flowing through a navigation point, and *fork* is the percentage of strength that does not go to the next planned navigation point (Bongiorno et al., 2015). The analysis of the fork metric identifies a given navigation point as an origin for fluctuations in the traffic flow (Bongiorno et al., 2015). These fluctuations are not always a negative phenomenon, as the study found that direct routing is one of the causes of fluctuation, resulting in a more efficient direct flight path to the destination.

Overall, controllers tend to change flight paths less (lower fork value) in conditions of heavier traffic to maintain stability and predictability of the flow, and change flight paths more (higher fork value) in lighter traffic conditions which roughly correspond to less-congested overnight hours (Bongiorno et al., 2015). Additional inputs to the fork metric include the diverse geographic factors of European airspace, the sector structure comprising that airspace, and the varied approaches taken by controllers of different nationalities with respect to air traffic management (Bongiorno et al., 2015). Considering these factors, the fork concept provides a useful tool for analysis of traffic flow, highlighting navigation points where there is a higher or lower probability of the traffic being routed other than planned and why this occurs.

Building on the fork metric, Bongiorno, Gurtner, Lillo, Mantegna and Micciche (2017) propose the *di-fork* concept which is an ordered pair of navigation points with a directional component rather than a single navigation point. Di-fork seeks to further clarify pairs of points on the navigation grid that have a higher or lower probability of variation from planned flight trajectories when compared with a baseline value (Bongiorno et al., 2017). Study findings identify time of day and traffic density as the primary factors affecting a di-fork value, the importance of these factors in the decision-making process of controllers, and their actions regarding the need to stabilize traffic flow (Bongiorno et al., 2017). This study was conducted in the en route environment; however, di-fork has the capability to be applied to shorter navigation segments such as those on an OPD, to identify navigation point pairs where controllers are more likely to change the planned flight trajectory (C. Bongiorno, personal communication, July 19, 2017). Furthermore, the application of the di-fork analytical method to an OPD and the terminal environment have direct applicability to this dissertation, in that, it may be possible to catalog individual navigation segments within an OPD that have the highest probability of intervention by ATC, and gain a better understanding of the reasons for this phenomenon.

Human Factors

While automation has the potential to provide new predictability and precision, debate and research continue to examine the proper balance of human operator and automation within a system (Billings, 1997). Early research in this domain is directly applicable to the increased use of automation in NextGen because it explores how tightly coupled aviation systems design should become, or if the current "… integrated but uncoupled …" design is optimum (Billings, 1997, p. 179). This becomes an important design consideration when automation has the ability to move and alter the "…nature and consequences of human error…" (Billings, 1997, p. 174) due to a potential lack of feedback and clear indication of a cause-and-effect relationship (Charette, 2018).

Workload Measurement Tools

The coupled nature of aviation systems and the human operator's role in the safety of those systems led Kirwan, Gibson and Hickling (2008) to begin the development of human reliability assessment tools for use in air traffic management. The researchers cited many of the concerns of Billings (1997) in their examination of the human-automation balance in aviation with regard to both pilots and air traffic controllers, but with the benefit of a more complete picture of the concepts proposed for SES. This led to a greater ability to investigate the specific interactions within and between the flight operations and air traffic management entities, and specifically explore these transactions from the human safety contribution to the system. Many of the concepts that form the basis for this study were obtained from human reliability assessment tools of other industries with the authors adding four factors unique to air traffic management: (1) high reliance on the human entity, (2) a 'live' and very dynamic setting where events may escalate quickly, (3) an 'open' system with unfavorable events that cannot be easily predicted or controlled, and (4) the inability to quickly and easily 'shut down' the system (Kirwan et al., 2008). The prominent role of the human operator within aviation systems makes the development of this type of tool and its input to system design, and workload analysis relevant to defining an appropriate human-automation balance as the human becomes more of a limiting factor.

Agent-Based Models

Agent-based models allow the researcher to identify individual actors or agents and simulate the relationships and interactions present between them within a complex system. This approach has direct relevance in the study of aviation science for several reasons: the conduct of experiments outside of simulation may not be possible or economically feasible; manipulation of variables such as inter-aircraft spacing distances may not be safe, and creating a controlled experiment and isolating the area of study may be impossible (Gilbert, 2008). Models are designed to replicate some type of real-world environment referred to as the *target*, in this case, a portion of the National Airspace System, and examine the relationships present within the target. Manipulations of the agents allow for determination of how a change affects the target, and the researcher may be able to learn more about the relationships present in the target through the model (Carley, 1999 as cited in Gilbert, 2008). This approach was taken by Tumer and Agogino (2008) when they identified the agent as an individual controller, manipulated the role and position of the agent within the target, and observed the various outcomes when experimental conditions within the target were changed. Interactions between agents may lead to outcomes that were not specifically built into the model; however, they lead to further understanding of the target (Macal & North, 2010). The closer the model represents reality, the greater its ability to generalize findings to the target.

Agogino and Tumer (2012) extend their agent-based concept to a scenario involving multiple agents working in a coordinated manner using real-world data from New York and Chicago. This multi-agent approach closely examines the importance of coordination between agents present in the National Airspace System and analyzes agent decision making in the context of finding the optimal balance between delay and congestion. In each scenario tested, agent-based methods performed better than centralized uniform policies, leveraging the ability of the agent to adapt and learn from the traffic situation presented to them within their area of responsibility. The agents were then able to choose the best course of action based on their experience and ability to evaluate the flow of traffic in real time and produce a notable reduction in congestion (Agogino & Tumer, 2012). This approach moves toward the decentralized concept of NextGen airspace modernization and the ability of local air traffic managers to apply the appropriate methods within their airspace to reduce congestion and delays, increasing overall system efficiency.

The Human as a Limiting Factor

The multi-agent approach addresses the complexity of air traffic management, with new and innovative thinking required if system capacity is to be increased to accommodate demand, and the workload limits of human air traffic controllers are approached. One method to mitigate the effects of human factor limitations is increasing the use of aircraft automation capabilities for routine functions such as maintaining aircraft separation. Prandini, Piroddi, Puechmorel and Brazdilova (2011) realize the importance of a more flexible approach than the rigid sector system and moving from ground-based air traffic management methodologies if National Airspace System capacity is to be increased. This shows the need to accurately measure complexity within the system, now narrowly defined as controller workload. The authors argue that this current definition may be inadequate to accurately account for different agents present in a decentralized and increasingly automated system and the differences in their interactions. Reliance on the current complexity definition may artificially constrain the use of automation technology and slow the rate of movement away from a ground-based system to increase system capacity.

Taking a more pilot-centric approach to workload analysis, Johnson et al. (2010) examine effects on pilot workload during simulated OPD arrivals using automated interval management procedures. Research indicates that a given unit of workload remains relatively static; for a given scenario, a reduction in workload for one entity produces an increase in workload for another entity (Billings, 1997). The distribution of this defined unit of workload has the potential to create an imbalance between the various actors in a given situation (Billings, 1997). Johnson et al. (2010) looked at different levels of pilot interaction with flight deck automation during inter-aircraft spacing operations when responsibility for aircraft arrival spacing was assigned to pilots. Findings indicated that arrival delivery accuracy was highest using automated tools that entered speed commands directly into the FMC, and lowest when pilots were required to manually enter and update speed commands. Manual entry required dividing cockpit workload between managing the speed assignments in the FMC and monitoring aircraft energy state to comply not only with OPD restrictions but also inter-aircraft spacing intervals (Johnson et al., 2010). While in this case total workload was not reduced, its redistribution via some level of automation allowed it to be present at an acceptable level to safely and accurately comply with procedural requirements. The authors also argued that the opacity of automation may limit feedback needed by the pilot when operating in the manual mode, and may adversely affect the pilot's ability to assess aircraft energy state during a period of heightened workload (Billings, 1997; Charette, 2018; Johnson et al., 2010).

One method of reducing workload for both pilots and controllers is through the use of automation to reduce the overall value of the workload unit in a given scenario (Billings, 1997; Meyn, et al., 2011). This is accomplished by reducing the need for controller interruption of an OPD to maintain separation, and the resulting pilot tasks to return to and comply with the OPD after separation has been re-established. Meyn, Erzberger and Huynh (2011) studied the addition of arrival meter fix crossing-time assignments to the Efficient Descent Advisor (EDA) during simulated arrival traffic at Dallas-Fort Worth (DFW) and Denver (DEN) with the goal of reducing controller interventions needed to maintain separation parameters. The authors argued that the addition of these meter fix crossing times and the corresponding increase in predictability would reduce conflicts and separation issues, decreasing the need for controller intervention (Meyn, Erzberger & Huynh, 2011). The use of RTA and its automated capability to comply with the meter fix crossing time schedule was not included in this study, and it is assumed that pilots complied manually as described in Johnson et al. (2010). In contrast to the

European SES concept that uses the FMS RTA function to accomplish time-based flow management, the United States continues to task controllers with manual trajectory time management with the associated inefficiencies and human limitations (Swierstra et al., 2019).

Central to any discussion of arrival flow into a terminal area is that of *freeze horizon* or the distance from the meter fix in which the assigned time at the meter fix becomes static (Meyn et al., 2011). This distance is generally expressed in units of time, 20 minutes in the case of this study, but represents an approximate distance of 80-100 miles from the TRACON boundary and roughly 130-160 miles from the airport. The relevance of the freeze point is its function as a demarcation point where the arrival schedule assumes a more rigid format, provides a fixed reference point for the evaluation of aircraft spacing, and determines the need for adjustments while in the higher altitude structure (Meyn et al., 2011). Figure 2 illustrates the concept of the freeze horizon on the REDDN4 Arrival to Dallas Love Field in Texas with PUDJE, PNUTS, MAJKK, NAVYS, and CHEVE being the freeze points.

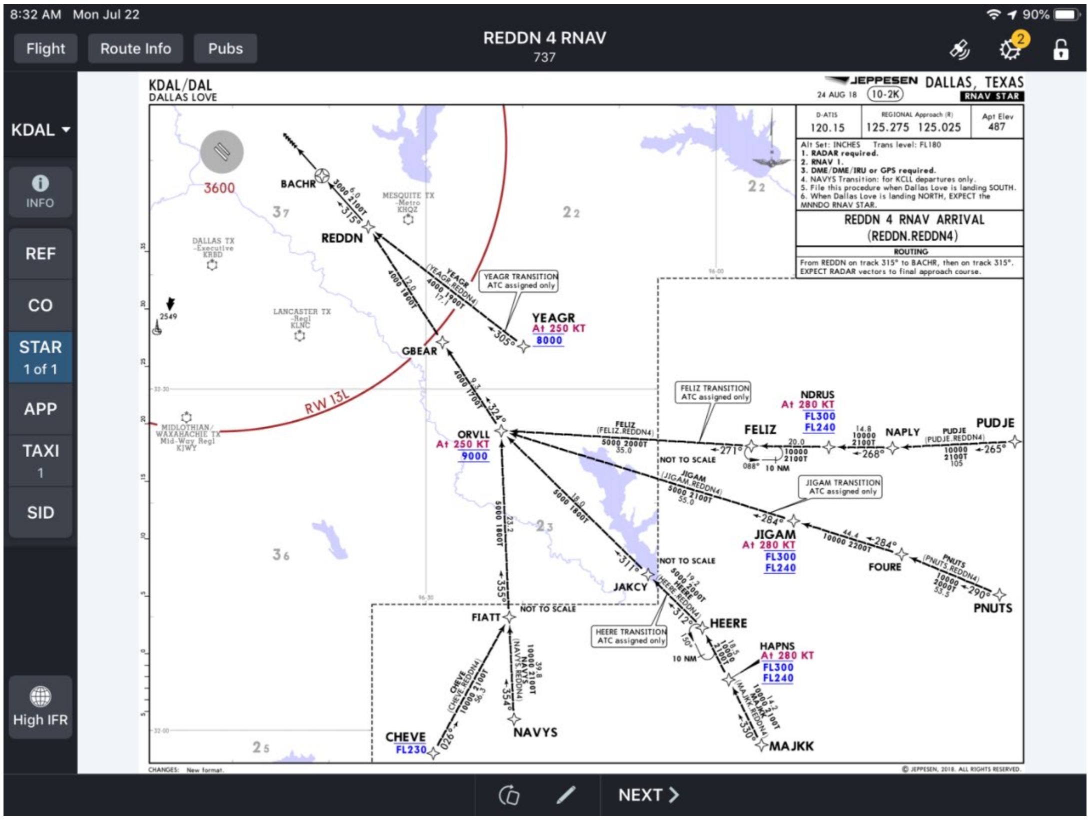

Figure 2. REDDN 4 RNAV Arrival

Many of the NextGen capabilities discussed benefit from the addition of some level of automated capability for flight operations and air traffic management. Billings (1997) observed that the optimal balance of human actor and automation within a given setting is located on the continuum between completely manual and completely automated. As the human element becomes more of a limiting factor in air traffic management, increased automation and redistribution of workload in some combination become a consideration for the NextGen goal of increased system capacity (Vu et al., 2012). Two useful definitions are provided here, those of workload and situational awareness. *Workload* is defined as "… the demand for resources required by the task …" and "… the supply of attentional and processing resources that the operator has available for completing the task …" (Tsang & Vidulich, 2006 cited in Vu et al., 2012, p. 108). *Situational awareness (SA)* "… refers to an operator's understanding of the rapidly changing events occurring in his or her task environment and typically involves perception, comprehension, and projection of information" (Durso & Dattel, 2004; Endsley, 1995 as cited in Vu et al., 2012, p. 108). Workload and situational awareness affect each other but are not the same thing.

Using this definition, workload has a capacity limit although the limit has the potential to be increased by the addition of automated processing resources. Vu et al. (2012) sought to evaluate workload and situational awareness effects on pilots under various conditions of responsibility for separation of aircraft. Vu and his colleagues found that some responsibility for traffic separation could be safely delegated to pilots without a significant increase in their workload, and that pilot situational awareness was optimal during the simulation scenario where pilots were responsible for separation (Vu et al., 2012). Pilots expressed no reservations about accepting responsibility for separation but did want controller participation in a monitoring or consulting role for an additional layer of safety (Vu et al., 2012). Furthermore, there was an automated merging and spacing tool available to pilots for this study, which did manage spacing to the runway and assisted pilots in maintaining separation but required some type of datalink capability such as ADS-B. The absence of this datalink capacity in the National Airspace System limits the ability to redistribute this responsibility to pilots and continues to impose the workload capacity of controllers as a system constraint (Vu et al., 2012).

As the human actor becomes an increasingly limiting factor to NextGen system capacity increases, future design considerations must include the elements of workload and SA if this capacity increase is to be accomplished safely (Chiappe et al., 2012). To accurately measure these metrics and allow for their inclusion in system design requires the development of analytical tools, and an understanding of system components and their effect on the development and maintenance of SA (Chiappe et al., 2012). While the concept of SA is a subject of debate within the scientific community, the authors argue that it is primarily contextual and displays more of a flexible connection to context than a fixed list of elements present in all cases, but has the common requirement to "…process a great deal of rapidly changing information in a time-sensitive way to achieve a particular task goal" (Smith & Hancock, 1995 as cited in Chiappe et al., 2012, p. 142). Similar to pilots, as the level of automation increases and adds distance between the controller and task, the level of SA decreases (Billings, 1997; Chiappe, et al., 2012). Care should be exercised in the design of NextGen systems to prevent the removal or modification of tools that further degrade SA the controller needs to safely accomplish a task (Billings, 1997; Chiappe et al., 2012).

Importance of a Holistic View

A holistic approach is needed in the design and implementation of NextGen systems that consider various inputs such as human factors. By detailed modeling of the host of interactions taking place in a complex system such as air traffic management, a better understanding is provided of how the diverse functions of human, technological, and organizational entities integrate to produce a safe airspace structure. The analysis of these relationships will lead to a better understanding of how they work together to reduce the creation of unintended consequences when the components are operating together. It is with this goal in mind that Santos, Montiero, Studic and Majumdar (2017) developed the Model of ATM Reality in Action (MARIA) to "… provide a sound base for system analysis, including safety, namely by describing the whole system and the interdependencies between its functions"(Santos et al., 2017, p. 445). The MARIA model dissects tasks into their individual components and examines them with respect to their positive or negative effects on the functioning of the system as a whole. The authors mention the challenge of quantifying concepts such as SA and the need to collect further data to "… operationalize … and map it with recordable functions and flows in MARIA" (Santos et al., 2017, p. 455). With an integrated system such as NextGen, it is essential that the components be scrutinized in combination, and not isolation. This optimal combination of human actor and automation described by Billings (1997) is proposed by Pongsakornsathien, Gardi, Sabatini and Kistan (2019) to safely increase capacity as human limits are approached. The holistic approach to human factors concepts of workload and SA has the ability to make them assets or liabilities in the integrated NextGen system.

Automation and Efficiency

One of the pillars of both NextGen and SES is the increased use of automated systems by air traffic management and airspace system users to increase system capacity, reduce fuel consumption, and enhance environmental sustainability (U.S. DOT, 2004). Before the airspace modernization initiatives were conceived with the U.S. air traffic system, aircraft automation had been used, and has, served as a template for many air traffic management systems worldwide. While aircraft automation and capabilities have received a significant upgrade in accuracy from GPS and satellite communication technology, the ground-based air traffic management system has yet to leverage these technological advances to address the issues facing the U.S. National Airspace System, becoming a restraining factor with respect to NextGen objectives (Economist, 2016).

Currently, automated technologies are available to assist air traffic management in the sequencing and separation of traffic (Barmore, Abbott & Capron, 2005). Early NextGen era research identified the runway itself as a significant choke point and developed an automated inter-aircraft spacing tool where aircraft follow each other to the runway, maintaining a defined spacing interval on a designated lead aircraft (Barmore et al., 2005). Dubbed Airborne Merging and Spacing for Terminal Arrivals (AMSTAR), the concept utilizes ADS-B data link to allow the aircraft in the arrival stream to communicate and adjust their speed to preserve a predetermined spacing interval, increasing the capacity of existing runways (Barmore et al., 2005). In addition, this tool reduces uncertainty in the arrival stream, increases predictability, and demonstrates the ability in simulation to deliver aircraft to the runway threshold with a mean error of 0.5 seconds and a standard deviation of 4.7 seconds (Barmore et al., 2005).

According to Billings (1997), not all aircraft and air traffic management functions have the ability to be completely automated, as the computational capacity required to program for every contingency and their possible combinations would quickly be reached for an onboard system. There is a region on the total automation-total human control continuum that benefits from a combination of human and automated inputs. The optimal balance of human and automated control has been the subject of discussion since the first-known example of aircraft automation was patented in England in 1891 (Billings, 1997) and is explored by Billings (1997) in his comprehensive examination of the subject. Although many of the automation and navigational advancements made in the last two decades were not operational when Billings initially broached the topic, his work has provided a foundational basis as these advanced systems were developed and operationally deployed. His concerns and observations have been validated numerous times since his work was published in 1997; in many cases, by researchers cited in this dissertation.

Role of Automation

According to IATA in 1994, the goal of aviation automation is not to replace the human entity but to support them (Billings, 1997). This precept is fundamental as advanced systems evolve where the human is conceptually relegated to the role of a systems monitor. The increased use of automation in both the aircraft and air traffic management environments has the ability to increase predictability and reduce uncertainty, but the dynamic and coupled capabilities of a complex, increasingly integrated system such as air traffic management will continue to require the human decision-making input to ensure safety and flexibility (Billings, 1997). Mechanized decision-making has the tendency to be rigid and inflexible, only having the capability to evaluate and act on tasks for which it was programmed. Billings (1997) suggests that there should be an avenue for the human actor to remain actively engaged in an automated process due to the decreased time horizon available to recover from errors in a highly coupled integrated system. This idea foreshadows the changing roles of human actors in future automated systems and proposes a belief that if the human is to retain the responsibility for system safety, then the human must also have the authority and control over that system to ensure safety (Billings, 1997).

Automation increases the distance between the human operator and the system for which they are responsible, and this distance has the potential to shift the indication and effects of human error to an unexpected location or time (Billings, 1997). The pilot function of control and the controller function of coordination require feedback in the form of system status and communication to build an accurate picture of system conditions in real time to execute their appropriate roles and maintain safe system parameters (Billings, 1997). Billings' projection of these types of issues was certainly visionary, given the fact that the NextGen *Integrated Plan* was not published until seven years later in 2004. However, the principles Billings developed are seminal guidelines, cautions, and considerations with respect to the role of the human actor in automated systems.

A central issue in automation design is the transparency of the automated function and the ability to assess the status of the system to determine if it is producing the desired outcome. The evolution of airline training has gone from the days of extensive systems knowledge to a user-based approach of how to use a system with a cursory understanding of how it operates. Understanding every aircraft system at an engineering design level is certainly not required to deploy it effectively and safely, but a more robust understanding is beneficial when the system is not functioning as intended and how it may affect other systems in an integrated coupled environment. This emphasis on transparency is the concept behind avoiding design of a system that allows automatic and manual control simultaneously, as the operator may not be able to determine which mode is in use, and built-in safety features may be bypassed (Billings, 1997). Transparency is essential for the aircraft operator or air traffic manager to fulfill their strategic management role over the automation, determining the appropriate level, evaluating if it is operating as intended, and reducing or disconnecting (Economist, 2019). Essentially, the point where automated and manual air traffic control techniques intersect provides the environment for errors and deviations.

Technological Infrastructure

The inability of air traffic management to take full advantage of advanced automated aircraft capabilities lies partially in ATC's mandate to sequence and separate aircraft using outdated surveillance technology in the form of ground-based radar (Billings, 1997). While there are various automated methods to assist with sequencing and separation, surveillance technology is not in place to adequately monitor and deploy them safely. The en route radar updates approximately every 12 seconds, terminal radar about every 5 seconds, and ADS-B updates 1-2 times per second (ICAO, 2007, 2008). The faster update rate of ADS-B provides improved accuracy for air traffic management to safely monitor the use of automated sequencing and spacing procedures, reduces separation criteria, and quickly identifies conflicts that impact flight safety (ICAO, 2007, 2008).

Extending their earlier research to include additional capabilities, Barmore, Abbott, Capron and Baxley (2008) studied flight deck automation for use in the en route environment known as Flight Deck Merging and Spacing (FDMS) which establishes arrival spacing intervals prior to the merge and metering points of terminal airspace. This simulation study using traffic data from the Dallas-Fort Worth terminal area showed the ability to further increase the accuracy of aircraft delivery at the runway threshold and facilitate the use of the OPD. Arriving traffic is not required to be sequenced in a linear fashion prior to the merge point, but "… two aircraft arriving via different routes will merge onto the common route without the need for any additional flight crew intervention or change in the spacing guidance" (Barmore et al., 2008, p. 3). Establishing arrival spacing while in cruise flight and maintaining spacing while utilizing different arrival routings is foundational to the work of Yoo et al. (2016) with respect to RTA, increasing the accuracy of delivery and reducing pilot and controller workload. Overall, the absence of ADS-B data link technology limits the ability to fully use this capability.

Airborne Precision Spacing

The sum of these components, RTA, OPD, and FDMS, comprise the National Aeronautics and Space Administration (NASA) Airborne Precision Spacing (APS) concept. RTA is not used in this context in its fully automated form as described by Yoo et al. (2016), but instead, as an ATC clearance delivered to the aircraft in the en route structure from a ground-based arrival scheduling tool. A simulation study incorporating both pilots and air traffic controllers was conducted by Murdoch, Barmore, Baxley, Abbott, and Capron (2009) to evaluate the integrated APS concept and also observe the effects on pilot and controller workload. Precision spacing to the runway in this integrated fashion has the potential to standardize airport arrival and approach procedures increasing predictability, providing a safer operation. Murdoch et al.'s, (2009) study was among the first to articulate the incompatibility of manual and automated NextGen air traffic management procedures, validating the hypothesis of Billings (1997) that these two forms of air traffic management may not be congruous. Murdoch and colleagues produced an 85% delivery accuracy of +/- 5 seconds at the runway threshold using a target spacing of 150 seconds, but aircraft that did not meet the target failed to do so due to an ATC speed intervention (Murdoch et al., 2009). These findings are consistent with the simulation study conducted by Dao et al. (2010) where the results showed an increase in delivery accuracy at the runway threshold when flight deck automation was used, and "… findings show that current interval management systems perform better at higher levels of automation where there is low human intervention" (p. 25). These findings are also consistent with Barmore et al. (2005) who demonstrated a mean error of 0.5 seconds and a standard deviation of 4.7 seconds at the runway threshold. While Murdoch et al. (2009) reported positive results with regard to pilot and controller acceptance of the procedures in an integrated format, it does not investigate deconfliction with departing traffic and depends on ADS-B for inter-aircraft spacing during the approach segment as observed by Dao et al. (2010).

Optimizing Arrivals and Departures

Addressing departing traffic within the arrival flow planning process, Favennec, Hoffman, Trzmiel, Vergne and Zeghal (2009) from EUROCONTROL developed the scalable point merge arrival methodology that increases predictability of arriving traffic supporting OPD arrivals (Figure 3). This arrival method builds on the work of Barmore et al. (2008) by sequencing the flow of arrival traffic into the terminal area via different routings and is adaptable to single and multi-runway airport configurations. Predictability of the arrival stream coupled with previously discussed methods of inter-aircraft spacing reduce the need for ATC to revert to manual sequencing techniques at lower altitudes which increase fuel burn and disrupt the precision of arrival schedules (Murdoch et al., 2009). The flexibility of point merge is one of its most appealing features with its ability to shorten or stretch arrival flight paths to maintain planned arrival schedules. Predictability of flight paths, increased situational awareness, and standardization of procedures were cited by both pilots and controllers in this study as contributors to flight safety (Hoffman et al., 2009). Standardized arrival flight paths enable the planning of standardized departure procedures and highlight potential conflict points for application of mitigating remedies. According to Favennec et al. (2009), point merge is completely compatible with the previously discussed APS concept and 4D trajectories, as it can address errors and adjust timing within the arrival stream to support the arrival schedule and maintain predictability.

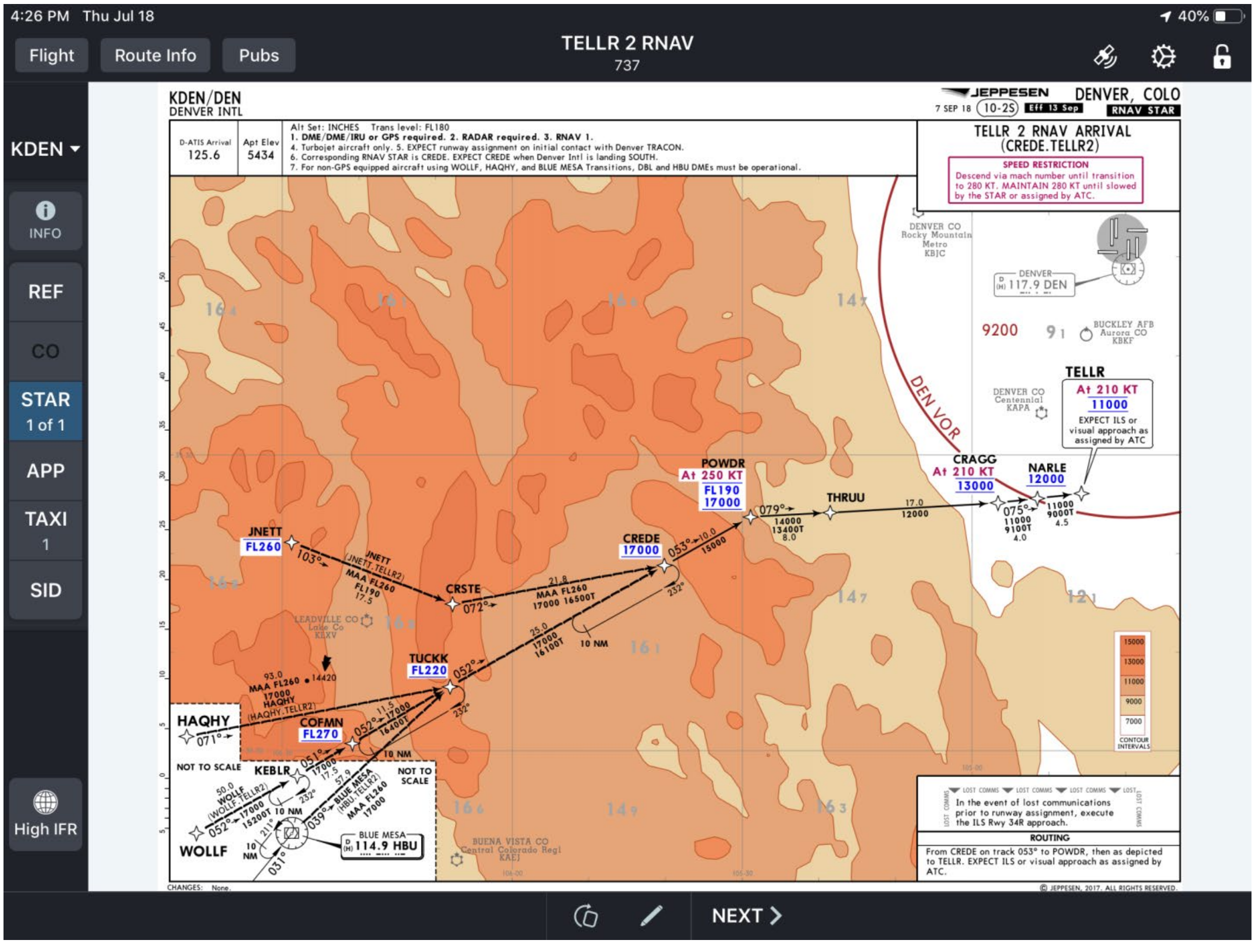

Figure 3. TELLR 2 RNAV Arrival

Not all terminal areas are conducive to the optimal construction of arrival and departure procedures, and compromises are made to develop the best solution for a given location (Shresta, Neskovic & Williams, 2009). Using the case study approach at Denver International Airport, Shresta, et al., (2009) developed an analytical model to analyze these compromises and determine the best solution given the constraints of a specific area. Taking a primarily environmental focus, the model evaluated differences in fuel burn with various combinations and modifications of OPD procedures in comparison to a baseline group of arrivals to derive best practices considering airspace limitations. This study extended the work of Favennec et al. (2009) into the vertical plane and evaluated a procedure where aircraft join the arrival from different cruise altitudes. While earlier research identified the elimination of level flight segments at lower altitudes as a contributing factor to fuel savings, Shresta et al. (2009) argued that the location of a level segment, preferably at higher altitudes, has the ability to capture a portion of fuel savings and emissions reduction. Deconfliction between arrivals and departures is generally accomplished by the use of altitude constraints on both the arrival and departure procedure necessitating a level flight segment in the design of one or both procedures. The results of this study show an arrival flown as an OPD has the potential to save 32.84 gallons of jet fuel compared to a baseline non-OPD procedure, and the elimination of a single level flight segment on an OPD results in saving 4.93 gallons of jet fuel or 15% of the fuel savings of the entire OPD procedure (Shresta et al., 2009).

Furthermore, the ability to tailor individual arrivals in response to airspace limitations to achieve some environmental and economic benefit removes the OPD from a rigid format to a flexible tool that delivers some benefit even when not used in its optimal form (Shresta et al., 2009). An example is provided by the JAGGR 3 RNAV arrival (Figure 4) and the EEONS 5 RNAV departure (Figure 5) at Denver International Airport (DEN). When approaching DEN via the JAGGR 3, the lower limit of the descent altitudes at OPREE and QWIKE is 11000 feet. At first glance, this may appear counterintuitive considering that the higher terrain of the Rocky Mountains is west of DEN and no significant terrain exists to the east. The EEONS 5 departure shows the maximum altitude at HIDEF, ROYYL, and KIDING when climbing via the EEONS 5 is 10000 feet, corresponding to the area beneath OPREE and QWIKE on the JAGGR 3 arrival. This design with a level flight segment provides vertical deconfliction between aircraft arriving and departing DEN from the east and southeast and enables simultaneous arrivals and departures separated by altitude. Shresta et al. (2009) allow OPD arrivals to be designed and evaluated to maximize benefits and minimize conflicts. In addition, OPD is scalable to a number of applications.

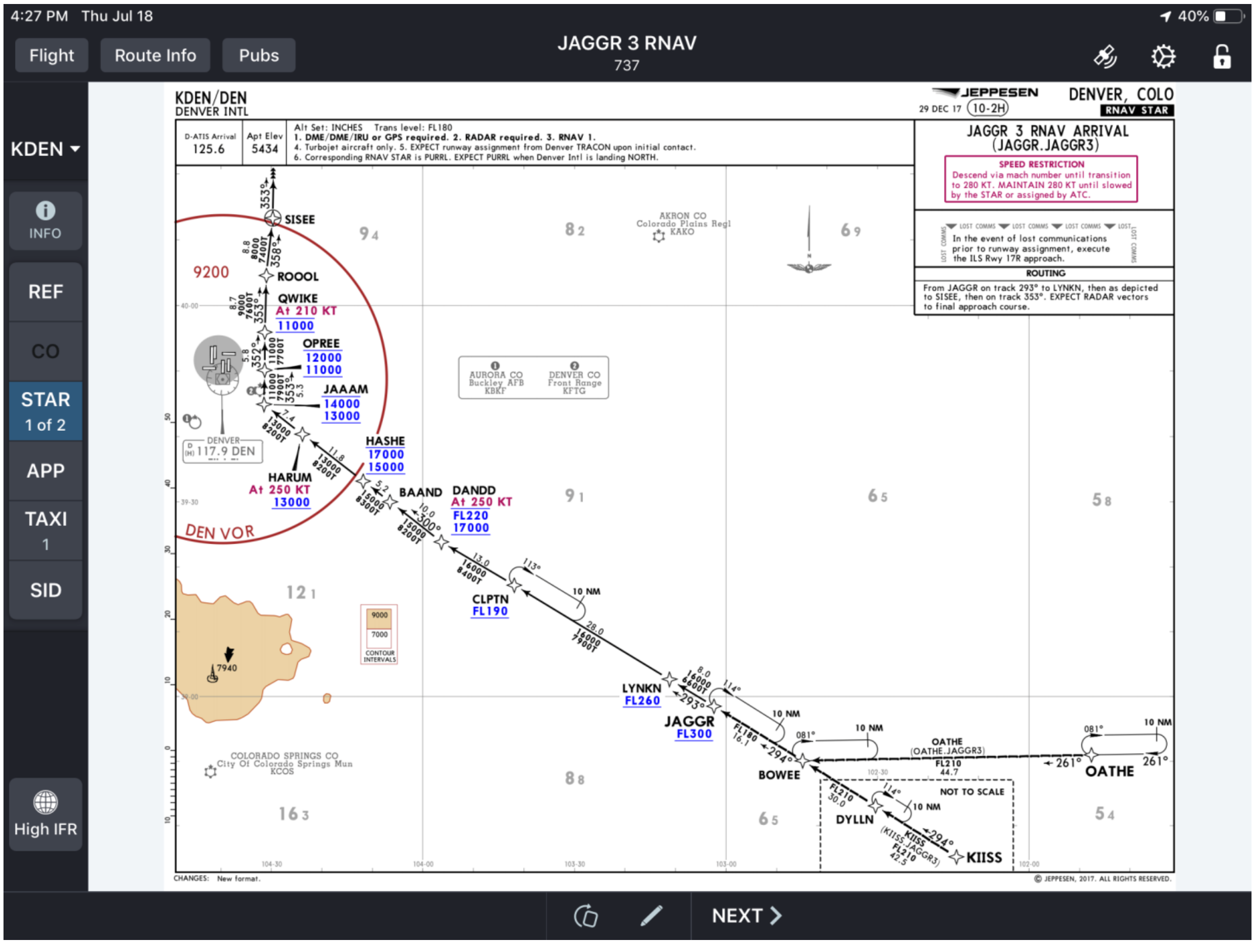

Figure 4. JAGGR 3 RNAV Arrival

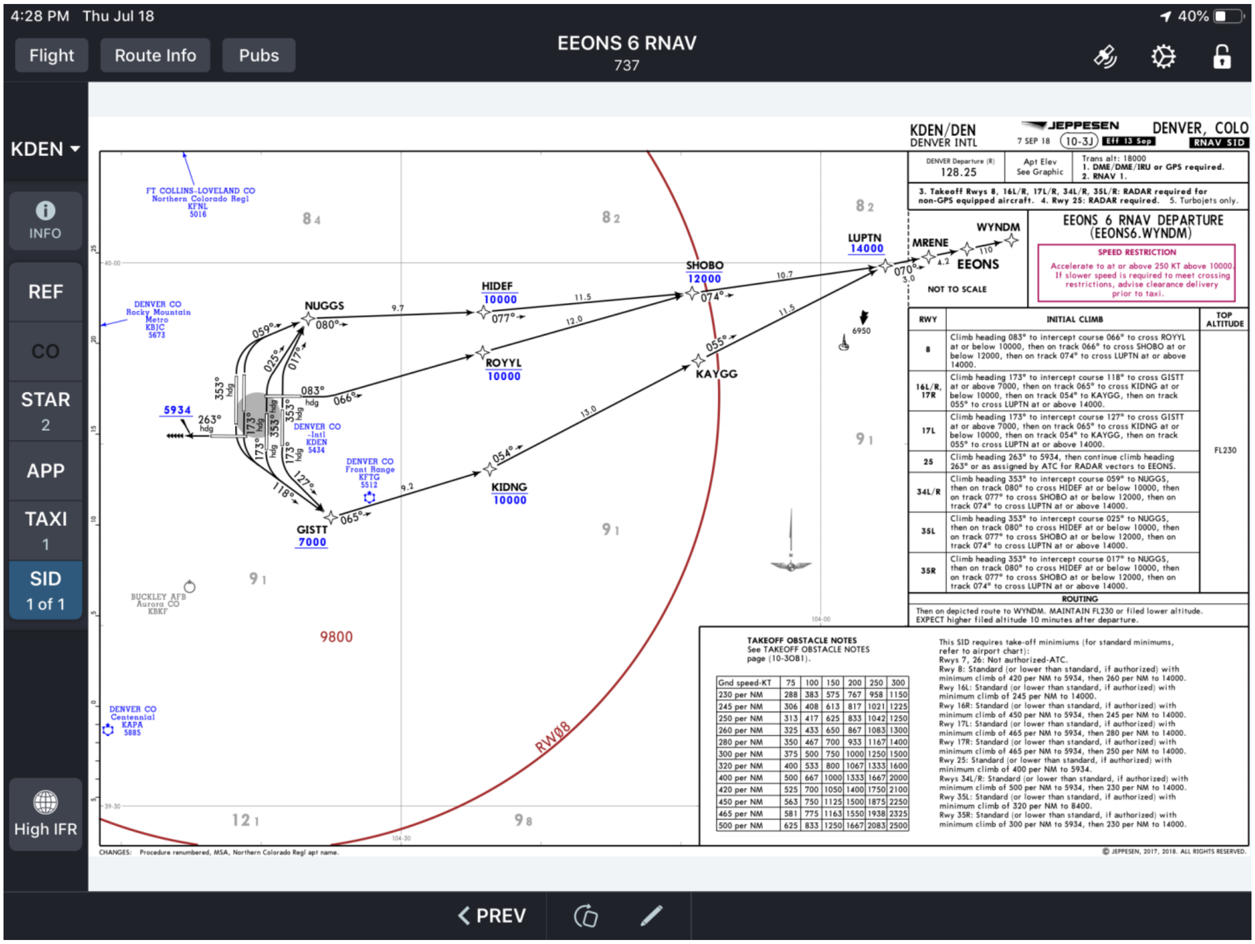

Figure 5. EEONS 6 RNAV Departure

Efficient Descent Advisor

The flexibility of tailored arrivals was tested with live traffic along with NASA's Efficient Descent Advisor (EDA) ground-based automated arrival scheduler in 2007 with the objectives of addressing controller workload in a high-density environment, executing an OPD to completion without ATC interruption, and continuing the OPD across several ATC sectors using a data-link clearance (Coppenbarger, Mead, & Sweet, 2009). The use of EDA was included in this study to increase the predictability of arriving traffic by relieving some of the scheduling workload of the controller, and reduce the need or perceived need to employ manual ATC sequencing techniques that negate the benefits of an OPD. The arrival schedule computed by

EDA was sent to the aircraft by CPDLC (controller pilot data link communication) in the form of a clearance, enhancing predictability by allowing downstream ATC sectors to anticipate and plan for arrival demand to continue an OPD through several sectors (Coppenbarger et al., 2009). EDA gives controllers the ability to meet time-based sequencing schedules that minimize conflicts, and its arrival schedule is compatible with RTA to further automate arrival sequencing and spacing. This study was conducted with oceanic traffic between Honolulu and San Francisco as CPDLC was not in use for US domestic traffic at the time (Coppenbarger et al., 2009). While it is not known if the findings of this study had any impact on the evaluation and eventual approval of CPDLC for domestic use in en route operations, they did demonstrate fuel, emissions, and noise reductions when compared to procedures in use at the time. CPDLC has the capability to load updated clearances, routings, and scheduled times of arrival (STA) directly into the FMC after verification by the flight crew which reduces pilot workload and potential error. The use of RTA with EDA would further increase the predictability and accuracy of delivering arrival traffic (Yoo et al., 2016).

Recognizing the need to deploy NextGen technology that is not dependent on data-link capability, Coppenbarger, Dyer, Hayashi, Lanier, Stell and Sweet (2010) continued to refine the Efficient Descent Advisor (EDA) seeking to facilitate uninterrupted OPD procedures in high-density terminal airspace by adjusting arrival traffic in the en route structure to comply with arrival schedules. EDA clearances can be delivered by voice, can be used in the current air traffic management system, and are fully data-link compatible when the capability exists (Coppenbarger et al., 2010). The global view of EDA informs controllers across several downstream sectors that the aircraft is on an EDA clearance providing a more global view as the flight progresses and replacing the limited view of individual sectorization. The addition of RTA would further enhance the accuracy of aircraft delivery to an upstream metering point and efficiently permit the adjustments needed in en route airspace to comply with TMA and EDA arrival schedules (Klooster et al., 2008).

Results of simulation and live traffic studies suggest that these efficiencies and accuracies are achievable with this technology, as 80% of arriving aircraft arrived at the meter fix within +/- 20 seconds of scheduled arrival time (STA; Coppenbarger et al., 2010). The main benefit is the information sharing between pilots and controllers throughout the entire trajectory once an EDA clearance is accepted. All sectors along the flight path know what the aircraft is doing, with known conflicts resolved when the EDA clearance is generated. Coppenbarger et al. (2010) report that controller workload was reduced by fewer manual maneuvering instructions needing to be issued, a 70% overall reduction of clearances in comparison with TMA-only automation, and a 95% reduction of maneuvering instructions in the inefficient low-altitude arrival structure.

Meyn et al. (2011) found that adding arrival fix crossing times to EDA with various levels of conflict resolution reduced the number of conflicts and led to a decreased number of controller interventions. The findings indicate the presence of a cascading effect that an ATC change to the meter fix arrival time of a single aircraft had the potential to increase the chance of conflict with the following aircraft (Meyn et al., 2011). Taking into consideration the effect of a single disruption of the arrival stream, the finding of an 80% reduction of predicted separation violations between arriving aircraft and an overall 50% reduction of all predicted separation violations simply by adding some level of EDA arrival advisory is significant (Meyn et al., 2011). The addition of RTA to maintain the arrival fix metering schedule would provide the benefits of increasing predictability and reducing controller workload.

One drawback to the addition of EDA was a reduction in situational awareness for controllers because EDA reaches an acceptable conflict resolution using different lateral paths instead of the linear in-trail format used in manual air traffic management (Coppenbarger et al., 2010). This makes the separation and conflict monitoring task more difficult by potential conflicts being more widespread geographically as opposed to concentrated along single arrival routes. A reduction in pilot workload after accepting an EDA clearance was reported due to the predictability of the arrival procedure and the ability of the FMS to comply with procedural restrictions. Overall, pilots could assume a greater role in conflict resolution and traffic separation with this decreased workload.

System Constraints

In 2020, further integration of NextGen components is limited by the absence of ADS-B data link capability and the increasing human workload constraints of the air traffic management system (Swenson et al., 2011). The increased surveillance accuracy due to the rapid update rate of ADS-B allows for a reduction in minimum required separation between aircraft, increasing both the capacity of the runway and airport throughput (Swenson et al., 2011). ADS-B is the enabling component needed for automated flight deck interval management (FIM) systems which maintain inter-aircraft spacing once the aircraft has entered terminal airspace (Coppenbarger et al., 2009). The use of RTA would maintain the TMA schedule, perform adjustments in the more efficient en route phase of flight, provide a more accurate delivery of arriving aircraft at the terminal airspace boundary, and reduce conflicts at merge points when aircraft are arriving via different routings (Favennec et al. 2009; Klooster et al., 2008; Yoo et al., 2016). The lack of these automated tools has begun to make controller workload a limiting factor when considering arrival rates and airport capacity. Research by EUROCONTROL has demonstrated that NextGen benefits are achievable with a parallel reduction in controller workload in European airspace where the use of air traffic management automation is more mature (Callantine, Kupfer, Martin & Prevot, 2013). The redistribution of workload between the en route and terminal sectors also enhances information sharing, permitting a more proactive automated approach to sequencing arrival traffic, in contrast to the reactive manual approach at congested waypoints requiring inefficient holding and vectoring (Callantine et al., 2013). While controllers in this simulation study found FIM automated operations more complex, they also realized an overall reduction in workload due to the increased use of automation (Callantine et al., 2013).

Economic Benefits

The economic costs of not having an integrated NextGen system are substantial, considering that 86% of the cost savings from OPD operations are derived from spacing, and 14% are realized from sequencing capabilities such as RTA (Chen & Solak, 2015). Airlines generally focus on economic savings such as lower fuel burn and reduction of time on the airframe and associated maintenance, but the pursuit of these operational efficiencies also results in the accrual of environmental benefits (Chen & Solak, 2015). The application of linear programming and arrival scheduling methodologies from operations management form a logical framework for the analysis of the benefits and limitations of OPD operations, and "... implies that an airline-centric approach in improving OPD operations is not in conflict with objectives that might be prioritized by other stakeholders" (Chen & Solak, 2015, p. 405). Metering points along the arrival become decision points where uncertainties (errors) in conforming to the arrival (production) schedule may be rectified; the objective being to minimize the total cost of all maneuvers during the entire descent and maximizing use of available runway capacity (Chen & Solak, 2015). The fuel savings found in this study are consistent with Porter (2006) and

Coppenbarger et al. (2012) when OPD is in use, but have an additional environmental benefit of primarily reduced emissions of 13-16% of total cost savings (Chen & Solak, 2015). By the airlines concentrating on minimizing fuel burn from a pure operational cost perspective, these actions will reduce environmental costs as well in synergy with NextGen goals.

Air Traffic Flow Management

The predictable flow of air traffic has been the topic of considerable study prior to the development of the NextGen concept, but NextGen objectives of airspace capacity increase, fuel burn reduction, and environmental responsibility have made this area increasingly prominent (U.S. DOT, 2004). The ability to leverage technology in the achievement of these objectives was envisioned well before the technology itself even existed in a reliable form (Billings, 1997). Erzberger and Tobias (1986) were among the first to identify the importance of time in the management of air traffic flow, adding time to the traditional three-dimensional (3D) view of horizontal, vertical, and speed to propose the four-dimensional (4D) trajectory. Their work used the common factor of time to increase the predictable delivery of air traffic to the terminal area boundary and argued that this common factor had the ability to accommodate both automated and relatively non-automated aircraft into the flow. Ultimately, the increased certainty would produce more accurate arrival scheduling, permitting a reduction of minimum safe separation parameters between aircraft and increase capacity. Since the concept of uncertainty directly affects the amount of aircraft separation required, an increase in uncertainty requires an increase in spacing (Erzberger & Tobias, 1986). Loss of the minimum required spacing has the potential to trigger an intervention by air traffic control to regain safe separation criteria Erzberger & Tobias, 1986; FAA, 2015). Increased accuracy also has the ability to reduce the lateral flight path due to a decreased need to vector an aircraft off course to regain safe separation parameters, an important consideration when avoiding noise-sensitive areas (Erzberger & Tobias, 1986). This early work also recognized the utilization of some type of data link system, such as ADS-B which would enable the use of aircraft-based inter-aircraft spacing methods to further reduce the need for ATC intervention. These ideas are the early conceptual framework for the RTA function of the FMS which uses time to arrive at a waypoint serving the terminal area (Erzberger & Tobias, 1986).

The discussion of time-based air traffic management before the technology and automation were mature enough to support it is a foundational step in the automation of air traffic management. Notably, in 2020, while the majority of the technology envisioned by the authors is installed in the majority of commercial transport aircraft, it is not being used in the U.S. National Airspace System; however, it is in use in Europe and for trans-oceanic international operations (Coppenbarger, et al., 2009; FAA, 2018). This early work shows that a 4D trajectory increases the arrival rate and accuracy of arrival scheduling into the terminal area (Erzberger & Tobias, 1986), and its foundational role was validated by Klooster, Wichman and Bleeker (2008).

The capacity restraints presented by a relatively finite number of airports and runways are further constrained by capacity limitations within en route airspace sectors that are of a more unpredictable and mobile nature, notably weather. The need to reroute air traffic around areas of weather can produce congestion along a given route segment and lead to delays. The importance of sharing information between the airlines and the air traffic management entity leads to cooperation, mitigation of delays, and a reduction in the costs of delays (Bertsimas & Patterson, 2000). The authors propose the air traffic system as a dynamic network and examine capacity allocation functions dealing with airborne traffic and the system effects of introducing additional traffic. This network view coupled with delay minimization and information sharing, have direct economic benefits to airspace users of decreased delay costs (Bertsimas & Patterson, 2000). They present one of the first proposals for cooperation between airspace managers and airspace users, and report benefits that accrue from that cooperation. The flexibility and cooperation are beginning to take shape with the FAA En Route Automation Modernization (ERAM) platform that also provides the substructure for the deployment of additional automated NextGen features (FAA, 2018).

Centralized Control Sub-Optimal

Centralized control and human factors limitations impede the ability of the air traffic management system to address capacity issues in a timely and effective manner. Isolated delays in one part of the system have the potential to produce larger delays affecting a wider area. The centralized control structure renders itself incapable of timely adaptation and recovery when the system does not operate as it is designed and needs a mechanism for local and regional air traffic managers to take charge of the situation. Free Flight, the ability of an aircraft to choose its own paths and trajectories with few restrictions, "... offers the most potential in terms of optimizing flow," but "... also provides the most radical departure from the current system" (Tumer & Agogino, 2008, p. 1). Within the context of implementation and political obstacles, the authors propose an agent-based system featuring local control. There would continue to be a framework of operational concepts and policies in which these local agents would operate, but they would be freer to manage the flow of air traffic as local conditions dictate and integrate it with a global view of their area’s effect on the entire system.

Germane to this discussion is the role of the individual air traffic controller as both an enabling entity with the ability to make nimble decisions which benefit the local airspace, and as a limiting entity with respect to sector capacity and the downstream effects of local decision-making in subsequent sectors. Without coordination, there is no increase in predictability, and the ability to plan beyond a limited time horizon is lost (Tumer & Agogino, 2008). One of the inputs that determine sector capacity is the number of controllers assigned to that sector, and as workload increases, some type of metering mechanism is employed to return the capacity-constrained sector to a balanced state (Tumer & Agogino, 2008). While there are benefits that accrue with this type of agent-based concept and its adaptability and flexibility (Tumer & Agogino, 2008), it would need to be integrated with other components and automation to fully realize its benefits.

Time-Based Sequencing

Time is an increasingly significant factor in the evolution toward more automation and achieving the goals of the *Integrated Plan* (U.S. DOT, 2004). Using time in a 4D trajectory as described by Erzberger and Tobias (1986) and Klooster et al. (2008), increases predictability and reduces uncertainty, providing enhanced safety and accuracy for the construction of aircraft flow and arrival schedules. Scheduling air traffic flow in a time-based manner and delegating a portion of the responsibility for aircraft separation to the aircraft will reduce both complexity and controller workload, delivering a predictable stream of traffic to the terminal area. This predictable stream will also identify potential conflict areas and congestion points within the 24-hour traffic cycle, allowing air traffic managers an earlier opportunity to proactively reconfigure airspace and redistribute complexity. The overall result is reduced complexity, increased predictability, and a longer time horizon for overall system planning (Prandini et al., 2011).

Time as a sequencing and separation method was tested by Hayashi, Coppenbarger, Sweet, Nagle and Dyer in 2011 with EDA. The emphasis of their study was to attain sequence and separation in the en route (strategic) phase of flight by adding an altitude change capability for conflict resolution. This vertical component would reduce the need for tactical intervention within the TRACON and reduce controller workload (Hayashi et al., 2011). An altitude feature allows an additional capability for conflict resolution other than lateral vectoring, using less congested altitudes for conflict resolution and maintaining a lateral course. Sequencing traffic in the en route environment has the additional benefits of permitting modifications to the flight trajectory during a period of reduced workload for both pilots and controllers, enabling the FMC sufficient time to update and reduce the chance of errors being made in programming. During simulation testing, 93% of the flights arrived at the TRACON meter fix within +/- 20 seconds of the scheduled arrival time and controllers found the altitude option for conflict resolution useful in the highest traffic scenario containing the greatest number of conflicts (Hayashi et al., 2011). Examined in the context of the crossing time parameters used by Yoo et al. (2016) in their study of RTA, +/- 60 seconds being the target goal and +/- 300 seconds being the marginal goal, the delivery accuracy demonstrated by Hayashi et al. (2011) is compelling. Some of the aircraft that did not meet the +/- 20 second window at the TRACON boundary missed it due to a manual ATC intervention involving a change in speed or lateral track prior to this point (Hayashi et al., 2011).

Coordinating the en route and terminal scheduling, merging, and spacing functions is important to realizing the benefits of NextGen. In the NextGen short phase, research concepts and procedures were studied individually to determine their applicability and feasibility, often overlooking a synergistic systems approach (U.S. DOT, 2004; FAA, 2018). The Terminal Area Precision Scheduling and Spacing (TAPSS) system takes the next step in integration by synchronizing the terminal and en route air traffic management environments to maximize synergies (Swenson et al., 2011). Although EDA was being developed concurrently at this point and not yet in its final form, Swenson et al. (2011) inserted it as the en route component of the TAPSS system. Beginning with maximizing capacity at the runway threshold, the TAPSS system aligns the various scheduling and spacing functions allowing for an OPD arrival into the terminal area using a 4D trajectory beginning in the en route airspace structure (Klooster et al., 2008). This seamless methodology promotes information sharing across air traffic management sectors as the aircraft travels a predictable flight path and schedule, minimizing the need to interrupt the arrival except for unknown traffic posing a separation hazard. The benefits of TAPSS are available without the increased surveillance accuracy and data link capability of ADS-B, but separation criteria may be further reduced, and runway capacity increased with its use. Intelligent Approach, an ATC terminal aircraft spacing tool in use at London Heathrow Airport since 2015, employs this approach and is being deployed to Toronto Pearson Airport (International Airport Review, 2019). ADS-B would also enable the use of automated inter-aircraft spacing tools to preserve arrival spacing intervals to the runway. The study found that TAPSS was able to increase runway throughput by 10% in simulation, distributed delays more evenly between the en route and terminal structures, and proved to be as safe as manual air traffic management techniques when measured against baseline separation violations (Swenson et al. 2011).

The EDA was further refined by simulation and released to the FAA for transition to operational deployment in 2012 (Coppenbarger, Hayashi, Nagle, Sweet & Salcido, 2012) incorporating enhancements over earlier versions (Coppenbarger et al., 2010). The authors emphasize the importance of accurate sequencing in the en route phase to perform OPD arrivals on a continuous basis and cite the present absence of additional automated tools to comply with the arrival schedule produced by the TMA. Required Time of Arrival (RTA) is the tool to maintain this schedule. By using EDA for all arriving aircraft in compliance with the TMA schedule, a reduction in potential conflicts is realized, and all aircraft benefit from this safety and efficiency because EDA is both voice and data link compatible. The results indicated a reduction in workload for both pilots and controllers, a 92% increase in the accuracy with which aircraft arrived at the terminal area boundary, a 60% reduction in ATC maneuvering instructions to maintain separation, and a reduction in fuel burn of 110 pounds (16.42 gallons) per flight (Coppenbarger et al., 2012; Porter, 2006). Considering the price of North American jet fuel in 2018, the findings of Coppenbarger et al. (2012) represent a savings of $34.37 per flight (IATA, 2018) when using EDA to coordinate an OPD arrival, a 9.3% improvement from Porter (2006). Applied to the earlier Southwest Airlines example, this represents a daily savings of $68,740, and annual savings of $25.1 million in fuel costs to a single airline when using EDA with OPD. Environmental and airport capacity benefits would be in addition to these fuel savings.

Research by Hayashi et al. (2011) illustrates the incompatibility between automated NextGen concepts and manual ATC procedures that reduce predictability and increase uncertainty. The authors designed their study to determine if an automated time-based method such as RTA has the ability to splice the time-based flow schedules produced by TFMS and TBFM. Newark Liberty Airport (EWR) was chosen for this study, as it continues to be one of the most delay-prone airports in the U.S. National Airspace System (FAA, 2019; Hayashi et al., 2011), and a mix of pre-departure and airborne aircraft was given crossing times (CT) for entry into the TBFM airspace. The objective is to determine the effects of pre-departure errors (not making scheduled takeoff time) and wind effects to determine if RTA is capable of mitigating these errors and delivering the arrival within its assigned time. The tolerances for CT arrival performance were set at +/- 60 seconds for the target and +/- 300 seconds for the marginal target. Wind conditions and wind forecasts did not have a large effect on CT and accuracy was improved with RTA; aircraft meeting their target times was primarily dependent on departing within +/- 5 minutes of their assigned departure time. Furthermore, 34% of non-RTA aircraft met their target CT and 76% met their marginal CT, while 67% of RTA aircraft met their target CT and 89% met their marginal CT. To provide context, in 2019, the non-RTA environment in the United States delivered only 34% of arriving aircraft within +/- 1 minute of scheduled crossing time, and 76% within +/- 5 minutes of scheduled crossing time. With the use of RTA, 67% arrived within +/- 1 minute of schedule (a 97% improvement) and 89% arrived within +/- 5 minutes (a 17% improvement). The increased accuracy of RTA improved flow scheduling through increased predictability and reduced uncertainty, maintaining the integrity of arrival schedules over longer time periods (Yoo et al., 2016).

One of the seminal studies relating time to air traffic flow management was conducted by Yoo et al. (2016) to investigate the use of RTA to meet TRACON boundary crossing times and increase certainty in the arrival stream. RTA is proposed as the time-based link between the strategic (en route) phase and the tactical (terminal) phase that increases accuracy by synchronizing arriving traffic and terminal area capacity (Klooster et al., 2008). Current methods use the Traffic Flow Management System (TFMS) to assign departure times that deliver aircraft to a downstream location at a scheduled time. Once airborne, these aircraft are currently metered manually by a miles in trail spacing scheme, withdrawing them from the TFMS arrival schedule. This disrupts their planned arrival time into the tactical Time-Based Flow Management (TBFM) system. RTA is the proposed automated bridge between these two functions which eliminates the inaccuracies and uncertainty of manual intervention and maintains the TFMS schedule. The linking of these systems with RTA is known as Integrated Demand Management [IDM] (Yoo et al., 2016).

Incompatibility of Techniques

Hayashi et al. (2011) describe the incompatibility between automated NextGen concepts and manual ATC procedures that disrupt arrival schedules. The authors designed their study to determine if an automated time-based method (RTA) has the ability to meld the flow schedules produced by TFMS and TBFM. Not only do arrival aircraft entering the terminal area need to be considered but also aircraft departing the terminal area that effect the airport acceptance rate and terminal area airspace capacity. Kistan, Garda, Sabatini, Ramasamy and Batuwangala (2017) state that airports are one of the most limited resources within the National Airspace System and one of the main delay sources. In addition, the authors state that synchronization of the arrival and departure flows in and out of an airport represents one of the most effective ways of increasing airport acceptance rates and terminal airspace capacity (Kistan et al., 2017). One of the primary benefits of RTA is its ability to deliver inbound traffic to the terminal boundary in a predictable manner, allowing precise scheduling of departures reducing arrival and departure conflict. In the same manner as arrivals, departures are sequenced into the en route structure by time to ensure adequate separation as they enter the en route stream. A global perspective is needed to facilitate coordination and information sharing, comply with international standards for new or updated air traffic management capabilities, compatibility with neighboring systems, and increased use of automation to reduce uncertainty and variability as the human operator becomes more of a limiting factor as airspace capacity is increased (Kistan et al., 2017).

In addition to increasing the accuracy of arrival and departure scheduling, traffic de-confliction remains a prominent concern (U.S. DOT, 2004). Also, the separation of flight paths and the spacing of individual aircraft continue to be a source of air traffic control interruption of automated flight trajectories. Bongiorno, Micciche and Mantegna (2017) developed an agent-based model to examine the interactions between air traffic control and individual aircraft with the objective of minimizing conflicts, reducing interruptions of planned flight trajectories, and increasing efficiencies through more direct flight paths. The authors list two main underlying reasons for conflict: (1) the flight was not planned with enough detail to consider potential conflicts between flight trajectories, or (2) there was an unplanned event requiring modification of the flight plan. Overall, flexible airspace configurations and increased freedom for air traffic managers to apply innovative delay mitigation strategies would allow for proactive solutions that minimize planned trajectory interruption. According to Bongiorno et al. (2017), one disadvantage of a more flexible airspace structure is that conflicts within the system will be more dispersed geographically. When the model was applied to archival Italian traffic data, it found a reduction in conflicts as the number of direct clearances increased (Bongiorno et al., 2017).

Application to the Methodology

Very minimal literature reporting findings that detail the air traffic management system in its current form after the operational deployment of some NextGen capabilities exists. The potential negative unintended consequences of NextGen being deployed and operated in a non-integrated manner introduce the possibility that safety issues are present that do not lend themselves to detection by traditional analytical methods. The increase in altitude deviations corresponding to the beginning of the NextGen mid-phase may be one of these consequences. The failure of the altitude deviation rate to return to a historically normal level described in the literature following a period of familiarization by both pilots and controllers is problematic. Chapter 3 details the analytical method used to determine the effect of air traffic control intervention on altitude deviations reported during optimized profile descent procedures in the U.S. National Airspace System from January 1, 2012, to January 1, 2018.

CHAPTER 3: METHODOLOGY

The purpose of this research was to determine the effect of air traffic control intervention on altitude deviations reported during optimized profile descent arrival procedures in the U.S. National Airspace System from January 1, 2012, to January 1, 2018. The hypothesis of this study is that there is a positive relationship between altitude deviations and air traffic control intervention on an OPD and that air traffic control intervention will display large positive correlations with the other independent variables related to altitude deviations. The dependent variable in this study is altitude deviation; the independent variables are air traffic control intervention, aircrew error, collision avoidance, communication error, equipment malfunction or limitation, other, terrain avoidance, and weather. This chapter describes the philosophical approach of the study, study participants, and data collection and analysis methods used to address the research question.

Theoretical Approach to the Method

This was an exploratory sequential mixed-methods study following the construct of qualitative-quantitative-interpretation with regard to the research question (Creswell, 2014). An exploratory sequential design was appropriate for this research due to the details of a specific altitude deviation event being contained in the textual narrative report of that event. The themes that exist within that qualitative narrative were identified and coded into one of the eight independent variables. This coding process produced numeric variables for statistical analysis that revealed relationships and patterns existing between the independent variables. Landrum and Garza (2015) refer to this process as quantification. The exploratory sequential approach also cataloged themes within each independent variable during the qualitative coding process, and these themes were reexamined during the interpretive step to confirm or refute the quantitative results (Maxwell, 2010). Given that the research question sought to identify the effects of air traffic control intervention on altitude deviations reported on OPD arrivals, the relationships between the independent variables were desired as opposed to the determination of a specific causal factor. The exploration of these relationships and patterns indicated the use of a mixed-methods approach with its increased depth of understanding and analytic density (Fielding, 2012; Flick, 2007). The real quantitative/qualitative distinction is not between number and text but between understanding the world by a theory of process in terms of events and interactions (Fielding, 2012; Maxwell, 2010). This leverages the analytic density of a mixed-methods approach where qualitative analysis reveals thematic patterns in the data, and quantitative analysis uncovers relationships between the variables (Fielding, 2012; Flick, 2007).

Furthermore, the concept of triangulation provided the justification for the use of mixed-methods research and the integration of both qualitative and quantitative data that has the ability to provide a more thorough and contextual explanatory framework (Mertens & Hesse-Biber, 2012). The examination of a single phenomenon, in this case, altitude deviations, from both the qualitative and quantitative perspectives of a mixed-methods study used the combined strengths of each method while reducing their biases and limitations (Creswell, 2014). Due to some overlap of methods in a mixed-methods study, triangulation enables the "… accuracy of each method to be validated to some extent by the other" (Kennedy, 2009, p. 2). The stated biases of the data used in this study (NASA, 1996) was another important consideration for the mixed-methods procedure, as triangulation tends to decrease bias and provide a more balanced analytical tool than a single method (Creswell, 2014).

Narrative Analysis. The qualitative portion of the study employed the narrative analysis method. Each qualitative narrative found in either the ASRS and ASAP data described an altitude deviation, was reported during the study's timeframe, and was submitted via one of two different data collection vehicles. Denzin (2012) argues that all qualitative research utilizes multiple methods and that the original concept of triangulation involved the use of more than one qualitative method for analysis instead of a combination of qualitative and quantitative methods. However, the exploratory sequential flow from qualitative to quantitative then reintroducing qualitative during interpretation to support or refute the quantitative findings give this dissertation convergent validation and analytic density (Denzin, 2010; Fielding, 2012).

By using the narrative portion of the ASRS and ASAP reports, the reporter was describing the altitude deviation event as one who experienced it and attempted to assign meaning to it by recounting relevant factors involved in its occurrence (Cohen & Crabtree, 2006). The narrative analytical structure used employed the methodology of Rogan and de Kock (2005) because of its synergy with the ASRS and ASAP data products and their presentation. Rogan and de Kock (2005) advocate a three-level analytical flow: performance, structural, and literary analysis. The performance level requests information by the "... solicitation of specific narrator experiences" (Rogan & de Kock, 2005, p. 632) and "... asking directly for information" (Rogan & de Kock, 2005, p. 632) which is the function of both the ASRS and ASAP reporting systems. During this step, the altitude deviation on OPD arrival theme was identified and the case was either included or excluded from the dataset that was used for further analysis. During the structural level, the narrative was examined for additional contextual information and "... probed for a deeper interpretation of meaning through rich thick evidential detail (Lincoln & Guba, 1985; Rogan & de Kock, 2005). This step identified a primary theme within the narrative that the reporter indicated had the greatest effect on the altitude deviation event. The literary level takes more of a holistic view of the narrative by looking at how the story is connected, and

"...evidence for interpretation in the stories was also sought by examining the literary convention of plot ... and the narrator's connecting logic of the sequence of events" (Rogan & de Kock, 2005, p. 641-642). The literary step took the evidence contained in the narrative context and allowed it to be interpreted with regard to a primary theme and coded into one of the independent variables identified from the Chapter 2 literature (Buono, 2014; Flight Safety, 2000; IATA, 2016; Margison, 2014). For the study period January 1, 2012, to January 1, 2018, 1156 ASRS and 1819 ASAP reports were subject to narrative analysis.

Correlation Analysis. The exploration of significant relationships between variables was performed by quantitative correlation analysis to determine their effect on altitude deviations (Field, 2013). Correlation analysis portrayed the relationships between variables and measured the magnitude of effects vice pinpointing the presence of a specific causal factor. The purpose of this study was to determine the effect of air traffic control intervention on altitude deviations reported during optimized profile descent arrival procedures in the U.S. National Airspace System from January 1, 2012, to January 1, 2018. This approach identified the interaction patterns present between altitude deviation variables identified in the literature (Buono, 2014; Flight Safety, 2000; IATA, 2016; Margison, 2014) and present in the data that highlighted contributing themes in reported altitude deviations. This quantitative method was useful in depicting not only the role of main contributors to altitude deviations but also their actions in concert producing combined effects. The archival data analysis strategy of Johnston (2014) was used due to the data being collected for aviation safety purposes prior to this study. Altitude deviations comprised a subset of these data and the ability to filter it for cases of OPD altitude deviations made it applicable to this research.

The correlation approach was used for this study because the data represented direct observation, user-reported events occurring in the U.S. National Airspace System that were not available for experimental manipulation for safety reasons, nor was the researcher present to influence results (Field, 2013). Both ASRS and ASAP reports "… are voluntarily submitted and are not obtained through a statistically valid sampling process" (NASA, 1996, p. 1). The data derived from these reports generally described a sequence of events leading to the safety issue being reported and were subject to self-reporting bias (Field, 2013; NASA, 1996). While this bias limited the generalizability of ASRS data, as does the disproportionately large number of reports received from pilots, the ASRS system states with certainty that its data represents the "… lower-bound estimates of the frequencies at which various types of aviation safety events actually occur" (NASA, 1996, p. 1). ASAP reports were subject to the same sources of bias but were also used for statistical trend analysis with a collection tool outlined by FAA regulation (FAA, 2002, 2009). The ASAP collection tool is similar to the ASRS reporting tool but collects additional information deemed useful to a specific airline's operation (FAA, 2002, 2009). This supplies contextual demographic data to the airline Event Review Committee for the report's formal regulatory review and creates generalizable statistical aviation safety trends applicable to a specific airline's operation (FAA, 2002, 2009).

Link to Systems Theory. The nominal nature of ASRS and ASAP self-reported data supported the Systems Theory approach to the analysis of altitude deviations, and it was assumed that there were correlations between variables. The narrative portion of a report was a textual description of the event being submitted. Non-narrative information contained in a report was primarily for classification purposes cataloging items such as date and time, location, aircraft type, and OPD procedure in use.

As stated in the Safety section of Chapter 2, altitude deviations have the potential to be a leading safety indicator in the context of this study (Leveson, 2015). Report narratives detailed the combination (if any) of factors present that contributed to the reported event and generally did not indicate the failure of a single system component as causing the deviation as is the case with traditional reliability theory (Fleming et al., 2013; Leveson, 2015). The correlation analysis method did not address the causal nature of a single variable or a combination of variables; rather, it described the strength of effect a variable contributed to the relationship (Field, 2013). An example of the type of positive correlation present in the data is the case of an aircraft that is vectored off an OPD then cleared to resume the arrival. The aircrew makes an error reprogramming the FMC resulting in an altitude deviation. The triggering event is the ATC intervention that led to the need to reprogram the FMC by the aircrew. In this example, a positive correlation between air traffic control intervention and aircrew error will be observed. By gaining a clearer understanding of these types of correlations, it is possible to determine how these interactions relate to the altitude deviations being studied.

Rationale for the mixed-methods approach. Due to the primarily textual format of both ASRS and ASAP sources, a mixed-methods approach produced a richer comprehension of the relationships present in the data and attempted to achieve convergent validation (Denzin, 2010). Narrative reports contain themes that allow for "... performing numerical analysis based on frequency of themes", the process of quantification (Landrum & Garza, 2015), and the addressing of relationships (Fielding, 2012; Maxwell, 2010). The mixed-methods approach used in this study was complimentary, not comparative, meaning that the methods supported each other (Landrum et al., 2015) and spoke to the value of triangulation (Creswell, 2014). Leveraging the strengths of each method, a complimentary procedure was applied that quantifies frequencies to create variables for statistical analysis but also relies on the narrative themes to gain a more thorough understanding of the correlations between variables (Landrum et al., 2015). This depth of understanding will provide a clearer picture of the National Airspace System as it currently operates, and if air traffic control intervention had an effect on reported OPD altitude deviations.

Participants

Participants in this study were U.S. FAR 121 airline pilots reporting through two aviation safety reporting systems during the period January 1, 2012, to January 1, 2018. This time period marked the beginning of the NextGen mid-phase to early 2018 when many of the conceptual procedures developed in the short phase 2004-2012 were deployed for operational use (Houston, 2017). The use of pilot-generated reports provides direct observation of the National Airspace System as it is currently used, and issues present in the system in its present form. NASA Aviation Safety Reporting System (ASRS) reports are publicly-available aviation safety reports presented in a de-identified format which protects the anonymity of the reporter. The ASRS group contains reports representing a random cross-section of aircraft types and fight management (FMC) systems, as well as different aircraft performance characteristics. NASA cautions the user of ASRS data with regard to the generalization of findings for several reasons: several reports may be combined to provide a more complete narrative of the event; data are not obtained through a statistically valid sampling process and are subject to self-reporting bias; not all cases may be included for a given time period, and pilot reports comprise the majority of ASRS reports (NASA, 1996). Appendix A shows the ASRS form used to submit an ASRS safety report. ASAP data used in this study represent a single aircraft type and flight management system, with minor differences in aircraft performance according to model. While there are no stated limitations on the generalizability of findings with the ASAP data, it is subject to the same sources of bias as the ASRS data, primarily self-reporting bias (NASA, 1996). These sources of bias are presented in greater detail later in this chapter.

Data Collection

The time period covered by the data corresponds to the NextGen mid-phase when many of the concepts developed during the short phase were put into operational use. The data comprised altitude deviations reported on OPD arrivals submitted to aviation safety reporting systems. Due to the confidential nature of these two reporting systems, any demographic information that may even tangentially identify the reporter or the reporter's air carrier has been removed prior to any public availability (FAA, 2002; NASA, 2019). In the case of the ASAP data provided by Airline A, any identifying demographic details were removed prior to the Event Review Process conducted by the airline and before its submission to the NASA ASRS database (FAA, 2002). ASRS data were collected from the public ASRS database on January 2, 2018, with the assistance of the ASRS Database Administrator. The search criteria included the time period, altitude deviation, OPD procedure, and FAR 121 air carrier status, yielding 1186 reports for initial narrative analysis. ASAP data were provided by Airline A on April 24, 2018, by an Airline A ASAP Safety Analyst and Database Administrator. This researcher did not have direct access to the ASAP database. The first three search criteria were used as in the ASRS search since Airline A is an FAR 121 air carrier and all reports from this source meet this condition. The ASAP search provided 1819 reports for narrative analysis. Data from both sources were stored on an external memory stick for this project and only loaded onto the researcher’s desktop computer for use in the qualitative (NVivo 12) and quantitative (SPSS 24) software applications.

During the qualitative coding process, a reasonable effort was made to eliminate data overlap between the ASRS and ASAP datasets. This was done by removing cases from the

ASRS data set that reported an altitude deviation involving an aircraft model flown by Airline A at an airport served by Airline A. ASRS cases that reported an altitude deviation at an airport served by Airline A but involving an aircraft model not flown by Airline A were included, as were cases involving an aircraft model flown by Airline A but at an airport not served by Airline A. This process was made more challenging by the de-identified nature of ASAP reports and the removal of any information identifying the airline involved.

ASRS Reports

When an ASRS report is submitted, it is read by a minimum of two analysts (Wood, 2019, p. 4). Their first priority is to ascertain if a report contains an immediate aviation safety hazard and report it to the proper aviation regulatory authority in a de-identified format. The second priority is to diagnose the event and determine any thematic factors and classify the report according to the type of event. The observations of the analyst along with the original de-identified report are then uploaded into the ASRS database (NASA, 2019). During the second step, reports may be combined by the analysts to create a more comprehensive presentation of the event for the ASRS user. The backgrounds of ASRS analysts include over 600 years of combined aviation experience, combined flight time exceeding 175,000 hours in 90 different aircraft types, and include air carrier, corporate, military, general aviation, air traffic control, and aviation maintenance specialties (NASA, 2019).

There is no formal regulatory review of an ASRS report by the NTSB or FAA unless it has come from an airline's ASAP program. Since one of the screening criteria used when the ASRS data was originally obtained from the ASRS Database Administrator was an altitude deviation reported on an OPD by a U.S. FAR 121 air carrier, all ASRS reports used in this study are from FAR 121 air carrier pilots and have a 70-80% probability (Wood, 2019) that they have undergone a formal regulatory review.

ASAP Reports

The second group, Aviation Safety Action Program reports from a US major airline (Airline A), was comprised of proprietary information. This data was obtained from Airline A by the execution of a non-disclosure agreement (NDA) between the airline and this researcher due to its confidential nature. The non-disclosure agreement required that all reasonable steps were taken to protect the identity of the airline, not disclose specific dates and times of reported events that could lead to identification of a specific flight, secure the data from disclosure on any public platforms, and submit the final report to Airline A for review prior to any publication or presentation. The specific steps taken to shield the data from public disclosure other than those outlined in the NDA included storage of the data on a removable memory stick, only loading the data on to the researcher's desktop personal computer (PC) for analysis by the NVivo 12 and SPSS 24 analytical programs, the removal of the data from these programs and the researcher's desktop computer at the completion of the analysis, and the storage of printed output from these analytical programs in a locked fireproof file cabinet. These terms were agreed to in exchange for access to the de-identified data on February 27, 2018.

ASAP data used in this study represented a single aircraft type and flight management system, with minor differences in aircraft performance according to model. While there are no stated limitations on the generalizability of findings with the ASAP data, it is subject to the same sources of bias as the ASRS data, primarily self-reporting bias (NASA, 1996). When an ASAP report is submitted, it is assigned a date and time and checked to ensure that it meets the reporting criteria for acceptance into ASAP according to FAA regulation. ASAP acceptance criteria include timeliness of submission generally within 24 hours of being aware of the possible violation or as defined by the Memorandum of Understanding, the violation was inadvertent and not intentional, and the violation did not involve criminal activity, alcohol, or drugs (FAA, 2002). During this time, the report is assigned to the Event Review agenda and investigated by members of the ASAP staff. In addition, the reporting entity may be contacted during this investigative period for further amplifying information. The report is then de-identified before it is presented and reviewed by the Event Review Committee (ERC) which consists of a representative from the airline, the regulatory body (FAA), and the applicable labor group (union). ERC members should be "… highly experienced personnel … empowered to make decisions within the context of the ERC discussions …" (FAA, 2009, p. 1) free from management pressures regarding decision-making, and be able to communicate with the various stakeholders who are parties to the Memorandum of Understanding (FAA, 2009). The review process and how it functions is defined in the Memorandum of Understanding between the three parties (FAA, 2002). The flow of the formal review process as defined by regulation for an ASAP report is depicted in Appendix B. Following the review, the de-identified report is included in the airline ASAP database for statistical analysis, and the ASAP data used in this study was obtained from that source. Reports are then uploaded to the ASRS database which could lead to some overlap with the ASRS group. During the de-identification process, all demographic information is removed from an ASAP report so that it cannot be linked to a specific air carrier or flight, but aircraft type information is retained. To prevent overlap of data from Airline A in the ASRS data group, all cases that specified the aircraft type and airport served by Airline A were removed from the ASRS data during the narrative analysis coding process. The diversity of aircraft types and FMC systems contained in the ASRS data compared to the single aircraft type and FMC system of the ASAP data provided a robust cross-section of aircraft and FMS systems for analysis. Correlations and effect sizes present within each data set identified similarities and minor differences and provided a more complete understanding of the National Airspace System as it is currently used.

Bias and its Mitigation

This study was designed to address the stated bias present in the data and mitigate it to the greatest extent possible. Bias is "… any systematic error in the design, conduct, or analysis of a study" (Althubaiti, 2016, p. 4). Self-reporting bias was the primary source delineated in the data, but it is comprised of two elements relevant to this research. One of these components, information bias, was a result of the observational nature of the data and the ASRS and ASAP reporting vehicles used to obtain it. The advantage of the self-reporting method was the absence of any influence from the researcher on the event being reported. A disadvantage to this approach was the reliance on the observations of the reporter, and the inability to contact the reporter after the initial evaluation stage of the report to gauge its accuracy (Althubaiti, 2016). In light of these constraints, the primary observer's description of the event increases the value of these data in forming an accurate view of the National Airspace System in its current form.

The second element related to self-reporting bias is recall bias, which is the reporter's ability to precisely recreate the event being reported. Timeliness of reporting, or the length of the recall period, has been cited as an important factor in the reduction of recall bias where "… a short recall period is preferable to a long one" (Althubaiti, 2016, p. 19). Both the ASRS and ASAP aviation safety reporting systems have mechanisms in place to reduce recall bias in the form of time limits for submission of reports. Both systems' time periods start with the event itself or the first "awareness" of the event, with the ASAP reporting period being 24 hours for initial notification and five days to submit the completed report, and the ASRS reporting period being 10 days to submit a completed report (FAA, 2002, 2009; Wood, 2019).

As mentioned, this researcher is a U.S. FAR 121 airline Captain with operational experience flying many of the OPD arrival procedures contained in the data. He was a source of confirmation bias in this study in that he was also coding the data during the narrative analysis portion of the exploratory sequential strategy. Confirmation bias "… is a type of psychological bias in which a decision is made according to … preconceptions, beliefs, or preferences" (Althubaiti, 2016, p. 34). A potential source of this bias was the study's hypothesis which stated air traffic control intervention has an effect on altitude deviations reported on OPD arrival procedures. The researcher as a FAR 121 airline Captain had an opinion on whether this hypothesis was true or false. Since it was not possible to resurvey reporters of altitude deviations due to confidentiality safeguards, mitigation of confirmation bias was through comparison of study results with previously reported results from Chapter 2, providing a source of "… independent feedback and confirmation" (Althubaiti, 2016, p. 36).

In addition to increasing reliability, triangulation was used as a bias mitigation strategy in this study, "… the act of combining several research methods to study one thing" (Kennedy, 2009, p. 1). Using a mixed-methods approach, both the qualitative (narrative analysis) and quantitative (correlation analysis) methods were able to confirm the analysis of the other method through triangulation (Turner, 2016). The examination of a single phenomenon, altitude deviations, from both the qualitative and quantitative perspectives of a mixed-methods study leveraged the combined strengths of each method while reducing their biases and limitations (Creswell, 2014). Given the stated biases of the data used in this study and the inability to resurvey study participants to validate it due to confidentiality restrictions, the use of the triangulation strategy in the selection of the mixed-methods approach to remove or decrease bias and provide a viable option to validation was appropriate (Turner, 2016).

Limitations of Self-Reported Data

Reports for both groups were voluntarily submitted during the study's time period through ASRS and ASAP programs and were not collected specifically for this study. Reports were submitted to both programs online using questionnaire formats (Appendix A) that included a narrative section that permitted a textual description of the event (FAA, 2002; NASA, 2018). An ASAP reporting form was not included in this dissertation due to its ability to be linked to Airline A, which would violate the terms of the NDA. Both ASRS and ASAP programs are voluntary aviation safety reporting systems and may not contain all cases from a defined time period. Even with this limitation, data from both programs represented a minimum number of events taking place in the National Airspace System (NASA, 1996). The ability to compare the statistical findings from these two groups with each other and with historical findings such as Buono (2014) had the potential to increase the generalizability and validity of the results through triangulation (Kennedy, 2009). This study assumed that the data from both ASRS and ASAP describe a minimum number of altitude deviation events taking place, were both subject to self-reporting bias, and were both analyzed using the same qualitative and quantitative techniques (Field, 2013; NASA, 1996). The voluntary reporting bias of these data may prove to be less limiting than stated if the findings are consistent with previous historic values.

ASRS and ASAP programs provide incentives for pilots to submit reports, the most prominent being the waiver of pilot certificate disciplinary action by the FAA for candid reporting (FAA, 2002; NASA, 2018). The removal of the possibility of punitive action encourages submission of more robust safety information by the reporter and encourages a more accurate portrayal of the system as it is currently used. This free-flow of safety data from these sources is congruent with the safety and safety reporting objectives of NextGen and provides more unfiltered feedback for system evaluation and improvement (DOT, 2004). Reports submitted to both programs undergo an initial review process that seeks to identify and classify the underlying conditions that led to the reported event (FAA, 2009; NASA, 2018). an ASAP report is subject to a more formal investigative and analytical process prescribed by FAA regulation, the ASRS report may or may not have been put through a formal investigation involving a regulatory body depending on its source (FAA, 2009; NASA, 2018). The intent of both programs is the same: the exemption from disciplinary action in exchange for candid safety information. The higher safety standards, regulatory oversight, and broader safety implications present in an FAR 121 airline operation prescribe a more formal investigative and review process (FAA, 2002, 2009). The data in the ASRS group included only OPD altitude deviation cases from U.S. FAR 121 air carriers which increased the probability that the majority of cases had been subject to regulatory scrutiny of some degree (FAA, 2002, 2009; NASA, 1996, 2018; Wood, 2019).

Variables

Eight independent variables were identified consistently throughout the literature as primary themes contributing to altitude deviations reported on OPD arrivals (Buono, 2014; Flight Safety Foundation, 2017; IATA, 2017; Margison, 2014). These variables are air traffic control intervention, aircrew error, collision avoidance, communication error, equipment malfunction or limitation, other, terrain avoidance, and weather. Each variable is discussed in the paragraphs that follow to provide a more thorough understanding of the elements that comprise each. The cases assigned to each variable were operational reports of the U.S. National Airspace system as it is used, which provided a snapshot of issues present when NextGen capabilities were not deployed in their designed integrated fashion. These variables are nominal with no degree of intensity or scalar component present.

Air Traffic Control Intervention

Air traffic control intervention included airspeed, altitude, or heading instructions issued to the aircraft by ATC that remove it or modify the published OPD procedure in some manner. This included the assignment of airspeeds, altitudes, or headings by air traffic control that differ from the published procedure or those issued in error (Flight Safety Foundation, 2000). One of the prominent factors present in the air traffic control variable was the issuance of a clearance that is late or unrealistic, making it difficult to comply with (Buono, 2014). Non-standardization in issuing the clearance leading to confusion on the part of the flight crew and lack of coordination between ATC entities is also applicable to the ATC variable (Buono, 2014; IATA, 2016). There is no level of air traffic control intervention associated with this variable, rather only whether the narrative indicated that it occurred.

Aircrew Error

Aircrew error is any incorrect action by the flight crew in control of the aircraft manually or in the programming and use of automated aircraft systems required to comply with published OPD restrictions or revised ATC clearances (IATA, 2016). Failure to effectively manage distractions on the flight deck and improper use of automated systems are recurring themes when discussing aircrew error (Buono, 2014; Margison, 2014). Ineffective task prioritization during periods of high cockpit workload has the potential to reduce the situational awareness of one or both crewmembers and lead to the improper utilization and monitoring of automated systems (Flight Safety Foundation, 2000). These errors and conditions are not exclusive to automated flight as inadequate manual aircraft control is cited as a lesser contributing factor and may have been a factor in the recent accidents involving the Boeing 737 Max8 (Charette, 2018; Margison, 2014). These errors would be specifically mentioned or referred to in the narrative.

Collision Avoidance

Collision avoidance involves the deliberate maneuvering of the aircraft in response to an onboard Traffic Collision Avoidance System (TCAS) conflict resolution advisory (RA) or traffic advisory (TA) to avoid colliding with another aircraft. This variable also included heading and altitude instructions from ATC to prevent a mid-air collision when this was specifically stated in an ASRS or ASAP report as being the reason for ATC intervention. Collision avoidance cases were relatively infrequent but more frequent than terrain avoidance (Buono, 2014). Traffic deconfliction is a design consideration of an OPD (Favennec et al., 2009; Shresta et al., 2009), but as with terrain avoidance, invalidates this safety feature when the aircraft is removed from the published OPD procedure (FAA, 2013).

Communication Error

Communication error is the misunderstanding of a clearance between air traffic control and the aircraft, the failure of inter-cockpit interactions onboard the aircraft, one flight erroneously taking a clearance intended for another flight, and ambiguity or errors contained in navigation publications and Notices to Airmen (NOTAMS) which result in flight at an altitude other than that assigned (IATA, 2016). Pilot/controller communication errors were a contributing factor in approximately 70% of altitude deviations cited in one study and identify a potentially significant source of error (Buono, 2014; Flight Safety Foundation, 2000). According to FAA (2018), the mitigation of pilot/controller communication errors prompted the FAA to approve a trial period for Controller Pilot Data Link Communication (CPDLC) in the U.S. National Airspace System in March 2018 to improve the “accuracy” of these communications. This action by the FAA was outside the timeframe of both data groups but did speak to the prominent role of communication errors as contributing factors to altitude deviations.

Equipment Malfunction or Limitation

Equipment malfunction or limitation includes any failure of an aircraft system that results in the inability to comply with published restrictions on an OPD. The limitation portion of this variable addressed the inability of the aircraft or FMS to comply with charted OPD restrictions due to system limitations or aircraft performance limitations (Buono, 2014). While OPD procedures are designed to accommodate the largest number of aircraft and FMS systems possible, their design does not guarantee that all aircraft and FMS combinations will be able to comply with OPD restrictions due to individual aircraft and FMS software performance limitations (FAA, 2013). Early in the NextGen mid-phase, altitude deviations related to equipment malfunction or limitation revealed problems with the design of an OPD itself. Unrealistic restrictions were initially incorporated into an OPD procedure due to an absence of actual operational data, but altitude deviations reported when the procedure was deployed for operational use provided data for procedure modification (Bongiorno et al., 2015).

Other

The variable "other" contained cases that indicate the use of an OPD arrival, but were not specific, or were unclear as to contributing factors. Other also included cases that utilized an OPD when a single factor did not stand out as the primary theme related to an altitude deviation. As in the case of collision avoidance and terrain avoidance, cases coded as "other" were infrequent in the large datasets because most narratives identified a primary theme.

Terrain Avoidance

Terrain avoidance is compliance with Enhanced Ground Proximity Warning System

(EGPWS) cautions and warnings on the flight deck or directives from air traffic control to avoid contact with terrain. Considering that 63% of altitude deviations occur below 20,000 feet, this variable was significant especially in the mountainous terrain of the western United States as well as the nations of the European Union (Buono, 2014). One of the priorities of OPD design is the avoidance of terrain conflicts; however, once the aircraft is removed from the charted OPD procedure this safety feature is no longer valid (FAA, 2013). Terrain avoidance represented a small number of reports within both data groups but was included because its probability is not zero, and it has potentially catastrophic consequences (Leveson, 2015; Margison, 2014).

Weather

Weather is any naturally-occurring meteorological phenomenon that prevents an aircraft from flying an OPD as published. Wake turbulence was included with weather because prevailing meteorological conditions have an effect on the presence of wake turbulence over the runway. Turbulence of all types was a leading contributing factor to altitude deviations being reported three times as often than the next contributing weather factors of thunderstorms and tailwind (Buono, 2014). The effects of tailwind are germane to the weather variable because they change the ground speed of the aircraft that may exceed the ability of the FMS to comply with OPD parameters (Yoo et al., 2016). Yoo et al. (2016) studied the effects of wind in the en route environment with longer leg lengths, but the effects of tailwinds were shown to be more pronounced on an OPD with shorter leg lengths and shorter time horizons on which to apply corrections. The effect of tailwind on the altitude deviation would be specifically mentioned in the narrative.

Data Analysis

Narrative Analysis

All cases contained in the ASRS and ASAP data were altitude deviations which occurred during an OPD; therefore, a mechanism was needed to determine the interaction of variables affecting each event. These details were present in the textual narrative of each report (Margison, 2014) and required extraction and classification (coding) to prepare the data for quantitative analysis. NVivo (Version 12) qualitative analysis software was used to code the qualitative data into the independent variables for statistical analysis (Landrum & Garza, 2015). This researcher, a FAR 121 airline Captain, manually reviewed each case from the data groups, highlighted sentences and phrases from the text that supported a primary theme, and assigned them to nodes according to the primary theme of one of the eight independent variables. Since the same individual coded both groups from the textual narratives, the same level of confirmation bias consistent with an operational user of the National Airspace System was present in both data groups (Field, 2013). The training and experience of the researcher provided a deeper understanding of the events being analyzed as compared to the cursory familiarity with these procedures by a casual reader. However, this same training and experience could have led the researcher to place too much emphasis on the effect of air traffic control intervention and not enough emphasis on the role of aircrew error. Frequency of themes within the qualitative data is not equivalent to the strength of an effect or statistical significance in the quantitative realm, and caution must be taken not to equate the two (Landrum et al., 2015). In this study, when discussing qualitative themes, the term frequency will be used.

Both the ASRS and ASAP datasets are arranged chronologically, earliest to latest, within four time periods which comprised approximately 18 months each from January 1, 2012, to January 1, 2018. This was primarily done due to the limitation of file size in transmitting the data from its respective source, but also provided a consistent delineation of time within the study period from which to conduct frequency comparisons of a variable over time. Each altitude deviation in the data had a unique case number assigned to prevent duplication. The researcher loaded the data into the NVivo 12 software which was structured to receive codes representing the eight independent variables derived from the literature in Chapter 2. Each case's textual narrative was individually read by the researcher and coded into the applicable NVivo 12 node along with supporting text according to the primary theme indicated by the text. An excerpt from the textual narrative was stored within each individual code, providing justification for assigning a particular code, and amplifying information describing subsequent events of a given case for further analysis. This process was repeated for each case included in this study.

There are differences in the depth of detail contained in individual reports. A report that could not be positively identified as having occurred during an OPD arrival was removed from the data set during initial narrative analysis. The operational experience of this researcher allowed for the confirmation of an OPD procedure, even by tangential means from the event narrative (Buono, 2014; IATA, 2016). The role of operational experience in research is best illustrated from the field of medicine. Operational experience provides specialized knowledge, and relevant resources can be found in the employees' competencies and experiences as an accumulated individual operational experience. Moreover, operational experience in the daily care of rare diseases is essential to detect potential problems in diagnosis and therapy, and professionals generally learn through observation (Hannemann-Weber, Kessel, & Schultz, 2012). Although a disease was not treated in this study, the specialized knowledge, direct observation, accumulated experience, and almost daily interaction with the National Airspace System provided the researcher the ability to identify problems (diagnosis) and apply appropriate actions (therapy), similar to the individual operational experience in the medical field. Certain phrases such as “descending via the arrival” and “cleared to resume the arrival” indicated the use of an OPD procedure if one was not specifically named. While every report included for analysis was an OPD event and excluded if it did not meet the selection criteria, each report varied in the amount of amplifying information included. In general, greater detail led to a deeper understanding of the elements involved in the event, but fewer details did not exclude an event from inclusion. The use of a standard qualitative analysis program (NVivo 12) produced a consistent coding structure for both groups.

Statistical Analysis

The purpose of this research was to determine the effect of air traffic control intervention on altitude deviations reported during optimized profile descent arrival procedures in the U.S. National Airspace System from January 1, 2012, to January 1, 2018. Correlation analysis was chosen as the quantitative method to identify the effects and underlying relationships in the data. The relative absence of literature investigating the U.S. National Airspace System as currently used does not provide a generally accepted value for statistical significance when conducting this type of study. A generally accepted level of statistical significance in social science research, $p < .05$, has provided a convenient but arbitrary benchmark and may inflate the Type I error rate (Cohen, 1990; Field, 2013). Statistical significance is affected by sample size and determining an appropriate level of statistical significance should defer to the research question and “…state of knowledge and theory in the field” (Tomkins, 1992, p. 39). The sample size and level of statistical significance discussed in the following paragraphs met these criteria.

Level of statistical significance for this study. Due to the absence of a best practice with regard to a level of significance in aviation science research, a conservative level of statistical significance used in this study was $p < .01$. It was derived by taking the generally accepted value of $p < .05$ as the upper limit and applying a Bonferroni correction to yield a value of $p < .00625$ as the lower limit to produce a range in which to set the significance level (Cohen, 1992). The Bonferroni correction was specifically chosen to reduce the Type I error rate, make the statistical analysis more rigorous, and reduce the possibility of reporting correlations that were not present in the data (Field, 2013). Statistical power, the capacity of a test to detect an effect if one is present in the data, was set at the generally accepted level of .80 (Cohen, 1992; Field, 2013). The size of both the ASRS and ASAP samples were sufficiently large for a statistical power of .80 at the $p < .01$ level (Cohen, 1992). The more restrictive significance level of $p < .01$ was able to identify significant correlations while minimizing the Type I error rate (Field, 2013). Conversely, the level of statistical significance should not be so restrictive that an effect present in the data is not found (Field, 2013). This level of statistical significance sought to limit both the Type I and Type II error rates and produce accurate findings with regard to the National Airspace System as currently used, taking into consideration the stated limitations of these data (Field, 2013).

Coefficients of determination. To identify a large effect size when using correlation analysis (the significance of a product-moment correlation, Pearson's r), the required sample size needed to be determined. For this type of test, "... when the population r is large ... a sample size = 41 is required" (Cohen, 1992, p. 158). Both the ASRS and ASAP data were divided into four time periods of 18 months each, and the data were coded according to time period to facilitate frequency comparison between time periods and identify frequency trends during the study timeframe. To preserve the relationships between variables within each of the four time periods, the coded value of each variable within each time period was divided by 15 so that the sample size for each time period in the ASRS and ASAP datasets is $n = 15$. The sample size for the entire ASRS or ASAP dataset was the product of four time periods of $n = 15$ each, or $N = 60$, which exceeded Cohen's minimum sample size requirement of $N = 41$ to detect a large effect at a power of .8 and $p < .01$ (Cohen, 1992).

The purpose of this study is to determine the effect of air traffic control intervention on altitude deviations reported on optimized profile descent arrival procedures in the U.S. National Airspace System from January 1, 2012 to January 1, 2018. A determination of effect size was required to interpret the effect sizes present in the data. Effect size was derived by squaring the correlation coefficient of two variables (R^2) and "… is a measure of the amount of variance in one variable that is shared by the other" (Field, 2013, p. 276). Sample size (*N*), statistical power, and the statistical significance level ($p < .01$ for this study) all influenced effect size (Cohen, 1992). For the correlation analysis used for this study, Cohen's values of effect size were: small = .10, medium = .30, and large = .50, values corroborated by Field (2013) and were used here to interpret effect size in the data.

Cronbach's alpha in the context of this study. The use of archival data in this study and the inability to resurvey individuals reporting due to confidentiality provisions created a challenge in establishing the reliability of the study. In addition, even though both ASRS and ASAP data were collected through their respective standardized reporting vehicles, these vehicles were not available for reliability and validity testing because of confidentiality protections for the reporter. This indicated the need for an indirect measurement of ASRS and ASAP data reliability, Cronbach's α (Taber, 2018). Given that this study assumed there will be correlations between variables, Cronbach's alpha breaks down the data into split-half coefficients and α represents the mean of the coefficients (Cronbach, 1951, as cited in Taber, 2018). Briefly, Cronbach intended alpha to reflect how much "… scores depend on general and group, rather than item specific factors" (Cronbach, 1951 as cited in Taber, 2018, p. 1285). A higher value of alpha in a data collection instrument indicates that "… every item in an instrument is measuring something similar to *some* of the other items" (Taber, 2018, p. 1292). The use of Cronbach's α in this study indicated the presence of some correlation between variables.

There continues to be a debate among scholars regarding an appropriate threshold value of Cronbach's α as an indicator of reliability (Field, 2013; Taber, 2018). An arbitrary value of 0.70 is used as an accepted benchmark in social science research, but there are two compelling reasons not to accept it without context. First, the value of Cronbach's α will be inflated as the number of items is increased on a data collection instrument. The larger number of items may be repetitive and may not add any additional information to the overall study (Field, 2013), but may be needed to validate and confirm earlier responses. Second, Cronbach's α is not a measure of unidimensionality or that the items in a data collection instrument are all measuring the same thing (Taber, 2018). There is an expectation that the variables or constructs in this study will correlate to some degree and alpha was not interpreted as a unidimensional measure. Sijtsma (2009) argues for the use of Cronbach's alpha not as a precise reliability value but as a lower boundary of reliability, consistent with stated ASRS limitations (NASA, 1996). Within the context of this literature and the stated limitations of these data, Cronbach's α was calculated for both the ASRS and ASAP datasets and interpreted as a lower boundary measurement of the presence of variable correlations within the data.

Statistical analysis process. The quantified data from narrative analysis were loaded into the SPSS 24 software package from its respective source, ASRS or ASAP. From the *Analyze* menu in the toolbar, *Correlate* was selected, and *Bivariate* was selected from the

Correlate submenu. The SPSS 24 default setting for *Correlation Coefficients* in the *Bivariate Correlations* submenu is Pearson's product-moment correlation, and this selection needed to be verified. All eight variables from the dialog box were dragged to the *Variables* box to "… create a table of correlation coefficients for all of the combinations of variables" (Field, 2013, p. 273). This ensured that all possible combinations of variables were analyzed for correlations during statistical analysis. The SPSS 24 software was set to run the generally accepted bootstrap sample size of 1000 samples; the confidence level was set to 99 ($p < .01$) for analysis, and the confidence intervals were displayed in the bias corrected accelerated (BCa) format (Field, 2013). Cronbach's α was calculated in SPSS 24 using the *Analyze* menu in the toolbar, selecting *Scale*, and selecting *Reliability Analysis* from the submenu. Within the *Reliability Analysis* submenu, Cronbach's α was the default setting, and this selection was verified. Selecting the *Statistics* bar in the *Reliability Analysis* submenu allowed for the selection of various descriptive statistics, one of which was *Scale if item deleted*. This output calculated values for Cronbach's α if each variable was deleted from the calculation. Examination of this information was helpful in determining if a given variable was contributing or detracting from the strength of α (Field, 2013). When discussing quantitative correlations and effect sizes, the term effect will be used.

Exploration of the air traffic control intervention variable. To develop a clearer picture of interactions taking place within the air traffic control intervention variable, the analytic procedure described above was performed on the air traffic control intervention variable separately. Qualitative theme narrative phrases coded to air traffic control intervention in both the ASRS and ASAP data groups were recoded into one of the seven remaining variables to create an ASRS air traffic control intervention dataset and an ASAP air traffic control intervention dataset. Correlation analysis was performed on these datasets to identify the relationships present within the air traffic control intervention variable, and Cronbach's α was calculated for each dataset. This process facilitated the examination of the subtheme relationships present when removing the air traffic control intervention variable, presenting a further analytic density with regard to the thematic frequencies and correlations contained within this specific variable. The additional level of analysis described provided a more robust understanding of the research question, how air traffic control intervention effects altitude deviations reported on OPD arrival procedures.

One of the strengths of a mixed-methods approach is the ability to reintroduce qualitative themes and frequencies after quantitative analysis as a corroborating mechanism for the quantitative results (Kennedy, 2009). The value of this reintroduction was twofold: it provided additional detail and focus on a smaller area, thus, greater analytic density, and provided triangulation of methods via a layered approach to minimize bias (Kennedy, 2009). This was of particular benefit in this research, given the stated biases present in the data. A reduction in bias increased the ability to produce more generalizable results that were applicable to the U.S. National Airspace System. The correlations discovered during statistical analysis benefitted from the return of qualitative data to confirm and verify the identified patterns and regularities (Fielding, 2012; Maxwell, 2010).

Overview of the Analytic Flow

To summarize the analytic flow, the researcher began by reading, coding, and cataloging textual narratives of ASRS and ASAP reports into eight variables derived from the literature. These variables, representing frequency of themes within the qualitative data, were quantified and analyzed quantitatively using correlation analysis to investigate the correlations between variables and effect sizes. Once these relationships were identified for both the ASRS and ASAP datasets, narratives cataloged in both the ASRS and ASAP Air Traffic Control Intervention variables were recoded into one of the seven remaining independent variables and quantified. Correlation analysis was performed and Cronbach's α was calculated for the ASRS Air Traffic Control Intervention data subset and the ASAP Air Traffic Control Intervention data subset. This was the reintroduction of qualitative narratives that facilitated the identification of subthemes and correlations when removing the air traffic control intervention variable, providing a clearer picture of the interactions taking place following the primary air traffic control intervention effect. This research protocol was approved by the Saint Louis University Institutional Review Board (Appendix C). Understanding these constructs and relationships provided a clearer picture of the U.S. National Airspace System as it is currently being used and identified areas of concern where safety is being compromised. The researcher in this study assumed a passive, observational role by the use of archival data. As a current FAR 121 airline Captain, the researcher has flown many of the OPD procedures described in the data, observing first-hand the nuances and problem areas in these procedures. The synthesis of these personal observations in the operational environment formed the basis of this study. The use of ubiquitous qualitative and quantitative analytic software (NVivo 12 and SPSS 24 respectively) was to reduce bias on the part of the researcher to the greatest possible extent, in addition to maximizing the benefits of triangulation provided by a mixed-methods strategy. Also, the operational experience of the researcher focused the investigative effort to this avenue of inquiry. As such, there was an assumption that these interventions by air traffic control are compromising safety and that it is important to identify the sources of continued intervention so they may be addressed. Chapter 4 presents the results of this analytical methodology and shows this assumption to be true.

CHAPTER 4: RESULTS

As stated in Chapter 1, the purpose of this study is to determine the effect of air traffic control intervention on altitude deviations reported during optimized profile descent arrival procedures in the U.S. National Airspace System from January 1, 2012, to January 1, 2018. This chapter is organized according to the structure outlined in Chapters 1 and 3. Initial data acquisition yielded 1186 cases from the ASRS database and 1819 cases from the Airline A's ASAP database prior to narrative analysis. Qualitative analysis consisted of narrative analysis using NVivo 12 software to assign an individual case to one of eight independent variables identified in Chapter 2. Using criteria in Chapter 3 for selection and coding into the ASRS or ASAP data set, narrative analysis produced 393 ASRS cases and 1791 ASAP cases that met the study's criteria. The notable decrease in ASRS cases was the result of removing cases that otherwise met selection criteria, but involved an aircraft model operated by Airline A. These cases were removed from the ASRS data set as described in Chapter 3 to eliminate the overlap of cases between the ASRS and ASAP datasets. The qualitative method also enabled the exploration of subthemes within each variable to clarify relationships between variables, and this was done for the Air Traffic Control Intervention variable in both the ASRS and ASAP datasets. Examples of ASRS aviation safety reports are included in Appendix D. These variables were then analyzed quantitatively using correlation analysis to determine the relationship between variables to provide a clearer understanding of the interaction of factors which had an effect on OPD altitude deviations. Specific details of each analytical step were described in Chapter 3, as was the progression of the method used to address the research question. Results presented in this chapter are the output from the strict application of this method as approved by the Saint Louis University IRB in Appendix C. The use of a mixed-methods approach in this study allowed not only the identification of factors affecting altitude deviations but also their interrelationships and a richer description of those correlations and strength of effects.

Qualitative Results

For both the ASRS and ASAP data groups, frequencies of the eight themes which form the independent variables were coded within the study time period. The data for both groups were divided into four equal time periods as described in Chapter 3, each representing approximately 18 months within the study period January 1, 2012, to January 1, 2018. Alt Dev 1 was the first 18 months of the study time period, Alt Dev 2 the second 18 months of the study time period, and so on. Division of the data in this manner allowed the researcher to analyze any frequency trends of a specific theme present during the study time period. These time periods were arbitrarily selected within the NextGen mid-phase 2012-2020 due to lack of specific guidance in the Chapter 2 literature with respect to consistent NextGen implementation timeframes (DOT, 2004; FAA, 2016; NASA, 2007). Cataloging the data in this way enabled trend analysis related to changes in one variable as well as changes to one or more of the other variables over time.

ASRS Frequencies

Air traffic control intervention, equipment malfunction or limitation, and aircrew error accounted for the majority of cases in the ASRS data group. Air traffic control intervention was the largest at 28%. Table 1 summarizes the case frequencies in the ASRS data by time period.

Table 1.

ASRS Altitude Deviation Frequencies

Time Period **Variable**	Alt Dev 1	Alt Dev 2	Alt Dev 3	Alt Dev 4	**Total**
Air Traffic Control Intervention	33	29	25	24	111
Aircrew Error	24	20	11	13	68
Collision Avoidance	5	6	3	1	15
Communication Error	28	13	6	8	55

Equipment Malfunction or Limitation	33	22	17	24	96
Other	1	1	1	1	4
Terrain Avoidance	0	2	0	1	3
Weather	12	5	12	12	41
Total	136	98	75	84	393

ASRS Air Traffic Control Intervention Subtheme Frequencies

Other, communication error, and equipment malfunction or limitation variables accounted for the majority of cases in the ASRS Air Traffic Control Intervention Subtheme group. The "other" variable was the largest at 48%. Table 2 summarizes the case frequencies in the ASRS Air Traffic Control Intervention Subtheme group by time period. One item to note about these frequencies was the relatively large values for the "other" variable which will be discussed in greater detail in Chapter 5. Using the definition for this variable from Chapter 3, there was no theme present in the narratives for coding into one of the remaining six variables; thus, the air traffic control intervention theme was primary with no other theme indicated.

Table 2.

ASRS Air Traffic Control Intervention Subtheme Frequencies

Time Period	Alt Dev 1	Alt Dev 2	Alt Dev 3	Alt Dev 4	**Total**
Variable					
Aircrew Error	4	6	0	0	10
Collision Avoidance	0	0	1	1	2
Communication Error	7	5	7	7	26
Equipment	1	5	3	3	12

Malfunction or Limitation					
Other	19	11	11	12	53
Terrain Avoidance	0	0	1	0	1
Weather	2	2	2	1	7
Total	33	29	25	24	111

ASAP Frequencies

Air traffic control intervention, aircrew error, communication error, and equipment malfunction or limitation accounted for the majority of cases in the ASAP data group. Air traffic control intervention was the largest at 43%. Table 3 summarizes the case frequencies in the ASAP data by time period.

Table 3.

ASAP Data Altitude Deviation Frequencies

Time Period **Variable**	Alt Dev 1	Alt Dev 2	Alt Dev 3	Alt Dev 4	**Total**
Air Traffic Control Intervention	206	233	202	126	767
Aircrew Error	138	94	121	84	437
Collision Avoidance	15	5	5	2	27

Communication Error	49	68	67	40	224
Equipment Limitation or Malfunction	53	68	54	39	214
Other	2	6	12	6	26
Terrain Avoidance	0	1	0	0	1
Weather	21	24	31	19	95
Total	484	499	492	316	1791

ASAP Air Traffic Control Intervention Subtheme Frequencies

Other, communication error, and aircrew error variables accounted for the majority of cases in the ASAP Air Traffic Control Intervention Subtheme group. The "other" variable was the largest at 52%. Table 4 summarizes the case frequencies in the ASAP Air Traffic Control Intervention Subtheme group by time period. As was the case with ASRS Air Traffic Control Intervention Subtheme, the "other" variable had the largest number of frequencies. Once again, using the definition for this variable from Chapter 3, there is no theme present for coding into one of the remaining six variables; thus, the air traffic control theme was primary with no other theme indicated.

Table 4.

ASAP Air Traffic Control Intervention Subtheme Frequencies

Time Period **Variable**	Alt Dev 1	Alt Dev 2	Alt Dev 3	Alt Dev 4	**Total**
Aircrew Error	21	22	17	13	73
Collision Avoidance	3	2	2	2	9

Communication Error	49	70	53	41	213
Equipment Malfunction or Limitation	22	16	12	7	57
Other	106	119	113	60	398
Terrain Avoidance	0	0	0	0	0
Weather	5	4	5	3	17
Total	206	233	202	126	767

Infrequent Events

Collision avoidance and terrain avoidance were two variables that contained relatively few cases in both the ASRS and ASAP data groups. They are both mentioned here due to the potentially catastrophic consequences of a single case. Following the narrative analysis method described in Chapter 3, collision avoidance was the more common of the two with cases in each data group, 15 cases for ASRS and 27 cases in ASAP. Terrain avoidance yielded 3 cases in ASRS and 1 case in ASAP. However, the presence of cases for both variables in the ASRS and ASAP datasets, while not unexpected, may prompt investigation into how they correlate with remaining variables and warrant further analysis.

Quantitative Results

Correlation analysis was done on the eight independent variables identified by the Chapter 1 and 2 literature using SPSS 24 software and was populated by narrative analysis frequencies to determine the relationships between variables and the strength of those relationships. The eight independent variables were air traffic control intervention, aircrew error, collision avoidance, communication error, equipment malfunction or limitation, other, terrain avoidance, and weather. Chapter 3 set the determination of statistical significance at $p < .01$. A positive or negative correlation further indicated the manner in which the variables interacted. A positive correlation indicated that the variables moved in the same direction, an increase in one produced an increase in the other whereas a negative correlation meant that the variables moved in opposite directions, an increase in one produces a decrease in the other (Field, 2013). The data frequencies were kept within the four 18-month time periods described in Chapter 3 to preserve the proportions between frequencies for that time period. This was done so that any patterns in the data were not disrupted due to data entry.

Skew and kurtosis were within a range of -2 to +2 for all independent variables with the exception of collision avoidance in the ASRS Air Traffic Control Intervention Subtheme data group and were considered normally distributed (Brown, 1997). Normally distributed data are important for accurate confidence intervals, accurate tests of significance, and to minimize error within the data (Field, 2013). The limitations of the ASRS data group documented in Chapter 3 and ASRS statistical findings are included for comparison purposes. Inclusion of the Airline A's ASAP data has shown qualitative and quantitative similarities between the two datasets and historic data from Chapter 2, minimizing the stated limitations of the ASRS data as expected.

ASRS statistical results. It was assumed in Chapters 1 and 3 that air traffic control intervention would have the largest number of frequencies and strongest correlations in the ASRS data group, and this proved to be true. Bias corrected and accelerated bootstrap 99% CIs are reported in square brackets. Air traffic control intervention was significantly correlated with aircrew error, $r = .96$ [.940, .973], communication error, $r = .95$ [.923, .973], and equipment malfunction or limitation, $r = .78$ [.591, .870]. Aircrew error was correlated with collision avoidance, $r = .76$ [.724, .817], communication error, $r = .93$ [.887, .962], and equipment malfunction or limitation, $r = .82$ [.688, .906]. Collision avoidance was correlated with communication error, $r = .57$ [.460, .708], and negatively correlated with weather, $r = -.69$ [-.816, -.503]. Communication error was correlated with equipment malfunction or limitation, $r = .92$ [.850, .960]. Terrain avoidance was negatively correlated with weather, $r = -.85$ [-.933, -.700] (all $p < .01$). Cronbach's alpha for the ASRS data group was .843 when the "weather" variable was deleted from the data as indicated by reliability analysis. In the context of Chapter 3, there exists high confidence that the ASRS data reliably measures the lower boundary of reported altitude deviations on OPD arrivals. Effect sizes (R^2), or the "... measure of the amount of variability in one variable that is shared by the other" (Field, 2013, p. 276) for significant ASRS correlations are presented in Table 5.

Table 5.

Effect Sizes of Significant ASRS Data Correlations

Correlation	R^2
Air Traffic Control Intervention / Aircrew Error	.92
Air Traffic Control Intervention / Communication Error	.90
Air Traffic Control Intervention / Equipment Malfunction or Limitation	.61
Aircrew Error / Collision Avoidance	.58

Aircrew Error / Communication Error	.86
Aircrew Error / Equipment Malfunction or Limitation	.67
Collision Avoidance / Communication Error	.32
Collision Avoidance / Weather	.48
Communication Error / Equipment Malfunction or Limitation	.85
Terrain Avoidance / Weather	.72

Large effects >.50

ASRS Air Traffic Control intervention subtheme statistical results. Review of the narratives coded into the ASRS Air Traffic Control Intervention variable produced 111 cases for recoding and correlation analysis. Bias corrected and accelerated bootstrap 99% CIs are reported in square brackets. Aircrew error had a significant negative correlation with collision avoidance, *r* = -.964 [-.976, -.949], communication error, *r* = -.773 [-.886, -.575], terrain avoidance, *r* = -.557 [-740, -.372], and positive correlation with weather *r* = .557 [.364, .752]. Collision avoidance was correlated with communication error, *r* = .577 [.392, .752], negatively with other, *r* = -.521 [-.766, -.310], terrain avoidance, *r* = .577 [.387, .764], and negatively with weather, *r* = -.577 [-.753, -.394]. Communication error was negatively correlated with equipment malfunction or limitation, *r* = -.816 [-.873, -.695], and positively with terrain avoidance, *r* = .333 [.208, .463]. Other was correlated with communication error, *r* = .390 [.248, .546], negatively with equipment malfunction or limitation, *r* = -.846 [-.898, -.771], and terrain avoidance, *r* = -.390 [-.574, -.262]. Terrain avoidance was correlated with weather, *r* = .333 [.210, .461]. Cronbach's α for the ASRS Air Traffic Control Intervention data group was -.801. Effect sizes (R^2) for significant ASRS Air Traffic Control Intervention correlations are presented in Table 6.

Table 6.

Effect Sizes of Significant ASRS Air Traffic Control Intervention Subtheme Correlations

Correlation	R^2
Aircrew Error / Collision Avoidance	.93
Aircrew Error / Communication Error	.60
Aircrew Error / Terrain Avoidance	.31
Aircrew Error / Weather	.31

Collision Avoidance / Communication Error	.33
Collision Avoidance / Other	.27
Collision Avoidance / Terrain Avoidance	.31
Collision Avoidance / Weather	.31
Communication Error / Equipment Malfunction or Limitation	.67
Communication Error / Terrain Avoidance	.11
Equipment Malfunction or Limitation / Other	.72
Other / Communication Error	.15
Other / Terrain Avoidance	.15
Terrain Avoidance / Weather	.11

Large effects >.5

ASAP statistical results. It was assumed in Chapters 1 and 3 that air traffic control intervention would have the largest number of frequencies and strongest correlations in the ASAP data group. Bias corrected and accelerated bootstrap 99% CIs are reported in square brackets. Air traffic control intervention was significantly correlated with aircrew error, $r = .46$ [.149, .704], collision avoidance, $r = .43$ [.218, .618], communication error, $r = .82$ [.688, .911], equipment malfunction or limitation, $r = .95$ [.919, .969], terrain avoidance, $r = .60$ [.458, .710], and weather, $r = .49$ [.249, .636]. Aircrew error was correlated with collision avoidance, $r = .86$ [.776, .929], and negatively correlated with terrain avoidance, $r = -.41$ [-.652, -.206]. Collision avoidance was negatively correlated with other, $r = -.62$ [-.750, -.352]. Communication error was correlated with equipment malfunction or limitation, $r = .85$ [.751, .918], other, $r = .55$ [.409, .685], terrain avoidance, $r = .58$ [.397, .753], and weather, $r = .82$ [.727, .898]. Equipment malfunction or limitation was correlated with terrain avoidance, $r = .82$ [.704, .874], and weather, $r = .41$ [.123, .593]. Other was correlated with weather, $r = .84$ [.716, .909] (all $p < .01$). Cronbach's alpha for the ASAP data group was .694 when the "other" variable was deleted from the data as indicated by reliability analysis. In the context of Chapter 3, there exists moderate confidence that the ASAP data reliably measures the lower boundary of reported altitude deviations on OPD arrivals. Effect sizes (R^2) for significant ASAP effect sizes are presented in Table 7.

Table 7.

Effect Sizes of Significant ASAP Data Correlations

Correlation	R^2
Air Traffic Control Intervention / Aircrew Error	.21
Air Traffic Control Intervention / Collision Avoidance	.18
Air Traffic Control Intervention / Communication Error	.67

Air Traffic Control Intervention / Equipment Malfunction or Limitation	.90
Air Traffic Control Intervention / Terrain Avoidance	.36
Air Traffic Control Intervention / Weather	.24
Aircrew Error / Collision Avoidance	.74
Aircrew Error / Terrain Avoidance	.17
Collision Avoidance / Other	.38
Communication Error / Equipment Malfunction or Limitation	.72
Communication Error / Other	.30
Communication Error / Terrain Avoidance	.34
Communication Error / Weather	.67
Equipment Malfunction or Limitation / Terrain Avoidance	.67
Equipment Malfunction or Limitation / Weather	.17
Other / Weather	.71

Large effects >.50

ASAP Air Traffic Control Intervention Subtheme Statistical Results. Review of the narratives coded into the ASAP Air Traffic Control Intervention variable provided 767 cases available for recoding and correlation analysis. Bias corrected and accelerated bootstrap 99% CIs are reported in square brackets. Aircrew error correlated with collision avoidance, $r = .444$ [.266, .673], communication error, $r = .771$ [.634, .872], equipment malfunction or limitation, $r = .876$ [.798, .935], other, $r = .845$ [.723, .919], and weather, $r = .590$ [.293, .785]. Collision avoidance correlated with equipment malfunction or limitation, $r = .815$ [.694, .900], and weather, $r = .512$ [.333, .705]. Communication error correlated with equipment malfunction or limitation, $r = .371$ [.123, .589], and other, $r = .791$ [.721, .849]. Equipment malfunction or limitation correlated with other, r = .665 [.462, .782], and weather, r = .709 [.496, .860]. Other correlated with weather, r = .796 [.622, .908]. Effect sizes (R^2) for significant ASAP Air Traffic Control Intervention correlations are shown in Table 8.

Table 8.

Effect Sizes of Significant ASAP Air Traffic Control Intervention Subtheme Correlations

Correlation	***R²***
Aircrew Error / Collision Avoidance	.20
Aircrew Error / Communication Error	.59
Aircrew Error / Equipment Malfunction or	.77

Limitation	
Aircrew Error / Other	.71
Aircrew Error / Weather	.35
Collision Avoidance / Equipment Malfunction or Limitation	.66
Collision Avoidance / Weather	.26
Communication Error / Equipment Malfunction or Limitation	.14
Communication Error / Other	.63
Equipment Malfunction or Limitation / Other	.44
Equipment Malfunction or Limitation / Weather	.50
Other / Weather	.63

Large effects >.50.

The results show that air traffic control intervention has the majority of large correlations within both the ASRS and ASAP data groups. Case frequencies in the ASRS data showed air traffic control intervention, equipment malfunction or limitation, aircrew error, and communication error as the variables with the most cases in descending order with large effect sizes for each variable. The ASAP frequency data showed air traffic control intervention, aircrew error, communication error, and equipment malfunction or limitation as the variables with the most cases in descending order with large effect sizes except for aircrew error. When removing the air traffic control intervention variable, both ASRS and ASAP frequency data indicated other, communication error, aircrew error, and equipment malfunction or limitation as the variables with the most cases in descending order with large effect sizes for each variable. These results were consistent with the literature in Chapter 2. When removing the air traffic control intervention variable in both ASRS and ASAP datasets, the variable “other” represented the air traffic control event being primary with no other theme indicated. While correlations did exist between the other variables, their effects were generally smaller with a few notable exceptions that will be discussed and examined in greater detail in Chapter 5.

When removing the air traffic control intervention variable, the “other” variable consistently indicated the largest number of frequencies and large effect sizes with the communication error, aircrew error, and equipment malfunction or limitation variables in both the ASRS and ASAP datasets. The similarities of these frequencies and effect sizes in both the ASRS and ASAP data, and consistency with the historic data of Buono (2014) and Margison (2014) in Chapter 2, reduced the limitations of the ASRS data with respect to the U.S. National Airspace System. The two datasets used for this study proved sufficiently robust in both quality and quantity to identify the effect being investigated. While not specifically able to test for reliability due to the de-identified nature of both the ASRS and ASAP data, the Cronbach α values calculated in this section and described in Chapter 3 indicated a high confidence (ASRS) and moderate confidence (ASAP) that the respective datasets measured the lower boundary of reported altitude deviations on OPD arrivals. Chapter 5 will use these results to address the research question: how are air traffic control interventions and altitude deviations related on an OPD and contribute to the literature regarding this phenomenon.

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CHAPTER 5: DISCUSSION

As stated in Chapter 1, this study investigated the effect of air traffic control intervention on altitude deviations reported on OPD arrival procedures. This final chapter returns to the research problem and briefly outlines the methodological steps taken to address the research question. The subsequent sections of the chapter summarize the results and provide a discussion regarding their interpretation and applicability. The findings presented have important implications for aviation safety and advocate for altitude deviation as a leading indicator of potential aviation safety issues. The deficiencies in the literature reporting findings with regard to the actual operation of the U.S. National Airspace System make studies such as this consequential to the accurate understanding of this system. The findings in Chapter 4 that shared consistency with the previously reported findings of Chapter 2 provide a more precise picture of the system in its current form and present the altitude deviation to be a leading safety indicator consistent with the proactive safety approach of NextGen (U.S. DOT, 2004).

Problem Statement

The purpose of this research was to determine the effect of air traffic control intervention on altitude deviations reported during optimized profile descent arrival procedures in the U.S. National Airspace System from January 1, 2012, to January 1, 2018. The results of this study will contribute to a better understanding of this phenomenon in aviation science and safety literature. This study analyzed the U.S. National Airspace System in its current form with its combination of manual and automated NextGen air traffic management techniques through the examination of aviation safety reports. Comparison of these findings with historic aviation safety data regarding altitude deviations minimized the limitations of the data used in this study. Additionally, the comparison allowed generalizations to the U.S. National Airspace System through the analysis of altitude deviations.

Methodological Synopsis

The data in both the ASRS and ASAP groups were analyzed using the exploratory sequential strategy of qualitative-quantitative-interpretation. Qualitative narratives from aviation safety reports were coded into independent variables identified in the literature using narrative analysis. These independent variables were analyzed quantitatively using correlation analysis to determine if there were relationships present in the data, and determination coefficients (R^2) were calculated to ascertain relationship strength (effect). Recoding of the qualitative narratives encapsulated in the ASRS and ASAP air traffic control intervention variables into the ASRS and ASAP Air Traffic Control Intervention Subtheme datasets provided a more thorough understanding of relationships when removing the air traffic control intervention variable.

Overview of the Results

Air traffic control intervention had the greatest number of statistically significant correlations at $p < .01$ as well as some of the largest effect sizes (R^2) for both the ASRS and ASAP data groups. This is an important finding in that the large effects of air traffic control intervention were found in the data at the more restrictive statistical significance level of $p < .01$ described in Chapter 3. ASRS air traffic control intervention had statistically significant correlations with aircrew error, communication error, and equipment malfunction or limitation at $p < .01$. ASAP air traffic control intervention had statistically significant correlations with aircrew error, communication error, equipment malfunction or limitation, terrain avoidance and weather at $p < .01$. These findings were consistent with the literature in Chapter 2. The coefficient of determination (R^2) was an indicator of the amount of variance in a factor (variable) that is explained by its relationship to another factor (variable) expressed as a percentage. For interpretation, R^2 was useful for describing the relationship strength between variables (Field, 2013).

The ASRS group, with respect to its stated statistical limitations of self-reporting bias, recall bias, and use of a non-statistical sampling procedure, are included for comparison purposes (NASA, 1996, 2018). ASRS data were used to further explore relationships and for comparison with the less-restricted ASAP data. The results were found to be consistent with the historic international findings of Buono (2014) and Margison (2014), and the stated limitations of the ASRS data proved to be less limiting with regard to generalization. The ASRS and ASAP data groups exhibited similarities with respect to relationships between variables and the strength of these relationships. This will be discussed in greater detail in the following paragraphs.

The Cronbach α calculation for the ASRS Air Traffic Control Intervention Subtheme data group in Chapter 4 was a negative value (-.801). A negative value, in this case, is likely due to the small number of items in the ASRS Air Traffic Control Intervention Subtheme data set, and does not necessarily indicate negative correlations. "Sample values of α may be negative even though the population values are positive" (Nichols, 1999, p. 4), as is the case in this study, and "... most likely with small sample sizes and small numbers of items, is that while the true population covariances among items are positive, sampling error has produced a negative average covariance in a given sample of cases" (Nichols, 1999, p. 5).

Findings

Air traffic control intervention was found to be a common element in altitude deviations reported on OPD arrival procedures. ASRS data had statistically significant correlations between air traffic control intervention and aircrew error, communication error, and equipment malfunction or limitation. ASRS air traffic control intervention frequencies (see Table 1) showed a steady decreasing trend during the study period as did ASRS aircrew error and communication error. Equipment malfunction or limitation in the ASRS data set had a steady declining trend in periods one through three before increasing in period four. The ASAP data had statistically significant correlations between air traffic control intervention and aircrew error, collision avoidance, communication error, equipment malfunction or limitation, terrain avoidance, and weather. ASAP air traffic control intervention frequencies (see Table 3) showed a decreasing trend during the study period, as did ASAP aircrew error and collision avoidance. ASAP communication error and equipment malfunction or limitation both increased in period two before declining in periods three and four. ASAP weather increased in periods one through three before decreasing in period four, and terrain avoidance remained steady.

When examined in the context of a decreasing trend in air traffic control intervention over the study period, these results suggest increased familiarity with NextGen procedures by both pilots and air traffic controllers. They also suggest improved maintenance of automated aircraft systems and FMC software upgrades, all positive trends with respect to aviation safety. Study results are consistent with the literature in Chapter 2, suggesting that the continued use of manual and automated procedures together is not compatible with the safe implementation of NextGen capabilities. One explanation for this is the non-integrated nature of NextGen deployment, necessitating the use of both manual and automated procedures to operate the U. S. National Airspace System in its present form. The results also suggest that the combined use of manual and automated procedures is still taking place and that safety is being compromised.

The size of the effect varies between data groups, as does the strength of the relationship (R^2). When discussing effect size, the values stated in Chapter 3 of large +/- .5, medium +/- .3, small +/- .1 were used to interpret the findings (Cohen, 1992; Field, 2013). While effect size does "...measure the amount of variability in one variable that is shared by the other," it measures the strength of a relationship but not causality (Field, 2013, p. 276). The discussion of findings will focus on air traffic control interventions to address the research question stated in Chapter 1 with brief mention of some other safety-related relationships found during analysis.

Frequencies. ASRS air traffic control intervention frequencies (see Table 1) showed a steady decreasing trend during the study period, as did ASRS aircrew error and communication error. Equipment malfunction or limitation in the ASRS data set had a steady declining trend in periods one through three before increasing in period four. When the air traffic control variable was removed, the ASRS Air Traffic Control Intervention Subtheme Frequencies (see Table 2) showed a decreasing trend in the other and aircrew error variables which is consistent with the larger ASRS data set. Communication error and equipment malfunction or limitation remained relatively steady during the study period.

ASAP air traffic control intervention frequencies (see Table 3) showed a decreasing trend during the study period as did ASAP aircrew error. ASAP communication error and equipment malfunction or limitation both increased in period two before showing declining trends in periods three and four. When the air traffic control variable was removed, the ASAP Air Traffic Control Intervention Subtheme Frequencies (see Table 4) showed a decreasing trend in the other and aircrew error variables consistent with the larger ASAP data set. Communication error showed a decline after a rise in period two, and equipment malfunction or limitation had a decreasing trend.

The frequency of air traffic control intervention for both the ASRS and ASAP groups ranged within the international historic values reported by Buono (2014) and Margison (2014). This finding minimized the limitations of the ASRS data stated in Chapter 3 and made the findings of this study more generalizable with respect to the U.S. National Airspace System. Margison's data included international aviation safety reports during the period 2009 to 2013, well before the NextGen mid-phase which began in 2012. However, Margison's data included a time period that was not affected by the introduction of NextGen procedures and, thus, includes more of a pre-NextGen historic baseline for comparison (Margison, 2014). Buono's data covered Q1 to Q4 of 2013 of the same period and provided more of a granular analysis of a segment toward the end of the 2009 to 2013 timeframe, during the NextGen mid-phase time period (Buono, 2014). Margison (2014) reported air traffic control intervention as a contributing factor at 50%. Buono (2014) reported this factor at 31% compared with the ASRS result in this study of 28% and an ASAP result of 43%. Even when correcting for the compressed time period of Buono at 31%, ASRS data produced 26%, and ASAP data produced 45% for air traffic control intervention.

There are several possible explanations for the small differences between the historic baseline findings of Buono (2014) and Margison (2014) and the results reported in Chapter 4. In their studies, they both looked at international aviation safety reports reporting altitude deviations. This international data included air traffic control systems and procedures that differ from the U.S. National Airspace System. Both datasets used in this dissertation were altitude deviations reported on OPD arrivals in the U.S. National Airspace System. The historic data also includes national air traffic control systems such as EUROCONTROL that were further along in their deployment of automated air traffic management capabilities and use of aircraft automation. The Buono (2014) and Margison (2014) studies concluded at the end of 2013, which was relatively early in the NextGen mid-phase (Houston, 2017). The data of Buono (2014) and Margison (2014) also did not account for the increased learning and familiarity with NextGen procedures on the part of pilots and air traffic controllers as the study period progressed (Coppenbarger et al., 2010; Meyn et al., 2011). The data used in this dissertation captured data on U.S. altitude deviations five years after the conclusion of these baseline studies and provide a more accurate portrayal of the deployment of NextGen capabilities in the United States. While there were small differences between Buono (2014) and Margison (2014) and the results reported in Chapter 4, these earlier studies provide a relevant foundation for analysis.

In the context of Margison (2014) providing a historic baseline, there are several possible reasons for the lower frequencies present in the ASRS and ASAP data used in this study. Both ASRS and ASAP data exhibited a declining frequency of air traffic control intervention during the study period 2012 to 2018. This trend was consistent with the introduction of automated NextGen procedures during the period for both pilots and air traffic controllers (Meyn et al. 2011; Murdoch et al., 2009). This declining trend could also have indicated learning and increased familiarity with new NextGen procedures leading to fewer errors and a reduced need for intervention as the study period progressed (Coppenbarger et al., 2010; Meyn et al., 2011).

Improved maintenance procedures on automated aircraft systems and FMC software updates have increased the ability of aircraft to comply with OPD restrictions (Billings, 1997). Lower frequency of air traffic control intervention toward the end of the study period suggested a greater level of NextGen capability integration (Bongiorno et al., 2015; Yoo et al., 2016). Frequency analysis (see Tables 1 and 3) showed decreasing trends in aircrew error and equipment malfunction or limitation over the study time period. When examined in the context of a decreasing trend in air traffic control intervention over the study period, these results suggest increased familiarity with NextGen procedures by pilots and air traffic controllers, and improved maintenance and FMC software which are positive trends from an aviation safety perspective.

Coefficients of Determination. The continued presence of large effects of air traffic control intervention on aircrew error, communication error, and equipment malfunction or limitation reported in this study in Chapter 4 and consistent with the literature in Chapter 2, suggest that NextGen is not being used in an integrated fashion. The large effects in the ASRS data (see Table 5) between air traffic control intervention and aircrew error (.92), communication error (.90), and equipment malfunction or limitation (.61) showed the continued significant effect of ATC interruption as a disruptive factor with regard to altitude deviations on OPDs. Furthermore, the large effects present in the ASAP data (see Table 7) between air traffic control intervention and communication error (.67) and equipment malfunction or limitation (.90), indicated the continued significant effect of air traffic control intervention. Since large effects were still present as the study period neared the end of the NextGen mid-phase, this demonstrated that air traffic control intervention is a common element in OPD altitude deviation to varying degrees. The presence of this common element elevates the importance of altitude deviation as a leading safety indicator in the National Airspace System with respect to NextGen in its current non-integrated form. The next section will examine effect sizes between variables when the air traffic control intervention variable is removed.

The failure of the altitude deviation rate to return to historic norms (Margison, 2014) indicates the continuing incompatibility of manual air traffic control techniques and more automated NextGen procedures. Pre-dating NextGen, work by Billings (1997), searching for the optimal human/automation balance in aviation, argued that these two operational concepts would likely not be compatible. Chiappe et al. (2012) also reported this incompatibility in their study, citing the differing operational philosophies of automated and manual control, the effects on situational awareness when switching between the two, and the increasing role of the human element as a limiting factor. Likewise, Murdoch et al. (2009) and Hayashi et al. (2011) found this incompatibility to be present during their respective studies, showing that automated procedures fulfilled a greater number of NextGen goals (U.S. DOT, 2004) in addition to being more efficient in their automated form. When viewed as a leading safety indicator (Leveson, 2015), altitude deviation provides evidence of this continuing incompatibility when these two procedural concepts intersect (Economist, 2019).

Air Traffic Control intervention subtheme effects. The identification of these relationships is relevant because they described relationships that take place after the initial air traffic control intervention event. As such, these relationships tend not to be apparent and not clearly linked to air traffic control intervention (Billings, 1997). By removing the air traffic control intervention variable from both the larger ASRS and ASAP datasets, it was possible to gain a more thorough comprehension of the interactions taking place after the triggering event of air traffic control intervention. Understanding these interactions and their effect sizes will facilitate the development of safer and less disruptive procedures for both pilots and air traffic management.

The more granular analysis of the air traffic control intervention variable in both the ASRS and ASAP datasets provides additional insight into these relationships. When the air traffic control intervention variable was removed from in the ASRS dataset, there were large effects between aircrew error and collision avoidance (.93), aircrew error and communication error (.60), communication error and equipment malfunction or limitation (.67), and equipment malfunction or limitation and other (.72). Similarly, when the air traffic control intervention variable was removed from the ASAP dataset, there were large effects between aircrew error and communication error (.59), aircrew error and equipment malfunction or limitation (.77), aircrew error and other (.71), collision avoidance and equipment malfunction or limitation (.66), communication error and other (.63), equipment malfunction or limitation and weather (.50), and other and weather (.63). The "other" variable is the primary air traffic control intervention effect in both the ASRS and ASAP Air Traffic Control Intervention Subtheme datasets consistent with its definition in Chapter 3, with no other theme present in the recoding process.

Furthermore, the large effects in the Air Traffic Control Intervention Subtheme datasets were consistent with the majority of the large effect sizes present in both the larger ASRS and ASAP datasets. The strong relationship between air traffic control intervention and aircrew error, communication error, and equipment malfunction or limitation in these data was indicated by these large effects. The consistency of both the ASRS and ASAP Air Traffic Control Intervention Subtheme datasets with the larger ASRS and ASAP datasets, and the consistency of these larger datasets with historic data reported in Chapter 2, make the results reported in Chapter 4 applicable to the U.S. National Airspace System.

The largest effect in the ASRS Air Traffic Control Intervention Subtheme dataset between aircrew error and collision avoidance, and in the ASAP Air Traffic Control Intervention Subtheme dataset between aircrew error and equipment malfunction or limitation illustrated the disruptive nature of air traffic control intervention on OPD arrival procedures and negative unintended consequences. The large effect between equipment malfunction or limitation and other (.72) in the ASRS Air Traffic Control Intervention Subtheme data, and the large effects between aircrew error and other (.71), communication error and other (.63), and weather and other (.63) in the ASAP Air Traffic Control Intervention Subtheme data showed the primary effect between air traffic control intervention and these variables (Buono, 2014; FAA, 2018; Margison, 2014). These relationships serve to clarify the possibly opaque series of factors that lead to an altitude deviation following the initial air traffic control intervention effect that puts these interactions in motion (Billings, 1997).

The safety implication of these large effects detailed a system not used in an integrated manner as designed, and the intersection of manual and automated procedures created opportunities for altitude deviation. This would be consistent with the increase in the altitude deviation rate and its failure to return to a more historic level from Chapter 2. The large effects present in the Air Traffic Control Intervention Subtheme data that take place after the initial air traffic control intervention event are less transparent. These findings oppose the stated NextGen objective of a proactive approach to safety and safety integration in procedure design (U.S. DOT, 2004). The studies in Chapter 2 repeatedly find that the combined use of manual and automated procedures was not compatible. The large effects reported in Chapter 4 indicate that this practice is still taking place, and safety is being compromised.

Air Traffic Control's primary mandate of separation and sequencing of aircraft (FAA, 2015) will lead to some instances requiring ATC intervention since not all aircraft are operating under more stringent instrument flight rules. There is still some unpredictability in the form of conflicting traffic for aircraft on an OPD that requires the tactical action of an air traffic controller. Examples include priority handling of an aircraft experiencing a mechanical failure, direct routing to the airport for an aircraft with an onboard medical emergency, and an aircraft that has experienced two-way radio communication failure that requires movement of other traffic. These scenarios demand time-critical action by the air traffic controller to maintain safe separation of aircraft, cannot be anticipated in advance, and are two arguments against the total automation of air traffic management (Kirwan et al., 2008). Billings (1997) asserts that there is enough unpredictability in the National Airspace System to require the actions of a human actor to maintain safe flight parameters.

Flying the OPD procedure as published reduces separation events and leverages the design collision avoidance features of an OPD procedure (FAA, 2017). This was shown in Chapter 4 by significant positive correlations in both the ASRS and ASAP data between air traffic control intervention, collision avoidance, and terrain avoidance. These positive relationships suggest that when air traffic control intervention increases, collision avoidance and terrain avoidance cases also increase. Removing the arriving traffic from the published procedure and its incorporated safety features creates an opportunity for additional air traffic control intervention.

The work of Meyn et al. (2011) identified areas for likely air traffic control intervention on an OPD and mitigated them with an automated solution where appropriate. Meyn et al. (2011) found that assigning meter fix crossing times reduced separation conflicts and also reduced controller workload by decreasing the need to intervene. Bongiorno et al. (2015, 2017) built on the work of Meyn et al. (2011), extended this reasoning, and released the controller from conventional separation and sequencing tasks that can be safely automated to address situations requiring more immediate, timely action. The reduced need for air traffic control intervention reduces the effect of air traffic control intervention on OPD arrival procedures.

One of the most cost-effective and efficient ways to accomplish routine separation and sequencing tasks is to fly the OPD arrival as published (Chen & Solak, 2015; Fleming et al., 2013). This increases the predictability of arriving traffic and reduces uncertainty in the air traffic management setting, as described in the Patterns and Predictability section of Chapter 2. OPD procedure design incorporates terrain and traffic separation laterally and vertically in addition to traffic separation by the addition of speed restrictions (FAA, 2013). One problem is the issuance of a descent clearance by ATC specifying a specific vertical speed which will require the use of an automated aircraft mode outside of the protections provided by VNAV (General Electric, 2010). This is problematic in that when VNAV is in use, it will meet charted speed restrictions and not allow an aircraft to descend below the lowest charted altitude on an OPD, whereas another vertical mode may not provide this protection (see Report 1109871 in

Appendix D; Southwest Airlines, 2014). These built-in safety features are bypassed when an aircraft is taken off a published OPD arrival and the calculated descent profile is interrupted.

Human air traffic controllers maintain a very significant place in the production of aviation safety, but their roles will change, as it will for pilots, as a given unit of workload is redistributed through automated capabilities. These changing roles were described in greater detail in Chapter 2. Automated tools are one method to relieve some of the routine administrative duties involved in sequencing and separation of traffic so the controller may bring his or her expertise to bear on more pressing time-critical safety issues (Vu et al., 2012).

Recommendations for the United States National Airspace System

One simple, cost-effective action that can be taken immediately is to fly OPD arrival procedures as published (Chen & Solak, 2015; Erzberger & Tobias, 1986; Fleming et al., 2013). An extensive amount of planning and analysis goes into the design and construction of these automated procedures, and safety and economic benefits go unrealized once the aircraft is taken off the published OPD (Brooks, 2006; FAA, 2013; Fleming et al., 2013; Porter, 2006). According to Prandini et al. (2011), air traffic controller workload is reduced by aircraft flying a predictable arrival path, reducing uncertainty, and leveraging design safety and separation criteria. Moreover, pilot workload is reduced by the ability to fly the arrival using automated aircraft capabilities, freeing the pilots to devote more attention outside the cockpit to look for traffic and maximize the economic benefits of aircraft automation (Chen & Solak, 2015; Johnson et al., 2010).

Required time of arrival (RTA) should be implemented into domestic operational use. Literature in Chapter 2 addresses time as a sequencing mechanism in air traffic management, its addition creating the 4D trajectory concept. RTA capability is incorporated on most FMS equipment currently in use, and its increase in accuracy and predictability in the operational environment were reported in studies such as Yoo et al. (2016). Manual ATC vectoring measures to meet crossing times and metering procedures are counterproductive to the NextGen goals described in Chapter 1. ATC develops schedules for required arrival crossing times at a given navigation fix that could be included in a flight's initial clearance and complied with using RTA. The delivery accuracy at the terminal airspace boundary provided by RTA reported in Chapter 2 directly addresses the NextGen goal of increased airspace capacity. RTA has the ability to adjust arrival times earlier, providing ATC flexibility to adjust arrival times to meet evolving operational conditions (Yoo et al., 2016). Moreover, RTA provides an automated capability to maintain terminal arrival schedules and reduces controller workload. As described in Chapter 2, RTA is also the automated link between en route and terminal arrival schedules.

The delay in ADS-B surveillance and inter-aircraft datalink capability is restricting the use of automated inter-aircraft spacing tools designed for the terminal environment (Barmore, 2005; Dao, 2010; Murdoch et al., 2009; Vu et al., 2012). The ability of aircraft to maintain spacing during an OPD arrival and subsequent approach procedure without controller input reduces controller workload with regard to spacing and increases runway capacity by improving delivery accuracy of arrivals at the runway threshold. Studies such as Coppenbarger et al.'s (2009) and Murdoch et al.'s (2009) in Chapter 2 report the benefits of these capabilities in simulation but require the datalink features of ADS-B for their implementation. The surveillance accuracy and update rate of ADS-B is a significant improvement from radar surveillance, reducing separation requirements, and increasing system and airport capacity (ADS-B Technologies, 2018; IATA, 2007, 2008). The benefits of ADS-B technology are detailed in the Air Traffic Flow Management section of Chapter 2 and enable automated sequencing and spacing functions presently conducted manually by ATC. With the methods of Chapter 3 designed to identify the role of air traffic control intervention on altitude deviations reported on OPD arrival procedures, the results of those methods suggest that there would be a reduction in frequency and effect size of air traffic control intervention with these automated capabilities in place.

Directions for Further Inquiry

The literature in Chapters 1 and 2 has addressed the reasons that currently available NextGen capabilities are not being utilized within the U.S. National Airspace System. The large effect sizes between air traffic control intervention and aircrew error, communication error, and equipment malfunction or limitation reported in Chapter 4 show that NextGen is not being used in an integrated manner. Current mandates and air traffic management procedures used by the FAA regarding air traffic management may be too restrictive and limit the ability of air traffic controllers on the local and regional levels to efficiently use airspace (FAA, 2015). A review and update of existing procedures in the context of evolving automated capabilities to integrate and realize the benefits of NextGen would be beneficial. The use of automated capabilities reducing controller workload is indicated in Chapter 2 by the human controller becoming more of a constraint on system capacity.

Using existing data sources to improve OPD arrivals, the FAA (2018, 2019) published a useful metric which reports the distance that an aircraft remains in level flight for an individual airport terminal area. Reduction of level flight segments is one of the design considerations of an OPD arrival described in Chapter 2. Time in level flight indicates a thrust setting greater than idle, increased fuel burn, emissions, and noise in direct contradiction of NextGen goals (U.S. DOT, 2004). This type of information identifies airports that consistently interrupt OPD arrivals, leads to inquiry regarding circumstances of interruption, and provides a data-driven approach to determine the underlying factors. Data analysis would identify if a certain type of aircraft has difficulties complying with OPD altitude and airspeed restrictions at these airports. This was the case with the Airbus A320 series aircraft during the early stages of the NextGen mid-phase, as reported in the ASRS data (see Report 1109870 in Appendix D; Billings, 1997; Bongiorno et al., 2015).

Conclusions

The continued use of manual and automated air traffic management procedures together creates opportunities for altitude deviations supported by the results in Chapter 4 and suggests that altitude deviation is a leading safety indicator with regard to the U.S. National Airspace System. Air traffic control intervention does affect altitude deviations reported on OPD arrival procedures, specifically aircrew error, communication error, and equipment malfunction or limitation for the data included in this study. This finding was expected and consistent with the literature in Chapter 2. The continued use of manual procedures in an increasingly automated system, a practice identified throughout the Chapter 2 literature as counterproductive to safety and efficiency, creates opportunities for altitude deviations as demonstrated by the large effect sizes reported in Chapter 4 between air traffic control intervention and several study variables. Frequencies and effect sizes were consistent with historic data, and failure of the altitude deviation rate worldwide to return to historic norms after the introduction of some automated NextGen capabilities is problematic. Mitigating tools such as RTA which reduce the need for air traffic control intervention on OPD arrivals are not being used in the U.S. National Airspace System. Chapters 1 and 2 presented entrenched political interests, lack of consistent funding, and the absence of enabling technologies such as ADS-B as possible reasons. This study will contribute to the aviation science and safety literature with respect to how the U.S. National Airspace System is used, as it identified altitude deviation as a leading safety indicator for the analysis of this system.

This is an important finding as NextGen development and deployment near the end of the mid-phase and the majority of NextGen goals detailed in Chapter 1 go unrealized. This study is applicable to regulators, elected representatives involved in the budgeting process, airlines, and air traffic management entities to refocus NextGen as an integrated plan with a corresponding reduction or elimination of safety concerns such as altitude deviations. The use of altitude deviation as a leading safety indicator signals the need for a closer examination of this phenomenon and its effect on safety, consistent with the proactive safety approach of the NextGen *Integrated Plan.*

Appendix A

ASRS Aviation Safety Reporting Form

B

DO NOT REPORT AIRCRAFT ACCIDENTS AND CRIMINAL ACTIVITIES ON THIS FORM.
ACCIDENTS AND CRIMINAL ACTIVITIES ARE NOT INCLUDED IN THE ASRS PROGRAM AND SHOULD NOT BE SUBMITTED TO NASA.
ALL IDENTITIES CONTAINED IN THIS REPORT WILL BE REMOVED TO ASSURE COMPLETE REPORTER ANONYMITY.

(SPACE BELOW RESERVED FOR ASRS DATE/TIME STAMP)

IDENTIFICATION STRIP: *Please fill in all blanks to ensure return of ID strip to you.*
NO RECORD WILL BE KEPT OF YOUR IDENTITY. This section will be returned to you.

TELEPHONE NUMBERS where we may reach you for further details of this occurrence:

HOME Area ______ No. __________________ Hours ____________
WORK Area ______ No. __________________ Hours ____________

NAME ______________________________________

ADDRESS/PO BOX ______________________________________

____

CITY ____________________ STATE _____ ZIP ________

TYPE OF EVENT/SITUATION

____

____

DATE OF OCCURRENCE ____________ (MM/DD/YYYY)

LOCAL TIME (24 hr. clock) ____________ (HHMM)

PLEASE FILL IN APPROPRIATE SPACES AND CHECK ALL ITEMS WHICH APPLY TO THIS EVENT OR SITUATION.

REPORTER		FLYING TIME (in hours)	CERTIFICATES & RATINGS		ATC EXPERIENCE
☐ Captain	☐ Single Pilot	Total Time ______ hrs	☐ Student	☐ Flight Instructor	☐ FPL ☐ Developmental
☐ First Officer	☐ Instructor		☐ Sport/Rec	☐ Multiengine	radar ______ yrs
☐ pilot flying	☐ Trainee	Last 90 Days ______ hrs	☐ Private	☐ Instrument	non-radar ______ yrs
☐ pilot not flying	☐ Dispatcher: ______ yrs		☐ Commercial	☐ Flight Engineer	supervisory ______ yrs
☐ relief pilot		Time in Type ______ hrs	☐ ATP	☐ Other: ______	military ______ yrs
☐ check airman	☐ Other: ______				

AIRSPACE		CONDITIONS / WEATHER ELEMENTS			LIGHT / VISIBILITY		ATC / ADVISORY SVC.	
☐ Class A	☐ Class E	☐ VMC	☐ fog	☐ snow	☐ dawn	☐ night	☐ Ramp	☐ Center
☐ Class B	☐ Class G	☐ IMC	☐ hail	☐ thunderstorm	☐ daylight	☐ dusk	☐ Ground	☐ FSS
☐ Class C	☐ Special Use	☐ Mixed	☐ haze/smoke	☐ turbulence	Ceiling ______ feet		☐ Tower	☐ UNICOM
☐ Class D	☐ TFR	☐ Marginal	☐ icing	☐ windshear	Visibility ______ miles		☐ TRACON	☐ CTAF
			☐ rain	☐ other ______	RVR ______ feet		ATC Facility Name: ______	

	AIRCRAFT 1			AIRCRAFT 2		
	Your Aircraft Type (Make/Model) (e.g. B737, Not "MD", "FK", etc.): ______		Operating FAR Part: ______	Other Aircraft: ______		Operating FAR Part: ______
Operator	☐ air carrier ☐ air taxi ☐ corporate	☐ fractional ☐ FBO ☐ government	☐ military ☐ personal ☐ other: ______	☐ air carrier ☐ air taxi ☐ corporate	☐ fractional ☐ FBO ☐ government	☐ military ☐ personal ☐ other: ______
Mission	☐ passenger ☐ personal	☐ cargo/freight ☐ training	☐ ferry ☐ other: ______	☐ passenger ☐ personal	☐ cargo/freight ☐ training	☐ ferry ☐ other: ______
Flight Plan	☐ VFR ☐ IFR	☐ SVFR ☐ DVFR	☐ none	☐ VFR ☐ IFR	☐ SVFR ☐ DVFR	☐ none
Flight Phase	☐ taxi ☐ parked ☐ takeoff ☐ initial climb	☐ climb ☐ cruise ☐ descent ☐ initial approach	☐ final approach ☐ missed/GAR ☐ landing ☐ other: ______	☐ taxi ☐ parked ☐ takeoff ☐ initial climb	☐ climb ☐ cruise ☐ descent ☐ initial approach	☐ final approach ☐ missed/GAR ☐ landing ☐ other: ______
Route in Use	☐ airway (ID): ______ ☐ direct ☐ SID (ID): ______	☐ STAR (ID): ______ ☐ oceanic ☐ vectors	☐ visual approach ☐ none ☐ other: ______	☐ airway (ID): ______ ☐ direct ☐ SID (ID): ______	☐ STAR (ID): ______ ☐ oceanic ☐ vectors	☐ visual approach ☐ none ☐ other: ______

If more than two aircraft were involved, please describe the additional aircraft in the "Describe Event/Situation" section.

LOCATION	CONFLICTS
Altitude: ______ (single value) ☐ MSL ☐ AGL	Estimated miss distance in feet: horiz ______ vert ______
Distance: ______ and/or Radial (bearing): ______ from:	Was evasive action taken? ◯ Yes ◯ No
☐ Airport: ______ ☐ ATC Fac: ______	Was TCAS a factor? ◯ TA ◯ RA ◯ No
☐ Intersection: ______ ☐ NAVAID: ______	Did terrain warning system activate? ◯ Yes ◯ No

NASA ARC 277B (May 2009) **GENERAL** OMB No. 2700-0172 Exp 7/31/2022

Appendix A. (continued)

DESCRIBE EVENT/SITUATION (continued)

Page 3 of 3

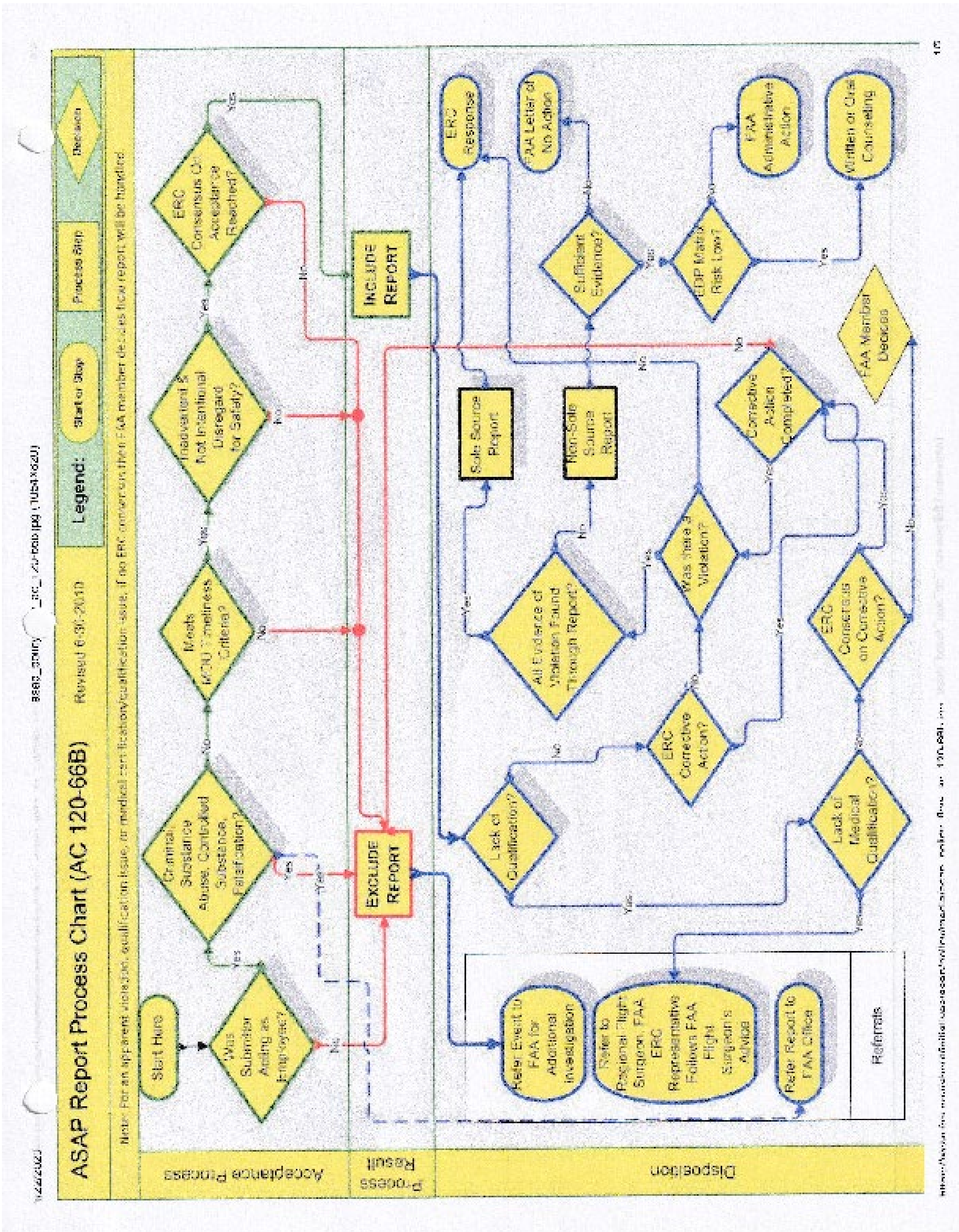
CHAIN OF EVENTS
- How the problem arose
- How it was discovered
- Contributing factors
- Corrective actions

HUMAN PERFORMANCE CONSIDERATIONS
- Perceptions, judgments, decisions
- Actions or inactions
- Factors affecting the quality of human performance

NASA ARC 277B (May 2009)

Appendix B:

ASAP Report Process Chart



Appendix C:

Saint Louis University IRB Approval Letter

SAINT LOUIS UNIVERSITY

Institutional Review Board
3556 Caroline Street, Room C110
St.Louis, MO 63104
TEL: 314 977 7744
FAX: 314 977 7730
www.slu.edu

NOTICE OF INSTITUTIONAL REVIEW BOARD APPROVAL

Date:	May 29, 2020
To:	Lyle, [illegible], Aviation Science-General
	Kelly, Terrence, Aviation Science-General
From:	Kisselev, Oleg, Chairperson, Professor, [illegible]
Protocol Number:	31141
Protocol Title:	The Effect of Air Traffic Control Intervention on Reported Altitude Deviations During Optimized Profile Descent Arrival Procedures

Sponsor Protocol Version Number and Version Date : Not Applicable

The above-listed protocol was reviewed and approved by the Saint Louis University Institutional Review Board.
Assurance No: FWA0000[illegible]

Below are specifics of approval:

Form Type:	NEW
Level of Review:	EXEMPT [illegible]
Form Approval Date:	May 29, 2020
HIPAA Compliance:	Not Applicable

The Saint Louis University Institutional Review Board complies with the regulations outlined in 45 CFR 46, 45 CFR 164, 21 CFR 50 and 21 CFR 56 and has determined the specific components above to be in compliance with these regulations, as applicable.

Approved Study Documents Include: Dissertation form (1) (2).docx; Dissertation Lit [illegible].docx; COI [illegible] 31141.pdf; AltDev4.pdf; Redacted NDA.pdf; Dissertation Method [illegible].docx; Approved_ASRS Form.pdf; Approved_IRB Exempt.pdf

SLU eIRB

Page: 1

Appendix D:

Sample ASRS Aviation Safety Reports

ACN: 1109870

Time / Day

Date : 201308
Local Time Of Day : 1201-1800

Place

Locale Reference.ATC Facility : ZTL.ARTCC
State Reference : GA
Altitude.MSL.Single Value : 19000

Environment

Flight Conditions : Marginal

Aircraft

Reference : X
ATC / Advisory.Center : ZTL
Aircraft Operator : Air Carrier
Make Model Name : A320
Crew Size.Number Of Crew : 2
Operating Under FAR Part : Part 121
Flight Plan : IFR
Mission : Passenger
Nav In Use : FMS Or FMC
Flight Phase : Descent
Route In Use.STAR : IVANE
Airspace.Class A : ZTL

Component

Aircraft Component : FMS/FMC
Aircraft Reference : X
Problem : Design

Person

Reference : 1
Location Of Person.Aircraft : X
Location In Aircraft : Flight Deck
Reporter Organization : Air Carrier
Function.Flight Crew : Captain
Function.Flight Crew : Pilot Not Flying
Qualification.Flight Crew : Air Transport Pilot (ATP)
ASRS Report Number.Accession Number : 1109870
Human Factors : Communication Breakdown
Human Factors : Human-Machine Interface
Human Factors : Situational Awareness
Human Factors : Time Pressure
Human Factors : Workload
Human Factors : Distraction

Appendix D. (continued)

Communication Breakdown.Party1 : Flight Crew
Communication Breakdown.Party2 : Ground Personnel
Communication Breakdown.Party2 : ATC

Events

Anomaly.Aircraft Equipment Problem : Critical
Anomaly.ATC Issue : All Types
Anomaly.Deviation - Altitude : Crossing Restriction Not Met
Anomaly.Deviation - Speed : All Types
Anomaly.Deviation - Procedural : Published Material / Policy
Anomaly.Deviation - Procedural : Clearance
Detector.Person : Air Traffic Control
Detector.Person : Flight Crew
Were Passengers Involved In Event : N
When Detected : In-flight
Result.General : Work Refused
Result.Air Traffic Control : Issued New Clearance

Assessments

Contributing Factors / Situations : Aircraft
Contributing Factors / Situations : Procedure
Contributing Factors / Situations : Chart Or Publication
Primary Problem : Procedure

Narrative: 1

On the IVANE RNAV STAR, approaching MAYOS...FMS message [repeatedly advising] "too steep path." ATC repeatedly re-assigning speed. Aircraft was attempting to exceed depicted speeds in order to make altitudes. I did not feel safe. Using [my best] judgment and PIC discretion, I requested a different arrival.

Why? The Airbus cannot reconcile [the complexities of] the IVANE [STAR]. The STAR is poor, no better than KELLS. Add in tailwinds and ATC continuously vectoring us off the arrival and continuously re-assigning speeds. We reduced speeds also because of turbulence. [Finally I] requested ATC re-clear us on the MAJIC STAR. ATC did so. Problem solved.

Lots of task loading, turbulent conditions, argumentative ATC. And then later, as I was trying to get home afterwards, my Chief Pilot calling my standby/spare/children's cell phone and leaving me messages to call him on Sunday night when I am OFF! ALL of these things put me "in the red."

Synopsis

An A320 Captain expressed his disgust for the IVANE RNAV STAR into CLT advising its complexities exceeded the capabilities of his autoflight system, compelling it to exceed required airspeeds in order to attempt to comply with the associated altitude restrictions. Further difficulties were provided by the demands of ATC to comply with the published restrictions and/or to reassign airspeeds, vector or otherwise interfere with the flight crew's efforts to comply with the published constraints of the arrival. They ultimately refused the IVANE and requested and were assigned the MAJIC, a less complex, non RNAV STAR.

Appendix D. (continued)

ACN: 1109871

Time / Day

Date : 201308
Local Time Of Day : 0601-1200

Place

Locale Reference.ATC Facility : CLT.TRACON
State Reference : NC
Altitude.MSL.Single Value : 11500

Environment

Flight Conditions : Marginal
Light : Daylight

Aircraft

Reference : X
ATC / Advisory.TRACON : CLT
Aircraft Operator : Air Carrier
Make Model Name : A319
Crew Size.Number Of Crew : 2
Operating Under FAR Part : Part 121
Flight Plan : IFR
Mission : Passenger
Nav In Use : FMS Or FMC
Flight Phase : Descent
Route In Use.STAR : IVANE
Airspace.Class E : CLT

Component

Aircraft Component : FMS/FMC
Aircraft Reference : X
Problem : Malfunctioning

Person : 1

Reference : 1
Location Of Person.Aircraft : X
Location In Aircraft : Flight Deck
Reporter Organization : Air Carrier
Function.Flight Crew : Captain
Function.Flight Crew : Pilot Not Flying
Qualification.Flight Crew : Air Transport Pilot (ATP)
ASRS Report Number.Accession Number : 1109871
Human Factors : Workload
Human Factors : Confusion
Human Factors : Distraction
Human Factors : Human-Machine Interface
Human Factors : Time Pressure

Appendix D. (continued)

Person : 2

Reference : 2
Location Of Person.Aircraft : X
Location In Aircraft : Flight Deck
Reporter Organization : Air Carrier
Function.Flight Crew : First Officer
Function.Flight Crew : Pilot Flying
ASRS Report Number.Accession Number : 1109872

Events

Anomaly.ATC Issue : All Types
Anomaly.Deviation - Altitude : Overshoot
Anomaly.Deviation - Procedural : Clearance
Detector.Person : Flight Crew
Detector.Person : Air Traffic Control
Were Passengers Involved In Event : N
When Detected : In-flight
Result.Flight Crew : FLC Overrode Automation
Result.Air Traffic Control : Issued Advisory / Alert
Result.Air Traffic Control : Issued New Clearance
Result.Aircraft : Automation Overrode Flight Crew

Assessments

Contributing Factors / Situations : Procedure
Contributing Factors / Situations : Chart Or Publication
Contributing Factors / Situations : Aircraft
Contributing Factors / Situations : Human Factors
Primary Problem : Procedure

Narrative: 1

The First Officer was flying the leg and was descending on the IVANE RNAV STAR to CLT. The ATIS advised landing south, so the First Officer briefed the arrival and the south transition and I checked all the constraints in the plan mode and everything checked fine.

We started out at 17,000 FT and crossed IVANE at 11,300 FT in managed mode. During this time we were handed off to Charlotte Approach and were again were cleared the IVANE but with a north transition, a speed of 250 KTS and to expect 36C, we were expecting 36L. I then pulled the 36C plate out. When I looked up at the Nav display we were below 11,000 FT (10550) about 8 NM north of GIZMO which must be crossed between 11,000 FT and 13,000 FT. I instructed the First Officer to stop the descent and climb back to 11,000 FT. At that point ATC told us to maintain 10,000 FT. We were then cleared to descend to 6,000 FT. ATC did ask what altitude we were showing for GIZMO.

I believe the reasons for this are as follows. ATC cleared us for the RNAV arrival but also, however, assigned a speed. While we stayed in a managed mode for descent we were in selected mode for speed. During the hand off to Charlotte we were given another change from what we had expected, i.e. land north with the North transition. While I thought the First Officer was monitoring the Aircraft he was also looking at his arrival plates to get ready to brief the north transition. Both of us should not have been reviewing our charts at the same time, there was a lack of communication. The First Officer and I got along fine.

The IVANE 1 is almost a joke. You never really fly the full arrival without ATC changes.

Appendix D. (continued)

Even though we were cleared for the arrival ATC changed it by changing our speed. Which brings up the question; were we really ever on it?

Get rid of the arrival or have ATC let us fly it.

Narrative: 2

We were [cleared to descend] via the IVANE RNA STAR but to maintain 250 KTS.

As we approached IVANE I commented we were crossing IVANE at 11,400 FT and proceeded to divert my attention to briefing [the approach to] 36C. When I looked back to monitor the descent we were still descending after IVANE, but the descent should have stopped [at 11,000 FT MSL] until GIZMO.

If ATC clears us to descend via the IVANE arrival they should let us do the arrival as published. No headings and then rejoin, No speed changes. Just let it work the way it is designed to.

Synopsis

An A319 flight crew suffered an altitude deviation while descending on the IVANE RNAV STAR to CLT but with an assigned speed; forcing them to operate their autoflight systems in a non-standard manner.

Appendix D. (continued)

ACN: 1104105

Time / Day

Date : 201307
Local Time Of Day : 0601-1200

Place

Locale Reference.ATC Facility : ZME.ARTCC
State Reference : TN
Altitude.MSL.Single Value : 9000

Environment

Flight Conditions : IMC
Weather Elements / Visibility : Thunderstorm
Weather Elements / Visibility : Turbulence
Light : Daylight

Aircraft

Reference : X
ATC / Advisory.Center : ZME
Aircraft Operator : Air Carrier
Make Model Name : A300
Crew Size.Number Of Crew : 2
Operating Under FAR Part : Part 121
Flight Plan : IFR
Mission : Passenger
Nav In Use : FMS Or FMC
Flight Phase : Descent
Route In Use.STAR : FNCHR1
Airspace.Class E : ZME

Component

Aircraft Component : FMS/FMC
Aircraft Reference : X
Problem : Malfunctioning

Person

Reference : 1
Location Of Person.Aircraft : X
Location In Aircraft : Flight Deck
Reporter Organization : Air Carrier
Function.Flight Crew : Captain
Function.Flight Crew : Pilot Not Flying
Qualification.Flight Crew : Air Transport Pilot (ATP)
ASRS Report Number.Accession Number : 1104105
Human Factors : Communication Breakdown
Human Factors : Troubleshooting
Human Factors : Human-Machine Interface

Appendix D. (continued)

Human Factors : Situational Awareness
Communication Breakdown.Party1 : Flight Crew
Communication Breakdown.Party2 : Flight Crew
Analyst Callback : Completed

Events

Anomaly.Aircraft Equipment Problem : Less Severe
Anomaly.Deviation - Altitude : Overshoot
Anomaly.Deviation - Altitude : Crossing Restriction Not Met
Anomaly.Deviation - Speed : All Types
Anomaly.Deviation - Procedural : Published Material / Policy
Anomaly.Deviation - Procedural : Clearance
Detector.Person : Flight Crew
Were Passengers Involved In Event : N
When Detected : In-flight
Result.Flight Crew : FLC Overrode Automation
Result.Flight Crew : Regained Aircraft Control
Result.Flight Crew : Overcame Equipment Problem
Result.Air Traffic Control : Issued Advisory / Alert
Result.Air Traffic Control : Issued New Clearance

Assessments

Contributing Factors / Situations : Aircraft
Contributing Factors / Situations : Chart Or Publication
Contributing Factors / Situations : Human Factors
Contributing Factors / Situations : Procedure
Primary Problem : Aircraft

Narrative: 1

We were coming in well rested and having planned ahead. Everything seemed to be going fine. We were filed for the TAMMY RNAV STAR but because of weather were given direct FNCHR for the FNCHR arrival. We plugged everything in [and were] seeming to make our targets well. We planned a hard 10[000] at FNCHR to give us a lead and be stable since there was weather was the airport as it appeared on radar and give us time to best plan.

As we crossed FNCHR the airplane suddenly dived and picked up speed to about 320 KTS. I was the pilot monitoring and called airspeed. We had 4,000 plugged in as we were cleared to descend [via] the FNCHR arrival at FNCHR. As we were accelerating the First Officer (pilot flying) reached down to [set] TACT [an FMS speed intervention mode] 290 KTS (we were around 310-320 KTS at this point). [At this time] I took the airplane, disconnecting the autopilot and pulling the nose up. The next crossing restriction was 9,000 [but we crossed it] at 8,500. The Controller evidently saw us dive through 9,000 [and cleared us to] maintain 8,000. We proceeded without incident for the rest of the flight.

I have 15 years in the jet and have never seen it dive on its own like that. It can get confused if above profile but I thought we were fine. Many lessons learned.

If I had intervened sooner and just hit altitude hold, this would have been a non-event. The First Officer is very diligent, helpful, no reason to expect he would not have corrected ASAP. I was surprised when the solution he came up [with] for the diving and increasing speed was to go to the box. I took it at that point but with the weather, Controller,

Appendix D. (continued)

surprise, and trying to coach too long about the speed I was [task] saturated and missed the altitude of 9,000. I should have taken it sooner. I am very watchful and aggressive in the approach environment and level offs but got caught by total surprise with the dive in the arrival environment, coming out of--what I thought was--nowhere.

I take full responsibility. I will be more aggressive and forward thinking in all phases in the future. I briefed the First Officer thoroughly on never flying the airplane via the box when it isn't doing what you want. Ask for what you want in the descent instead of reaching down. FLY. Rapidly correct by the most expeditious means safely possible. Aviate, navigate, communicate. I am sure he heard me. As I said, he is a really diligent guy. I've heard it said the good ones are the ones that get you. As for me I just came back from vacation and had a four day layover in PHX. I was a little rusty. I assure you I will change habits to prevent this from happening again.

Callback: 1

The reporter advised that, when she started to describe the event to her safety department, they quickly interrupted and spoke words to the effect of "...wait, let us guess..." and then went on to tell her what had happened and advised there had been several of these events on their fleet of A300s. The reporter expressed concern that the company had not, to her knowledge, passed that information on to the flight crews.

The subject of the capability of the FMS/autoflight system on this more or less "first generation autoflight aircraft" was discussed. She advised that while it is true that the FMS has problems with some of the more complex RNAV STARs her technique is simply to disconnect autoflight when she deems it no longer capable of compliance and to, instead, manually "make the jet go where it needs to go." She did stress that, in her experience, the FMS will prioritize programmed VNAV path over any associated speed constraints.

The reporter called back later and clarified the "TACT" mode autothrottle function, advising it is not a "conventional" glareshield based speed intervention tool but is, instead, one of two FMS programmable mach/airspeed inputs, Strategic or Tactical. Strategic being a takeoff to touchdown speed strategy (cost index, minimum flight time, etc) and a Tactical mode designed for alterations within the strategic plan to address interim or short term needs due to ATC constraints, weather, turbulence etc. She emphasized she felt it was a poor choice to address the already anomalous actions of the autoflight system. Thus, she assumed control to arrest the descent.

Synopsis

An A300-600 flight crew was caught by surprise when the autoflight system initiated an abrupt descent and accelerated after crossing FNCHR waypoint on the FNCHR RNAV STAR into MEM. The jet descended ~500 FT below the next minimum crossing restriction of 9,000 and accelerated to about 320 KTS before the autopilot was disconnected and a recovery completed.

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