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OBJECTIVES

The University Aviation Association publishes the Collegiate Aviation Review International throughout each calendar year. Papers published in each volume and issue are selected from submissions that were subjected to a double-blind peer review process.

The University Aviation Association is the only professional organization representing all levels of the non-engineering/technology element in collegiate aviation education and research. Working through its officers, trustees, committees, and professional staff, the University Aviation Association plays a vital role in collegiate aviation and in the aerospace industry. The University Aviation Association accomplishes its goals through a number of objectives:

- To encourage and promote the attainment of the highest standards in aviation education at the college level
- To provide a means of developing a cadre of aviation experts who make themselves available for such activities as consultation, aviation program evaluation, speaking assignment, and other professional contributions that stimulate and develop aviation education
- To furnish an international vehicle for the dissemination of knowledge relative to aviation among institutions of higher learning and governmental and industrial organizations in the aviation/aerospace field
- To foster the interchange of information among institutions that offer non-engineering oriented aviation programs including business technology, transportation, and education
- To actively support aviation/aerospace oriented teacher education with particular emphasis on the presentation of educational workshops and the development of educational materials covering all disciplines within the aviation and aerospace field

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Bayesian Network Education Method to Produce a Condition-Based Maintenance Strategy in Aviation Maintenance Programs

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With an understanding of the current industry and organization orientation, the aviation maintenance industry is preparing a new paradigm shift toward a CBM (Condition-Based Maintenance) strategy. However, one challenge the aviation maintenance industry faces is the lack of CBM training support in the current education setting. This study aims to fill the gap in the CBM strategy training in current aviation maintenance programs. The authors propose Condition-Based Maintenance Bayesian Network (CBM-BN) training materials. The BN has a different principal approach than other frequentist principles, which can generate a prediction model concerning all heterogeneous information. In this paper, the authors describe a framework to develop CBM-BN training material that can be performed in aviation maintenance education. The proposed CBM-BN framework has probability concepts and ten steps; each step has three sections, including materials, activities, and examples for instructors and students. The case study demonstrates that the developed CBM-BN framework and training materials could facilitate CBM strategy training in aviation maintenance programs. A mechanic who can do CBM analysis will be more beneficial and demandable in the job market and contribute to full CBM implementation. Moreover, other CBM educational materials would be needed to compensate for the limitations of BN and increase the maturity level of CBM.

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Introduction

Aviation maintenance is critical for the continued operation of any asset, system, or aircraft. As the aircraft ages, structures and instruments that are fatigued by friction and vibrations eventually reach their failure point. To prevent a part failure during the aircraft's operation time and to continuously operate in safe conditions, the aviation industry has adopted and implemented a time-based maintenance strategy (Oikonomou et al., 2022). However, these traditional time-based maintenance programs have efficiency issues that increase operational costs and downtime (Prajapati et al., 2012; Oikonomou et al., 2022).

The Advisory Council for Aviation Research and Innovation in Europe (ACARE) (2017) addresses Flightpath 2050, which aims to maximize aviation safety and operational efficiency. Of many plans, ACARE (2017) aims to complete a paradigm change to condition-based maintenance (CBM) from time-based maintenance (TBM) by 2035. In addition, Boeing's outlook (2022) also highlights the need to implement CBM in line with changes in the new-generation fleet.

With an understanding of the current industry and organization orientation, the aviation maintenance industry is preparing a new paradigm shift towards a CBM strategy. However, one challenge the aviation maintenance industry faces is the lack of CBM training support in the current education setting. One methodology for generating the prediction models needed for CBM is the Bayesian Network (BN) principle. It can create an uncertainty prediction model that includes all current heterogeneous information from diagnosis and continuously updates it instead of relying on fixed reliability or frequentist stochastics. Therefore, the authors propose that CBM-BN training materials would assist aviation maintenance institutions in aligning their curriculum with the industry's trend toward CBM practices. This CBM-BN comprises prognosis and diagnosis practices that enable students to predict failure points based on an understanding of the aircraft's condition. The proposed CBM-BN training practice is expected to ease the hurdle of CBM implementation for collegiate aviation institutions.

The problem of this study is the lack of CBM modeling instruction in aviation maintenance programs.

Literature Review

Issues of Current Aviation Maintenance Program Education

The requirements for becoming an Aircraft Maintenance Technician (AMT) have been laid out by the Federal Aviation Administration (FAA) in 14 CFR part 65 subpart D. There are two ways to meet eligibility requirements referred to in 14 CFR part 65.77, and this study is focused on section (a); at least 18 months of practical experience related to powerplant and airframe in FAA approved institutional settings (FAA, 2022).

During the 18 months of hands-on experience, the prospective technician should be trained in concepts of maintenance in FAA-approved schools (Code of Federal Regulations, 2022a). The prospective aviation technicians are expected to attain 'critical thinking' skills that enable them to understand current aircraft conditions and decide whether to 'return to service' an asset based on the technician's judgment (Michmerhuizen, 2014). To develop the prospective technicians' critical thinking skills, the U.S. Federal Aviation Administration (FAA) previously set instructional hours in the curriculum (FAA, 2007). However, changes in the regulations as of September 2022 have allowed for competency-based instruction (Aviation Technician Education Council, 2022). However, White et al. (2000) pointed out an issue of this curriculum that it still educates old-fashioned techniques and does not align with industry development and needs. Kraus and Gramopadhye (1999) stated that there is a lack of preparation in the industry setting, such as interpersonal and socio-technical competence in the current aircraft maintenance technician's education setting. Moreover, Kraus and Gramopadhye's (1999) study highlighted the importance of using computer-based training, which enables prospective technicians to expand their insights for in-depth systems in fault diagnosis and repair.

This study will use the aviation maintenance program at Purdue University, Aeronautical Engineering Technology (AET), as the exemplar for building the training materials. The current maintenance program is ABET-ETAC (The Accreditation Board for Engineering and Technology – Engineering Technology Accreditation Commission) 2022-2023 accredited and aligns with FAA CFAR Part 147 requirements (ABET, 2021; Code of Federal Regulations, 2022b; Purdue University, n.d). The AET program is focused on educating students on the proper techniques of using tools and developing troubleshooting skills in preparation for their aeronautical careers (Yother & Johnson, 2021). The more specific course objectives to AET each course level proposed (Ropp et al., 2012) (Refer to Table 1):

Table 1
AET Course-Level Objectives (Ropp et al., 2012)

AET Course Level	Learning Objectives
100 Level	Knowledge/Remembering Define-list-recall-remember
200 Level	Comprehension/Understanding Describe-discuss-explain-identify
300 Level	Application/Applying Employ-demonstrate-explain-illustrate
400 Level	Analysis/Analyzing Compare-contrast-differentiate-experiment
Capstone and applied projects level	Synthesis/Creating Assemble-construct-design-develop

For instance, Yother and Johnson (2021) proposed essential aeronautical industry career skills in a 300-level logistics class: Failure Modes and Effects Analysis (FMEA), life cycle cost calculation, and fault trees. The FEMA has significant knowledge of constructing CBM, which enables it to produce equipment failure modes at an early stage (Teixeira et al., 2020). However, the concept is not associated with CBM.

Challenges of CBM Implementation

The Advisory Council for Aviation Research (ACARE) (2017) aims to achieve the implementation of CBM by developing predictive maintenance. Boeing (2022) also implicitly highlights the need for the skills required for technicians who can analyze and interpret collected data from sensors and flight information. Therefore, educational institutions have to teach students both predictive and traditional maintenance skills (Boeing, 2022).

A deep body of literature concentrates on CBM approaches using various modeling techniques; meanwhile, only a few studies have defined the implementation of CBM (Texieria et al., 2020). Focusing on the implementation plan, Texieria et al. (2020) stated that an adequate level of 'training support' is required to prepare for a successful CBM implementation. Therefore, this training support would be crucial to implementing the CBM strategy. Teixeira et al. (2020) pointed out that technicians' experience and knowledge are crucial to their careers and help build critical thinking systems. Hence, they require solid insight into different methodologies, skills, and principles that compose CBM. Furthermore, during training, technicians are required to understand the objectives and justification of CBM principles (Texieria et al., 2020). To maximize CBM effectiveness, it is essential to understand asset criticalities such as safety, failure behavior, and operational cost benefit. (Ellis, 2009).

Bayesian Network (BN) Applications

Bayesian network applications have been widely adopted in predictive modeling. It is also a significant tool to guide a person to a proper decision in uncertain conditions (Chen & Pollino, 2012; Farinha, 2018). BN is defined as a process where

> … variables are represented by nodes linked by arcs that symbolize dependent relationships between variables. The strength of these relationships is defined in the Conditional Probability Tables (CPTs) attached to each node. CPTs specify the degree of belief (expressed as probabilities) that the node will be in a particular state, given the states of the parent nodes. Evidence is entered into the BN by substituting the a *priori beliefs* of one or more nodes with observation or scenario values. Through belief propagation using Bayes Theorem, the a priori probabilities of the other nodes are updated. This belief propagation enables BNs to be used for diagnostic or explanation purposes (Chen & Pollino, 2012, p. 134).

Moreover, it enables a combination of all heterogeneous information, such as performance data, technician perspectives, testing data, and mathematical approaches (Li et al., 2017). Farinha (2018) stated that the Bayesian theorem differs from typical frequentist probabilistic approaches, and it can consider various disciplines to achieve direct and intuitive answers to real-world examples. To be specific, several papers have conducted studies using BN to analyze human factors related to general aviation accidents (Yang & Mott, 2020), human factors related to maintenance accidents (Chen & Haung, 2014; Luxhoj et al., 2003), human safety assessment of accidents (Zhang & Mahadevan, 2021), and human safety analysis of unmanned aircraft systems (Washington et al., 2019). Understanding that the BN can be applied to different domains in aviation, the researchers focused on the application of BN in CBM in the next section.

Theoretical Reasonings for CBM-BN in Collegiate Aviation Institutions

Researchers understand the need to update old-fashion curricula from discrepancies between collegiate institutions and industry direction. The CBM is approached by big data (Zhang et al., 2019). For example, Airbus A350 produces 2.5Tb of data from 6,000 sensors daily in operation (Rolls-Royce, 2018). In other words, collegiate students will be dealing with big data in their jobs and will be required to have skills in data acquisition, handling big data (pre-processing), diagnosis, and prognosis (Xu et al., 2019).

In addition, BN is a fundamental knowledge that can be applied to various CBM models. The CBM-BN is a new educational material that enables students to understand stochastic future failures by considering heterogeneous information (Dinis et al., 2019), not just relying on pre-determined failure rates given by manufacturers. Once collegiate students understand the practical understanding of CBM-BN, they can develop further advanced CBM models by applying fundamental Bayesian theorems such as Bayesian linear regression (BLR) (Oikonomou et al., 2022) and Naïve Bayes (Saeidi et al., 2019).

Aviation-Related CBM-BN Studies

Many researchers have studied CBM-BN; the authors review other studies on CBM-BN validity approaches applied to aircraft components. These studies show the ability of BN models to be used in predictive modeling for aviation maintenance.

Sun et al. (2019) studied the aircraft condition system (ACS), built-in sensors were installed to monitor and collect data such as Static Air Temperature (SAT), Total Air Temperature (TAT), Static Air pressure (SAP), Mach number (Ma), Altitude (ALT), Engine Anti-ice (V1) Ram Air Temperature (RAMT), Pack Temperature (PKT), Wing Anti-ice (V2), Low-pressure rotor speed (N1), High-pressure rotor speed (N2), Bleed air temperature (BAT), Bleed air pressure (BAP), Cabin Pressure (CP), Mix Manifold Temperature (MFDT). Based on these ACS behavioral history data, the Bayesian method was used to predict ACS failure.

Ferreiro and Arnaiz (2010) provided a diagnosis and prognosis of aircraft break degradation using Bayesian networks; they designed a ‘condition view’ that estimates the remaining life of components based on break wear drive factors such as aircraft weight, landing velocity, brake operation, flight distance, runway length, weather, and runway condition.

Przytula and Choi (2007) studied the avionics diagnosis and prognosis model using a BN concerning various factors such as system usage, health condition changes, and operation conditions.

Summary

Based on the literature review, training has been demonstrated as a substantial element of successful CBM implementation. The authors identify gaps in the current exemplar AET program in teaching the CBM concept to prospective students; even more, the curriculum focuses on traditional skills and knowledge that are not in line with evolving industry needs and techniques. Research shows that CBM will be implemented in the aviation maintenance industry, and the technicians will be required to do predictive maintenance for coming next-generation aircraft. The BN has a different principal approach than other frequentist principles, which can generate a prediction model concerning all heterogeneous information.

In the next section, the authors propose a new CBM-BN training procedure that is expected to contribute to filling the gap between CBM implementation and providing new training material to aviation maintenance programs in line with new industry needs.

Methodology

Theoretical Foundations

Fundamental Principles of CBM

The main goal of implementing CBM is to minimize operating costs. Specifically, by understanding current asset components ‘live condition,’ the operator can minimize redundancy maintenance tasks, which reduce asset downtime and optimize replacements of pointless parts that still have a useful life. This is a new paradigm in the aviation maintenance industry; the CBM strategy enables maintenance based on an aircraft’s health condition, not the traditional TBM strategy, which is reliability-based. Therefore, the operator could achieve a situation known as lean maintenance.

Fundamental Principles of BN

BN is structured by inputting all current component conditions or the operator's perspectives/evaluation. For example, suppose an operator wants to know a component's failure point or current degradation level. In that case, the operator must understand the failed component's interconnection systems and quantify each system variable. The outcome guides the component's current health condition. This method differs from the reliability approach, which does not consider the specific asset's current condition.

Probability concepts

Conditional probability:

The probability of A occurs in the given probability of B (Triola, n.d.):

$$P(A|B) = \frac{P(A \cap B)}{P\ (B)} \tag{1}$$

Bayes' theorem

Bayes' theorem is another way to calculate conditional probability by concerning the prior probability, likelihood, and evidence. To be specific, $P\ (B)$ refers to evidence; $P(A)$ refers to prior probability; $P(B|A)$ refers to likelihood; and $P(A|B)$ refers to posterior probability (also known as updated probability) (Triola, n.d.):

$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B) = [P(A) \cdot P(B|A)] + \left[P\left(\overline{A}\right) \cdot P\left(B\middle|\overline{A}\right)\right]} \tag{2}$$

CBM-BN Framework

The CBM-BN framework is created based on Chen & Pollino's (2012) steps of BN practice. The following are the author's proposed steps for the CBM-BN structure:

1. Select a component.
2. Troubleshooting methods.
3. Analyze probable causes.
4. Determine each variable collection method.
5. Determine conditional probability table methods.
6. Conditional probability diagram and table.
7. Construct a CBM-BN model.
8. Diagnose and determine engine running condition.
9. Prognosis.
10. Evaluate the framework and discuss limitations.

These framework steps guide constructing a solid practice of the CBM-BN prediction model. Since their problem-solving approaches will show operators how their proposed modeling is reasonable and credible, evaluation and discussion can significantly enhance the maturity of targeted CBM-BN modeling by reflecting others' insights.

To construct the CBM-BN framework and calculate network correlation, the authors propose a *Genie Model*. This model helps to structure the BN model by solving complicated calculations and providing visual support through graph and chart analysis. One requirement is that operators need insight into the principle of the Bayesian theorem concept to generate the modeling, such as setting an observation target, identification of variables, and the data value of each variable.

Education Material Development

In this section, the authors describe how they used Chen and Pollino's (2012) framework to develop CBM-BN training material that can be performed in the aviation maintenance education setting. In line with the course level objective, this CBM-BN training material can be used in multiple aviation maintenance courses. Using this material, students will collect the data, quantify them, and input them into variables to construct the BN; in other words, students will create various variables of their targeted component and then input the quantified experiments and observations into the conditional probability table (CPT). From the generated BN outcome, students can diagnose and prognosis their targeted aircraft component.

For each step of the process, there are three sections. The first section is for the instructor. It will include any materials the instructor needs to provide the students. The second section is for the students. It will include the activities the students should complete. The final section is an author-developed example of how to complete the task.

Step 1. Select a Component

The first step in the process is to select a system component to evaluate for condition-based maintenance. There are no real limitations on what the component should be. Only that there is supporting material and knowledge to support the activity.

Instructors. The instructors should provide students with troubleshooting charts where students can choose components. The troubleshooting charts will also be used in future steps.

Students. Using the material provided by the instructors, the students will select a component they wish to evaluate.

Example. To provide an example of proposing a teaching method, the authors selected an opposed reciprocating engine.

Step 2. Troubleshooting Methods and Step 3. Analyze Probable Causes

Instructors. No new material is needed.

Students. Using the material provided by the instructor in step 1, the students shall identify failure modes and causes of their system. For this assignment, one failure mode is selected.

Example. The focus of this example is on the rough running of the engine. Refer to Table 2 for a section of the troubleshooting table from the FAA.

Table 2
Opposed Engine Troubleshooting Directives (FAA, 2018)

Trouble	Probable Causes	Remedy
Rough running engine	Cracked engine mount(s)	Repair or replace engine mount(s)
	Unbalanced propeller	Remove the propeller and have it checked for balance
	Defective mounting bushings	Install new mounting bushings
	Lead deposit on spark plugs	Clean or replace plugs
	Primer unlocked	Lock primer

Step 4. Determine Each Variable Collection Method

Instructors. The instructors provide students with raw data on target component variables. The variables can be found in various references. For example,

- Logbook
- Consult with experts and technicians
- Publications
    - Advisor Circular (AC)
    - Airworthiness Directives (AD)
    - Type Certificate Data Sheet (TCDS)
    - Service Bulletins (SBs)
- Reliability level from manufacturer’s standards
    - Mean Time between failures (MTBF)
    - Mean time to failures (MTTF)

Students. The students analyze the given raw data and convert it to probability/reliability.

Example. The authors developed a CBM model of the condition of the engine running, and various conditional data can be applied to each variable (Refers to Table 3). Each variable is required to measure the probability/reliability in certain periods, such as operation hours, flight cycles, and calendar months. For example,

- The reliability level of parts by manufacturers.
- Frequency of defect found during the observation period.
- Components failure likelihood rates by technicians and experts.

- Historical data of aircraft accidents/incidents associated with components.

Table 3

Probability of Engine Operation Variables

	Variable	Condition	Percentage
(a)	Spark Plugs	Clean:	80 %
		Dirty:	20 %
(b)	Primer Inspection	Pass:	80 %
		Fail:	20 %
(c)	Propeller	Balanced:	90 %
		Unbalanced:	10 %
(d)	Engine Mount(s)	Pass:	99 %
		Fail:	1 %
(e)	Mounting Bushing(s)	Pass:	90 %
		Fail:	10%

Step 5. Determine Conditional Probability Table (CPT) Methods

Instructors. The instructors inform CPT and collection methods per step 5 *Example.*

Students. Understand CPT concepts and collection methods.

Example. The CPT is an essential part of constructing the BN model. This step is a process of how parent nodes correlate to a child node. In other words, the probability of a child node occurs when the parent node already occurred. A combination method is selected to determine the correlation between the two nodes: observational data and expert knowledge.

- Observational data: This is a simple data collection method by observations. i.e., count the probability that an event (child node) occurs when events (parent node) occur.

- Expert knowledge: Consult with industry experts. i.e., ask how frequently an event (child node) occurs when an event (parent node) occurred in a certain period.

Step 6. Conditional Probability Diagram and Table

Instructors. The instructors provide students with conditional probability diagrams and table guides. It was developed by the authors to show an example of a conditional probability diagram and table guide (Refer to Table 4).

Table 4
Conditional Probability Diagram and Table Guide

1. How many parent nodes (Variables) does your component have?
   Answer: i.e., 5 parent nodes: Mounting Bushing(s), Engine Mount(s), Propeller, Spark Plugs, and Premier Inspection
2. What is your child node?
   Answer: i.e., 1 child node: Running Engine
3. Decide the order of parent nodes
   Answer: i.e., the parent node order is 1. Spark Plug; 2. Primer Inspection; 3. Propeller; 4. Engine Mount(s); 5. Mounting Bushing(s)

   Note. The actual order is subject to change by students
4. Determine the probability of the target component for each conditional branch
5. Construct a conditional probability diagram
6. Construct CPT in Excel or manually input the value based on the conditional probability diagram

Students. The students follow the conditional probability diagram and table guide and structure the conditional probability diagram. The completed students' conditional probability example refers to Figures 1, 2, and Table 5. Once students complete filling out each conditional probability diagram, they will convert it to an Excel file and import it to the *Genie model* or manually input the value into the *Genie model*. The Excel file example is represented in Table 5.

Figure 1

Completed Example: Conditional Probability Diagram – Clean Spark Plug

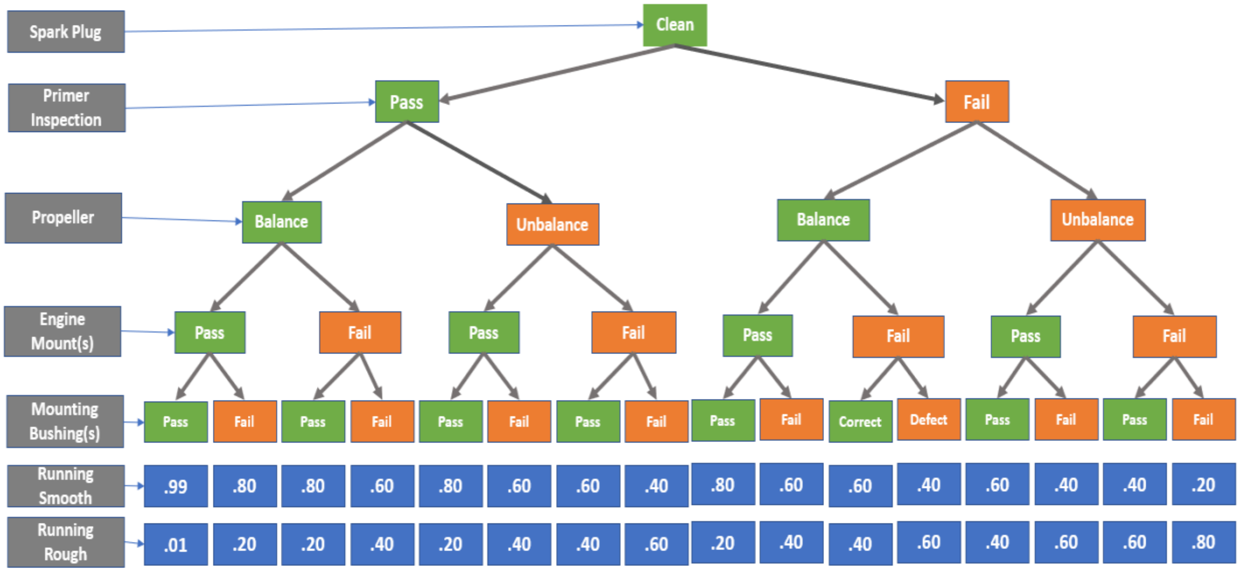


Figure 2

Completed Example: Conditional Probability Diagram – Dirty Spark Plug

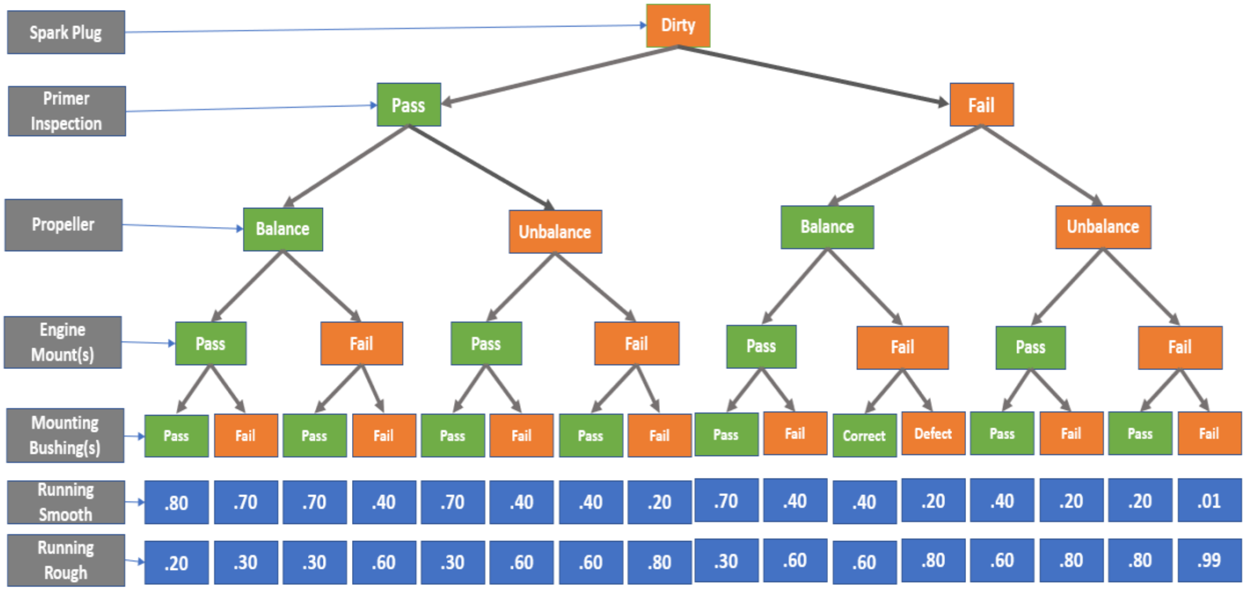


Table 5

Completed Example: CPT of Running Engine Condition

Spark Plugs	Clean															
Primer Inspection	Pass								Fail							
Propeller	Balanced				Un-Balanced				Balanced				Un-Balanced			
Engine Mount(s)	Pass		Pass		Pass		Fail		Pass		Fail		Pass		Fail	
Mounting Bushing(s)	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail
Running Smooth	.99	.80	.80	.60	.80	.60	.60	.40	.80	.60	.60	.40	.60	.40	.40	.20
Running Rough	.01	.20	.20	.40	.20	.40.	.40	.60	.20	.40	.40	.60	.40	.60	.60	.80

Spark Plugs	Dirty															
Primer Inspection	Pass								Fail							
Propeller	Balanced				Un-Balanced				Balanced				Un-Balanced			
Engine Mount(s)	Pass		Fail		Pass		Fail		Pass		Fail		Pass		Fail	
Mounting Bushing(s)	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail
Running Smooth	.80	.70	.70	.40	.70	.40	.40	.20	.70	.40	.40	.20	.40	.20	.20	.01
Running Rough	.20	.30	.30	.60	.30	.60	.60	.80	.30	.60	.60	.80	.60	.80	.80	.99

Example. Because of the complexity of understanding the CPT, the students are required to generate a conditional probability diagram first. This will help students to understand each conditional probability (Refer to Figures 3 and 4). To fill out the conditional probability diagrams, the students need to identify the probabilities of each conditional branch.

Condition: What is the probability of the engine running either (smooth) or (rough) in the given five conditions (Refer to Figures 4 and 5)?

(a) Spark plug = (clean) or (dirty);
(b) Primer inspection = (pass) or (fail);
(c) Propeller = (balanced) or (unbalanced);
(d) Engine mount(s) = (pass) or (fail);
(e) Mounting bushing(s) = (pass) or (fail).

For example, referring to the first left branch of Figure 3., to identify the probability of an engine running smooth (A= child node), students need to be concerned with 1 through 5 conditions (parent nodes). The probability value will fill ‘**A**.’

Condition: The engine is running smooth

(a) Spark plugs are clean and;
(b) Primer inspection pass and;
(c) Propeller is balanced and;
(d) Engine mount(s) pass and;
(e) Mounting bushing(s) pass.

Conversely, the probability of an engine running rough with the same conditions will be a complementary value of the engine running smooth. This probability value will fill ‘**B.’**

Figure 3

Conditional Probability Diagram – Clean Spark Plug

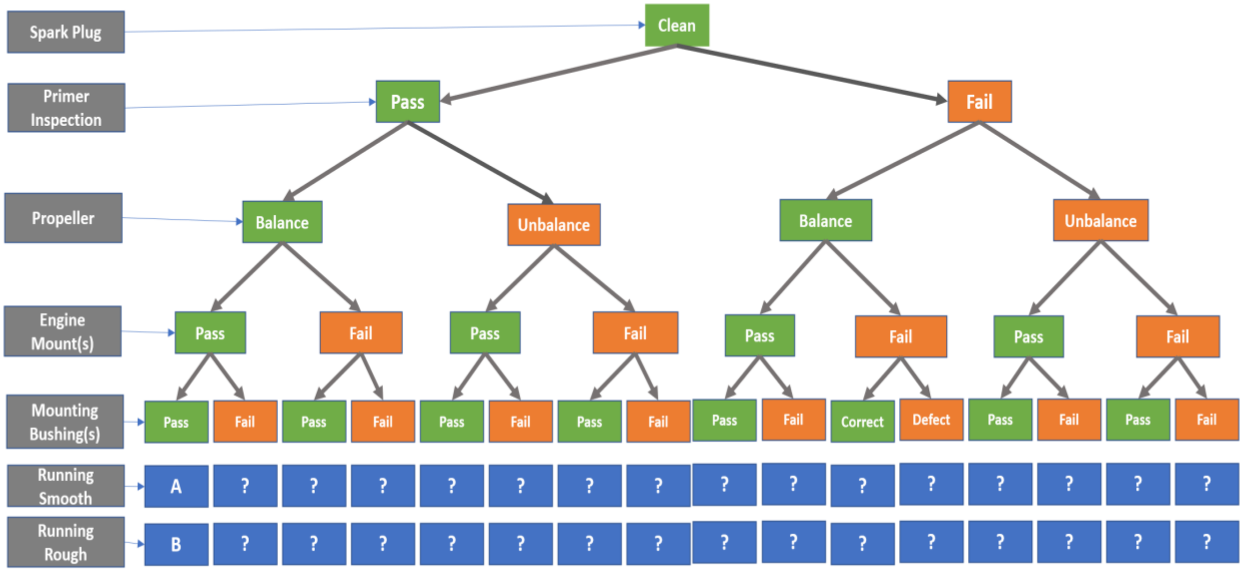
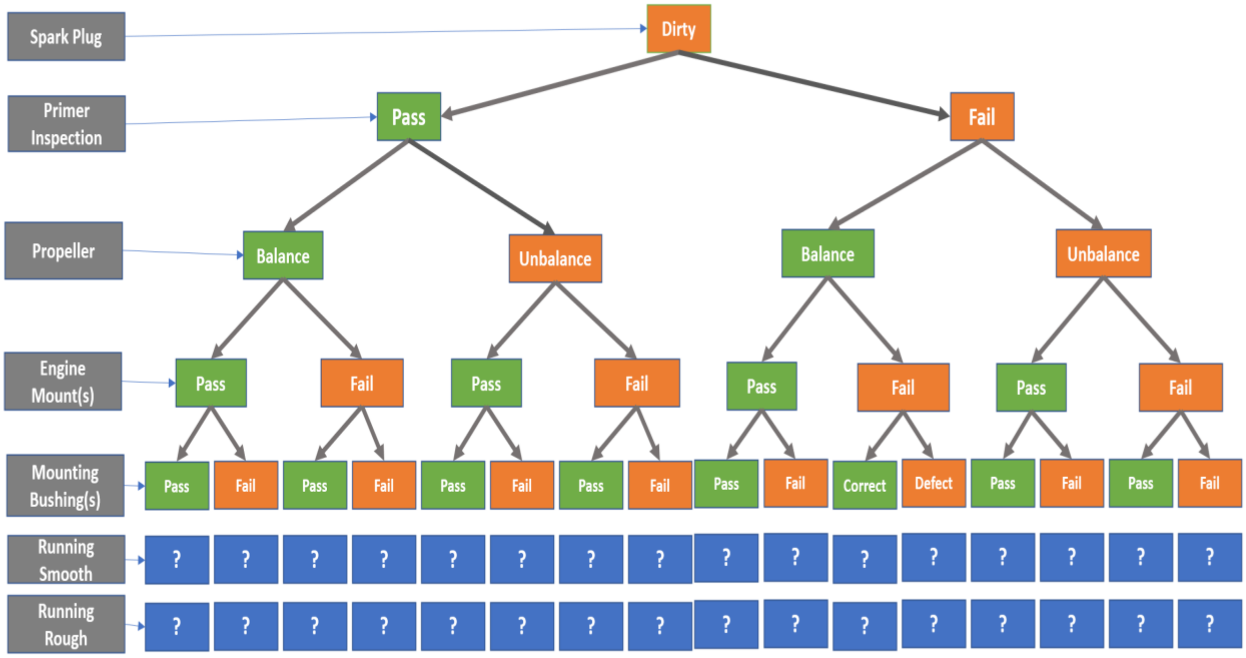


Figure 4

Conditional Probability Diagram – Dirty Spark Plug



Step 7. Construct CBM-BN Model

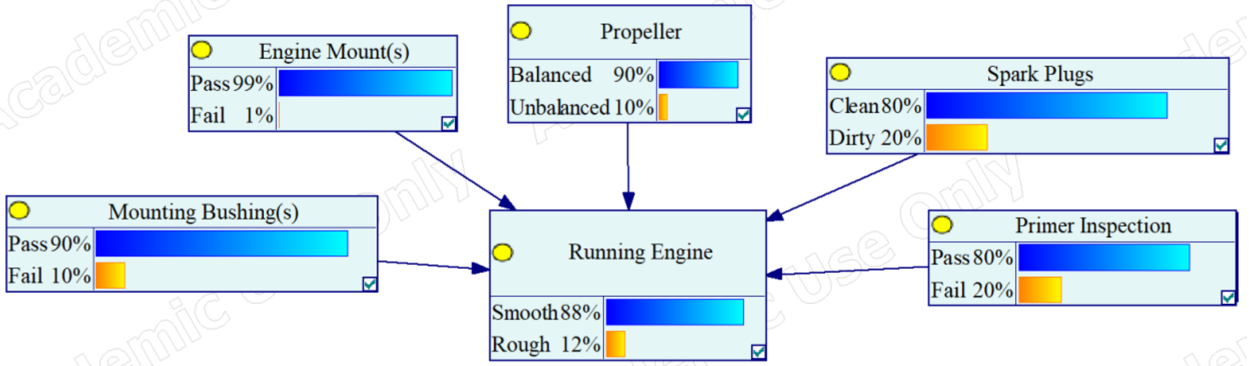
Instructor. Demonstration of *Genie software* instructions per *Genie manual* (BayesFusion, 2020). Provide students with the structure of the CBM-BN model.

Students. Download the student version of *Genie software* and review the structure of the CBM-BN model from the *Genie software*.

Example. The data values in this proposed simulation example assume and substitute verisimilar numbers in the general aviation industry (Refer to Figure 5). This is an outcome of the engine running the CBM model using BN.

Figure 5

Prediction Model of Engine Running Condition using the BN



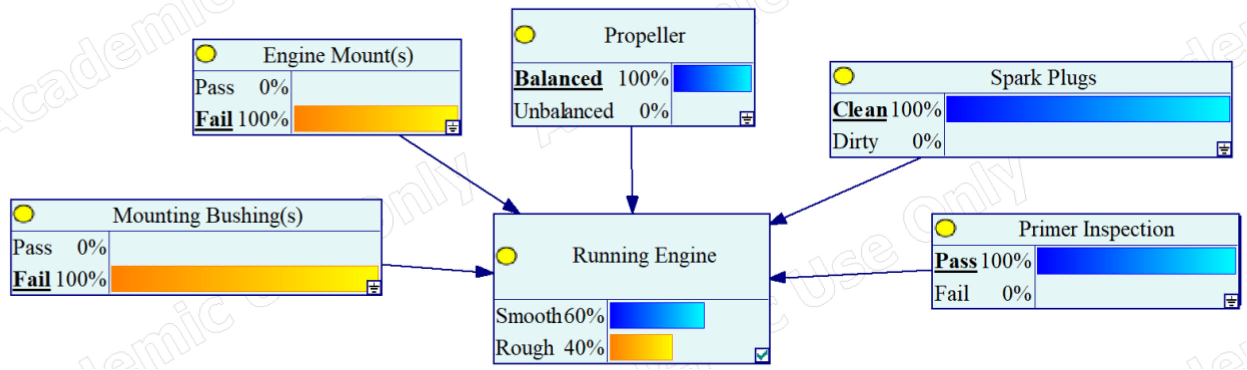
Step 8. Diagnose and Determine Engine Running Condition and Step 9. Prognosis

Instructors. The instructors provide an acceptable airworthiness level and condition for student models.

Students. Based on the given acceptable airworthiness level and condition, update the CBM-BN model; if the updated model has un-airworthy results, then generate a maintenance plan; if the updated model is airworthy, a maintenance plan is not needed.

Example. The *Genie model* allows the operator to control evidence; for example, by controlling 100% of the accuracy level of inspection and/or conditions, the operator can understand the updated predictive level of engine running condition (Refer to Figure 6).

Figure 6
Updated Prediction Level of Engine Running Condition



Each parent node is linked to the child node, which is targeted to determine the condition of the 'Running Engine.' Concerning variables (parent nodes) that are composed of a 'Running Engine,' the operator can predict the level of engine running condition. Referring to Figure 5, if the engine is running smoothly, the value is determined to be 88%. If students want to know the following probability of the engine running smoothly, they will refer to the **Condition** statement. **Condition**: After X-hour operations, students find defective mounting bushings and engine mounts, and the other three variables (propeller, spark plugs, and primer inspection) are in good condition. What is the current probability of the engine running smoothly?

At this point, students selected the two bad variables in failed and selected the other three variables that are good in goods in the *Genie model* (Refer to Figure 6). Then, the CBM-BN model determines the updated chances of running smoothly and roughly for the next operation if maintenance is not performed. In addition, to enhance the validation of this model, the students may be required to declare an acceptable engine running condition. For example, an instructor set 80% as the acceptable airworthiness level for running the engine smoothly. If the outcome is not determined at 80% and only reaches 40% (Refer to Figure 6), then students are required to generate a maintenance plan and perform maintenance concentrated on the issued variables such as 'Engine Mount' and 'Mounting Bushings.' This diagnosis and prognosis practice will provide insights into the understanding of current conditions as well as guide what maintenance practice needs to be done in a current situation.

Step 10. Evaluate the framework and discuss limitations

Instructors. The instructors evaluate students' CBM-BN model per the author's developed assessment items (Refer to Table 6).

Table 6
Assessment Items

BN assessment	1. In the CPT, the sum of the probability values of each child node must equal 1 2. Structure model considering relationships between parent nodes and child node 3. Properly identify the probability/reliability of variables 4. The conditional probability diagram and table guide match the *Genie model*
CBM assessment	1. Logical understanding of target CBM component 2. Model data collection method selections
CBM-BN assessment	1. Corrective model updates based on given conditions by an instructor 2. Maintenance plan generation based on diagnosis and prognosis model output 3. Model practicability evaluation per industry standards (FAA, AC, AD, Manufacturer's Manual, etc.) 4. Analysis of model risks and benefits compared to traditional maintenance strategies 5. Model evaluations: discussion, limitations, future improvements, and final decision

Students. The students evaluate their model through three assessment items, then make a final decision and future development in terms of CBM-BN model policies, standards, and limitations.

Example. This project is designed to work with a small group of three to four students. This intentionally mimics the use of small groups in the aerospace industry. For example, each detailed part of the Boeing 777 is widely distributed to engineers who designed the parts using simulation tools (Madhavan et al., 2016). There are many engineers, but they do not all work together. The aircraft is broken into smaller sections and divided up. A small group of engineers will work on their section before combining it into a larger section until the entire aircraft is complete.

Therefore, student groups will concentrate on one issue of the aircraft troubleshooting table (e.g., Refer to Table 2). The group is expected to build a prediction model of the intended component by referencing the assessment rubric and collecting parameters using reliable resources and equipment such as maintenance manuals, FAA documents, manufacturer documents, and testing equipment. Then, the group will use the *Genie model* program to build the CPT to find the visual outcome of each variable connection (Figures 2 and 3). All groups will analyze and present their focused components and have a discussion session regarding the proper actions of the component if the predictive outcome is a non-airworthy condition.

Discussion

The aviation industry is preparing for a new maintenance strategy. Modern aircraft collect performance data through the Airplane Condition Monitoring System (ACMS) (Sun et al., 2019). Oikonomou et al. (2022) state that new-generation aircraft such as Boeing 787 and Airbus 350 are equipped with thousands of sensors for recording and monitoring health conditions. One example is the aircraft's brake system: "…the aircraft itself measures the position of the actuators when clamped to the carbon discs and infers the carbon thickness from this measurement" (Oikonomou et al., 2022, p. 2). Therefore, aligning with the aviation industry's direction, aviation maintenance institutions should teach CBM strategy to prospective students. This proposed CBM-BN material will help instructors teach the CBM concept to students as well as expand student insights into an aircraft component's failure point by analyzing hidden probability. Moreover, this teaching material enhances students' decision-making techniques.

The current aviation industry has aimed to meet the goal of the International Civil Aviation Organization (ICAO)'s 2050 carbon net zero (n.d.). By reviewing Ha et al. (2022) study, the researchers find that this CBM-BN education method can be a way to foster sustainable concepts in students by contributing to operational improvements. Therefore, in the future, a mechanic who can do CBM analysis will be more beneficial and demandable in the job market and contribute to full CBM implementation.

This research requires two future developments to be a step closer to a practical approach and increase model creditability. CPT calculation verification and CBM-BN output validation are required with actual industry data. First, manual coding by subject matter experts (SMEs) is essential to compute CPT and map the original CBM-BN network (Yang & Mott, 2020). Second, it is important to find the relational weights between the child node and the parent node. In other words, find the causality of the failure and evaluate the components' contribution to the failure (Pitchforth & Mengersen, 2013). When students carefully compute the correct probabilities, taking into account the root cause of the failure, and enter them into the correct nodes, then Genie software computes diagnosis and prognosis outputs.

For validation of CBM-BN output, it is a process to validate the CBM-BN model's performance by comparing observed and predicted output. Many researchers use various validation methods such as absolute deviation (MAD) (Dinis et al., 2019), mean absolute percentage error (MAPE), root mean squared error (RMSE) (Oikonomou., 2022), mean squared error (MSE) (Ferreiro & Arnaiz, 2011), and relative error (Sun et al., 2019).

Limitations

The limitation of this study is that CBM-BN is one approach among various CBM approaches. The disadvantage of the BN is that when multiple factors are considered together, the logic will be complex and require substantial data (Rath et al., 2022). Therefore, future researchers are required to study other analytical CBM skills that can compensate for the disadvantages of the CBM-BN model and increase the maturity level of CBM operation. As discussed in the literature review, Boeing highlighted the importance of analytical skills to the new technicians' generation, so more CBM skills and techniques need to be developed and taught to the next generation of aviation technicians. For example, other CBM techniques include hidden Markov chain modeling, Artificial Neural Networks (ANN), Fuzzy Logic (FL), and Convolutional Neural Networks (CNN).

Conclusion

This paper aims to provide training materials for instructors to educate prospective aviation technicians on a new strategy for aircraft CBM modeling that can be used in any FAA CFAR Part 147 aviation maintenance program. The authors review the issues and challenges of the industry. To ease the hurdle of the CBM implementation challenge, the authors propose CBM training materials for the aviation maintenance program in line with future industry needs. The authors create CBM models using the BN. The CBM-BN training material is supplemented with an example. Prospective aviation technicians are expected to learn the CBM-BN and apply it to the construction of CBM strategy. CBM-BN analytical skills knowledge will be beneficial to potential technicians and a more important skill set in the future. Moreover, other CBM educational materials would be needed to compensate for the downside of BN and increase the maturity level of CBM.

Acknowledgment

The CBM-BN model is developed using the *Genie* model (Refer to Figures 3 and 4), available free of charge for academic research and teaching use from BayesFusion, LLC, https://www.bayesfusion.com/.

Conflict of Interest Statement

The authors declare no conflict of interest.

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Benchmarking Australia and New Zealand Aviation Academic Research Output between 2017 and 2021

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The purpose of this study was to achieve a better understanding of the boundaries of the aviation education discipline and academic composition as well as patterns of research output in tertiary aviation education in Australia and New Zealand. This study developed a framework to identify aviation academics in Australia and New Zealand and operationalized a definition for aviation research. Based on these boundaries, a database of aviation academics and associated peer-reviewed research publications over a 5-year period between 2017 and 2021. From the database, this study was able to identify staffing profiles of aviation academics as well as patterns of research output at different levels of seniority to include the ratio of research publications that were considered aviation and non-aviation. Additionally, based on the relevant research area represented by journals of publication, aviation research disciplines were inductively developed. The study found that research outputs increase across levels until Level E, at which publications drop sharply, and that non-aviation research output was present at all levels but notably higher at Level C and Level D. It also found a research output profile for each level for both aviation and non-aviation research that can support performance benchmarking. In addition, the study identified seven aviation research disciplines based on the research area of periodicals in which aviation research was published. Lastly, the study highlighted the significant challenge of distinguishing aviation research and identifying aviation academics as well as limitations for external quantifying aviation research performance.

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Introduction

The body of academic research that supports the aviation industry as a component of greater STEM research is growing in importance and impact (Li et al., 2020). However, in the academic community, aviation researchers, as well as practitioners who identify as researchers in aviation, lack clear definitions; applied research in aviation is prevalent throughout a wide range of disciplines, including psychology, law, education, communication, and organizational management (Dunn et al., 2022; Lee et al., 2017; Wu and So, 2018). But while Australia and New Zealand have a mature system of categorizing research fields and disciplines, there is no category for comprehensively addressing aviation research that reflects the community of practice. This is problematic in two ways: first, for assessing the research output of academics with regard to a defined professional standard (for professional development purposes). It also creates difficulty in tracking the discipline-level capability of a university's research team, as research may be classified under a related discipline individually. This presents challenges for both individual academics and academic institutions alike; accurate evaluation of research output in context is useful for performance tracking and strategic decision-making (Broome and Swanepoel, 2020; Donkin et al., 2020). The purpose of this research is to achieve a better understanding of the boundaries of the aviation education discipline and academic composition, as well as research output in tertiary aviation education in Australia. It operationalizes a definition for aviation research and seeks to develop a standard profile of performance for academics that is based on aviation research output as well as identify patterns of publication for aviation research and key journals. A better understanding of what constitutes aviation research, typical profiles of publication performance at different levels of seniority, and where aviation research is being published will not only help academics self-evaluate and set goals for their professional development but also provide more clarity for universities seeking to ensure staff research is appropriately captured.

Literature Review

The Australian and New Zealand Standard Research Classification (ANZSRC) provides for a system of categorization against which academic research can be assessed. It utilizes three different approaches to understanding what kind of research is being produced: activity-based, discipline-based, and impact-based (Bureau of Australian Statistics, 2020a).

The ANZSRC Type of Activity classification organizes research "…according to the type of research effort, namely, pure basic research, strategic basic research, applied research, and experimental development" (Bureau of Australian Statistics, 2020b, Explanatory Note 2). This classification does not consider the discipline of research involved, simply how the activity might be considered from a methodological perspective.

The other two ANZSRC classification systems do consider the relevant discipline. The Field of Research (FoR) classification system is specifically discipline-based. It seeks to organize research around "common knowledge domains," and a FoR code is intended to "describe the nature of the research being performed and reflects the area of knowledge discovery" (Bureau of Australian Statistics, 2020c, Explanatory Note 2). This system utilizes a numeric code to identify related research at three levels: division, group, and field. Divisions have two-digit codes and are further specified into groups by adding two additional digits. Groups are further specified into fields by adding two more digits, creating a six-digit field code. If two fields fall under the same group and division, this will be reflected by both fields having the same first four digits. Whereas if two fields fall under the same division but fall into different groups, only the first two digits of their codes would match. Divisions include broad areas of research, including health sciences, law and legal studies, and education. There is also a division of Engineering, under which sits the group of Aerospace Engineering, within which there are eight fields: aerospace materials; aerospace structures; aircraft performance and flight control systems; avionics; flight dynamics; hypersonic propulsion and hypersonic aerothermodynamics; satellite, space vehicle and missile design and testing; and aerospace engineering not elsewhere classified. In this classification system, there is no distinction between aviation and aerospace, and aviation is not addressed as a division, group, or field.

In the ANZSRC Socio-Economic Objectives (SEO) classification system, research is organized based on the outcome or area of impact of the research. It uses the same nomenclature of division, group, and field as the FoR classification system. However, the category titles are different. In this system, there is a division of transport that is grouped into aerospace transport, environmentally sustainable transport activities, ground transport, water transport, and other transport. The aerospace transport grouping is described as "…R&D directed toward improving the efficiency, safety, and utility of international and domestic air transport for passengers, freight, and livestock" (Bureau of Australian Statistics, 2020d, Table 4). It includes fields of air freight, air passenger transport, air safety and air traffic management, air terminal infrastructure and management, autonomous air vehicles, space transport, and aerospace transport not elsewhere classified.

While the ANZSRC provides a framework for assessing areas and significance of research impact, measuring individual academic performance is complex, as well as establishing in-field profiles of performance. Research has indicated a need to better understand research productivity at the discipline level. Broome and Gray (2017) explored how occupational therapy academics produce research and contribute to their field across various levels of seniority to develop profiles of performance. The resulting profile suggested benchmarks in the areas of publications, citations, and co-authorship. The researchers outlined implications for both academics and universities; for individuals, benchmarking can be useful for self-evaluation career planning. For universities, benchmarking "can be used to guide appointment levels during recruitment, academic promotion opportunities, and professional development discussions" (Broome and Gray, 2017, p. 405).

Similar benchmarking exercises have been completed in other disciplines and are not a new endeavor. The exercise of benchmarking research output and patterns of publication was conducted by Howard et al. (1987) with the aim of assessing institutional research quality. In

Australia, Broome and Swanepoel (2019) conducted a similar study in the area of dietetics academics to benchmark research output. Donkin et al. (2020) explored research track records with regard to academic levels in the area of medical science. Echoing the sentiment of Broome and Gray (2017) and Broome and Swanepoel (2019), Donkin et al. (2020) identified a need to establish field-based standards for the assessment of research productivity, noting:

> University-wide expectations of research performance are often applied to promotion without considering intricacies and variances between disciplines. For example, for academics publishing high-quality research of value to society in less populous fields (e.g., medical education), it may be prudent to accept lower citation rates when judging against benchmarks. (p. 7)

Subsequently, these studies have been able to benchmark productivity with their respective disciplines, including but not limited to the number of publications by appointment level as well as profiles of academic output using different metrics such as h-index, citations, and coauthors.

Other studies have explored research breadth, productivity, and targeted journals in STEM. Li et al. (2020) conducted a systematic review of STEM-designated research between 2000 and 2018 with the aim of exploring how to quantify STEM research outputs and identify patterns of publication. Similarly, Li et al. (2019) analyzed the first five years of publication of the International Journal of STEM Education to explore demographic factors of publication and access, as well as publication trends within the discipline.

While there is a precedent for discipline-level benchmarking of academic performance in well-defined disciplines, the field of aviation has the added challenge of needing to identify the boundaries of the discipline. This is not unique to aviation; studies that have attempted to quantify research outputs, disciplines, and publication patterns have grappled with the methodological challenge of defining/operationalizing a working definition for the field. In many cases, research has relied on either author self-identification or keywords in article titles to determine their inclusion as data, such as Li et al. (2020) and Mizell and Brown (2016). As to this problem with the STEM field, Li et al. (2020) note, “A review of research development in a field is relatively straightforward when the field is mature, and its scope can be well defined” (p. 2), and “Multiple perspectives about the meaning of STEM education adds further complexity to determining the extent to which scholarly activity can be categorized as STEM education” (p. 2). These parallel challenges in STEM highlight this difficulty in the field of aviation.

To better understand the scope and publication patterns of aviation academics throughout Australia, this study poses the following research questions:

> Research Question 1: What is the staffing profile of academics at tertiary aviation education institutions in Australia and New Zealand?
>
> Research Question 2: What are the patterns of research output of aviation academics in Australia and New Zealand?

RQ2a. What is the volume of output at various levels of organizational seniority?
RQ2b. Which journals are targeted for aviation academic-generated research?
RQ2c. Which research disciplines in aviation are represented by publication patterns?

Methodology

Aviation Academic Research Output Database

For this study, a database was developed of publicly accessible staff and research outputs of universities that have tertiary aviation education programs in Australia and New Zealand that are distinct from engineering disciplines (e.g., Aerospace Engineering). This was done by identifying relevant universities with aviation degrees at the bachelor level or higher using a general search engine. Full-time academics that teach and/or conduct research in the context of these programs were identified using that university's aviation contacts page or, if none, searching that university's name and aviation as keywords. Honorary, emeritus and adjunct academics were excluded.

Each academic in the database was cross-referenced with Scopus and Web of Science to establish their profile of publications between January 2017 and December 2021 (a five-year window). Each piece of research was categorized as being aviation-related or non-aviation-related. For the purpose of this study, the definition of aviation research was operationalized to include any research that supports the development, operations, and management of global civil aviation, excluding research that was reasonably considered part of an engineering discipline. For each piece of aviation research, the journal of publication was recorded, as well as its associated discipline areas identified through Scopus/SJR Scimago Journal and Country Rank.

Method

To answer RQ1 regarding staffing profiles of aviation academics, descriptive statistics were generated to understand the distribution of academics by seniority as well as their composition of teaching and research duties. To establish patterns of aviation and non-aviation research outputs, publications were first identified as being aviation or non-aviation publications per the operationalized definition of aviation research used for the study.

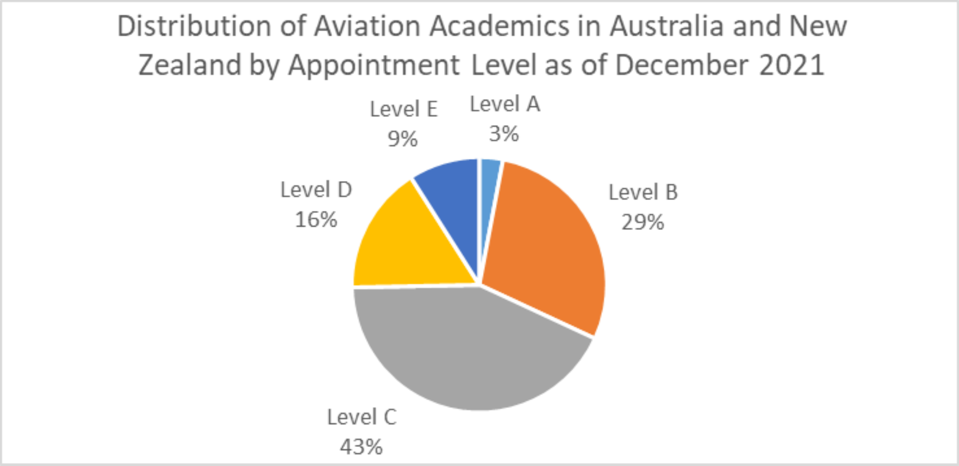
RQ2 investigated aviation research output from three aspects: number of publications by seniority level (RQ2a), which journals were targeted for publication across aviation academics (RQ2b), and what aviation research disciplines are represented by publications (RQ2c). For RQ2a, descriptive statistics were used to describe aviation research output from academics organized by academic seniority. For RQ2b regarding the journals targeted by aviation academics, journals (as well as book chapters) were ranked according to their unique publications from the data set; where multiple researchers had collaborated on a single journal article, it was only included once. Additionally, the H-index of the periodicals was obtained to explore any relationship between journal quality and volume of output. To answer RQ2c regarding the research disciplines represented, the relevant research area of each aviation publication was established by cross-referencing the publication with the discipline areas of that particular journal as defined by Scopus. Where multiple research areas were associated with a journal, the most relevant area was selected to represent the publication; to ensure reliability, this was established by both researchers. Those areas were then consolidated into like-categories to establish research disciplines within aviation.

Results

RQ1 addressed identifying aviation academics in Australia and New Zealand in terms of appointment level and discipline areas of their aviation publications. It explored the staffing profile of academics at tertiary aviation education institutions in Australia and New Zealand. The database identified 56 academics across nine universities in Australia and New Zealand, distributed across standard academic levels A-E as of December 2021, as shown in Figure 1. Senior Lecturers (Level C academics) represented 43% of the population. Associate Lecturers, Lecturers, Associate Professors, and Professors, respectively, comprised 3%, 29%, 16%, and 9% of the population.

Figure 1

Distribution of Aviation Academics in Australia and New Zealand by Appointment Level as of December 2021

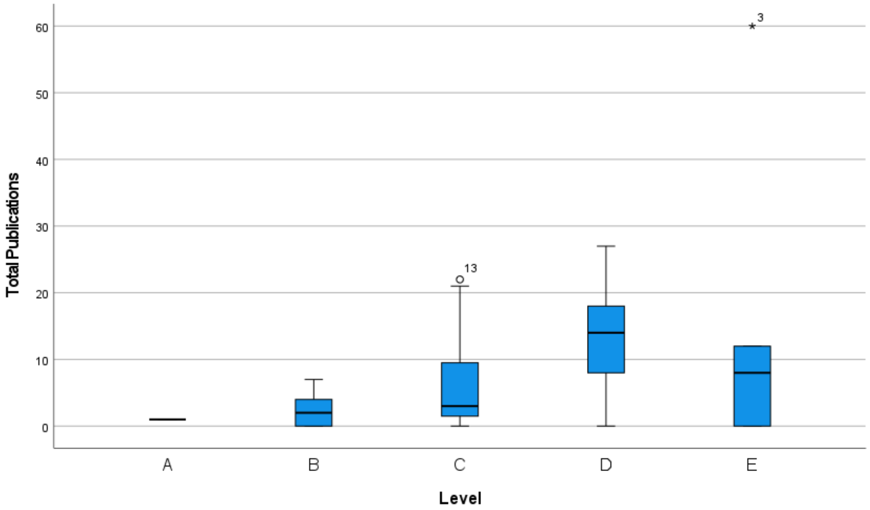


Regarding teaching and research duties among the 56 academics, on average, 43 (77%) were identified to have teaching and research roles, while 10 academics (18%) were identified as teaching only. The remaining three (almost 5%) were identified to hold only an administrative or leadership role as well as a teaching and research role.

RQ2 addressed patterns of research output of aviation academics in Australia and New Zealand, with RQ2a exploring research output as a function of academic level. Of the academics whose role included research, Figure 2 presents boxplots of the breakdown of total research output between 2017 and 2021 at each level.

Figure 2

Boxplots of the total research output of Australia and New Zealand aviation academics between 2017 and 2021



For the Level E group (full professor academics), one potential outlier was identified; one academic's publication record was more than three times the interquartile range above quartile three for total research. Considering the potential for influence affecting the interpretability of results for this category, the results below present both the original Level E data as well as Level E adjusted data that exclude the outlier.

Corresponding to Figure 2, Table 1 shows the means and standard deviation of total research output as well as aviation research output by Australia and New Zealand aviation academics between 2017 and 2022.

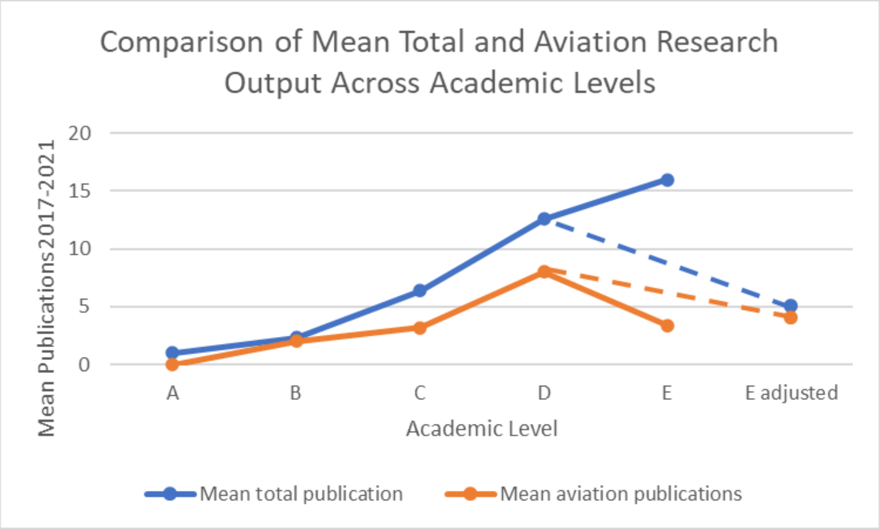
Table 1

Descriptive statistics for all research output by level between 2017 and 2021.

Level	N	Mean Total Research	Total Research Std Deviation	Mean Aviation Research	Mean Aviation Research Std Deviation
A	1	1	-	0	-
B	12	2.33	2.309	2	2.174
C	20	6.4	6.847	3.2	3.847
D	9	12.56	8.974	8	8.322
E	5	16	25.14	3.4	4.219
E adjusted	4	5	6	4	4.169

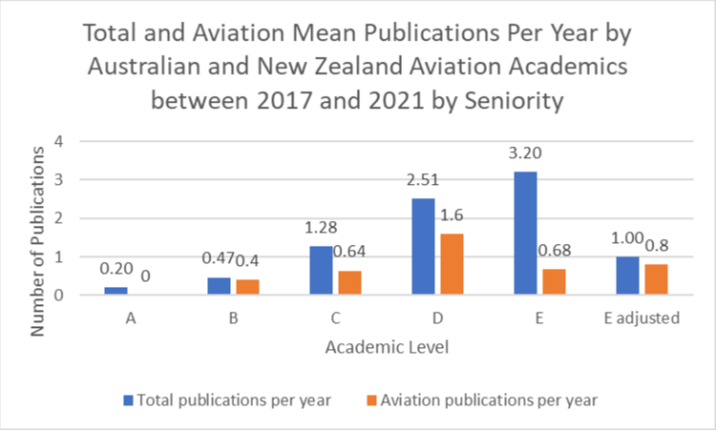
Further to this, a comparison of mean total research output over the five-year window and mean aviation research output is shown in Figure 3. This provides an indication of the percentage of research outputs at each level that were determined to be aviation research outputs. For Levels A-E (including E adjusted), the percentages of total research that were aviation research over the interval of 2017-2021 were found to be 0%, 85.7%, 50%, 63.7%, 20.2%, and 80%, respectively.

Figure 3
Comparison of mean total research output and mean aviation research output across academic levels.



Additionally, the mean number of publications per year over the five-year window of 2017-2021 is displayed in Figure 4. This provides an indication of the average annual research productivity for an aviation academic whose role encompasses research. Figure 4 distinguishes between total research outputs and aviation research outputs.

Figure 4
Total and aviation mean publications per year by Australia and New Zealand aviation academics over 2017-2021.



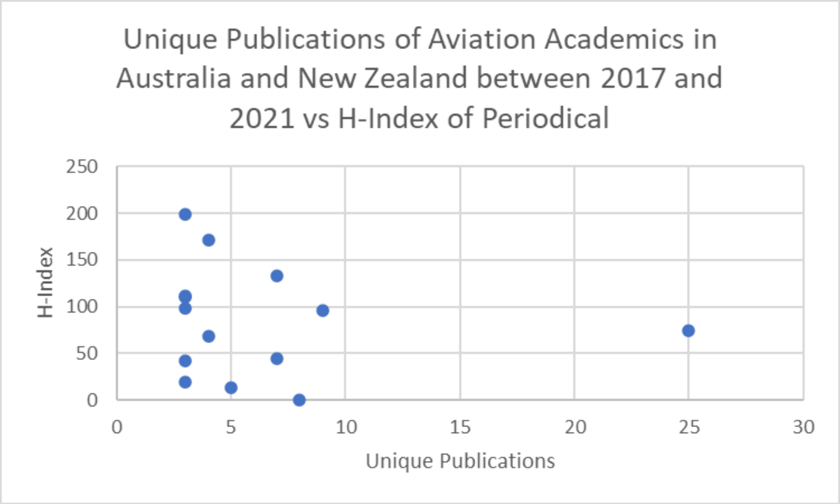
RQ2b explored journals that were targeted for publication by aviation academics between 2017 and 2021. During this interval, aviation academics across Australia and New Zealand published 326 journal articles and books/book chapters, of which 156 were aviation-related based on the operationalized definition of aviation research used for the purpose of this study. Among the 156 publications, 148 of them were published in 68 academic journals, while eight outputs were books/book chapters. The most frequently targeted journal of publication was found to be the Journal of Air Transport Management, in which 25 unique research outputs were identified. Table 2 exhibits journals of publication for aviation academics' research outputs, where there were at least three unique publications between 2017 and 2021. Those 13 journals accounted for 79 publications, representing 53.4% (79 out of 148) of the research outputs of aviation academics. Not listed in Table 2 were the 16 journals that had two unique publications and the remaining 39 journals that had a single unique publication. In addition, Table 2 lists the impact factors (H-Index) of the journals, which ranged from 2 (Air and Space Law) to 199 (Tourism Management).

Table 2
Journals with greater than three unique publications by aviation academics in Australia and New Zealand between 2017-2021.

Name of Journal	Unique Publications	H-Index (SJR)	CiteScore (Scopus)
Journal of Air Transport Management	25	75	10.2
Transport Policy	9	96	10.7
Book or Book chapter	8	N/A	N/A
International Journal of Aerospace Psychology	7	44	1.8
Transportation Research Part A: Policy and Practice	7	133	12.4
Aviation	5	13	2.4
Aerospace Medicine and Human Performance	4	69	1.1
Annals of Tourism Research	4	171	15.9
Aerospace	3	19	3.0
Applied Ergonomics	3	98	6.9
Safety Science	3	111	12.4
Tourism Management	3	199	22.9
Transportation Planning and Technology	3	42	3.6
Transportation Research Part E: Logistics and Transportation Review	3	110	14.7

Additionally, Figure 5 explores the relationship between the volume of unique output and the H-index of the set of periodicals in Table 2.

Figure 5
Unique publications of aviation academics in Australia and New Zealand between 2017 and 2021.



The observed correlation between the number of unique publications and the H-Index was found to be -.107, corresponding to p=.728. Considering the Journal of Air Transport Management as a potential outlier, the correlation between the unique publications and H-Index for all publications excluding it was found to be -.082, corresponding to p=.801.

RQ2c sought to identify the research disciplines represented by the pattern of research publications by aviation academics between 2017-2021. To address RQ2c, the 148 aviation research outputs were cross-referenced with the research area of their journal of publication. As a result, 26 unique research areas were identified, as shown in Table 3. To identify research disciplines, those 26 research areas were amalgamated into like-categories. This process yielded seven research disciplines: Engineering, Human Factors, Safety, Management, Tourism, Transportation, and Other.

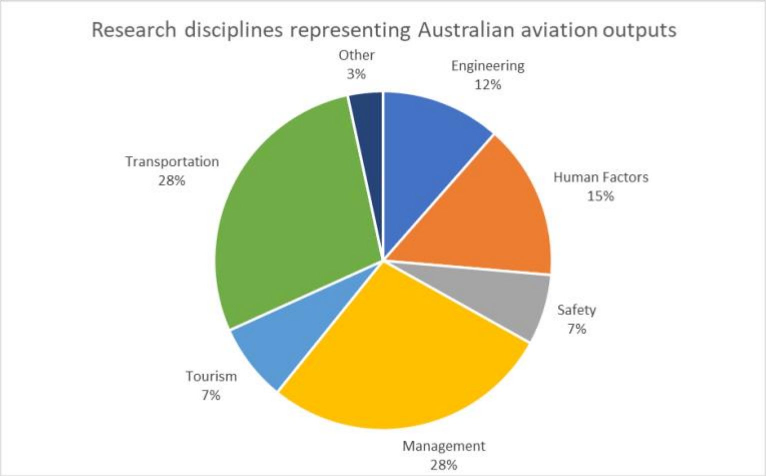
Table 3
Disciplines associated with research areas corresponding to Australia and New Zealand aviation publications between 2017 and 2021.

Discipline	Research Area	Frequency
Engineering	Aerospace Engineering	12
	Civil and Structural Engineering	1
	Mechanical Engineering	2
	Materials Science	2
	Total	17
Human Factors	Human Factors and Ergonomics	7
	Human-Computer Interaction	2
	Public health and Occupational health	4
	Applied Psychology	7
	Experimental and Cognitive psychology	2
	Total	22
Safety	Safety Research	7
	Safety Risk Reliability and Quality	3
	Total	10
Management	Strategy and Management	30
	Management	2
	Management, Monitoring, Policy, and Law	2
	Law	1
	Business, Management, and Accounting	1
	Management Science and Operations Research	1
	Marketing	1
	Information Systems and Management	3
	Total	41
Tourism	Tourism, Leisure and Hospitality Management	11
	Total	11
Transportation	Transportation	40
	Operations Research Transportation	2
	Total	42
Other	Social Sciences	1
	Urban Studies	1
	Emergency Medicine	1
	Education	2
	Total	5

Figure 5 shows the percentage of each of the seven identified research disciplines relative to the totality of aviation research. With 28.4% (42/148), Transportation was found to be the largest discipline represented. Following closely was Management, which represented business-related areas such as strategic planning and decision-making in aviation, representing 27.7%

(41/148) of the total publications. Third was Human Factors, which represented 14.9% of outputs. Ranked fourth was the category of Engineering, which, despite the removal of non-aviation research, represented 11.5% of the outputs. The categories of Tourism, Safety, and Other represented 7.4%, 6.8%, and 3.4% respectively, as shown in Figure 5.

Figure 5
Research disciplines representing Australia and New Zealand aviation outputs between 2017 and 2021



Discussion

The research was found to be a required component of the vast majority (77%) of aviation academic positions in Australia and New Zealand. From a professional development perspective, this suggests that the research output is, in some capacity, part of the expectation of productivity and career progression. Though inadvertent exclusion of academics by the methodology was possible based on the search criteria, the Aviation Academic Research Output Database compiled for this study provided some insight into the profile and productivity of aviation academics in New Zealand and Australia. Further to this, it is important to note the limitations of the Aviation Academic Research Output Database, namely that it only explored a specific 5-year window. It is possible that there have been changes to seniority level or position description by staff members within this window, and it is possible that confounding events (such as the COVID-19 pandemic) disrupted research patterns. As such, the academic level of a staff member was recorded based on their status in December of 2021; for example, a Lecturer (Level B academic) who was promoted to Senior Lecturer (Level C academic) in 2018 would be included in the database as Level C. Further research could seek to approach quantifying research output by longitudinally assessing academics and averaging their research output at each level, which may provide additional insights.

From a productivity perspective, average total research outputs per year were observed to range from .2 (Level A) to 2.51 (Level D, excluding the Level E outlier). These numbers include research that was not considered aviation-related; looking at only aviation research yields outputs ranging from zero (Level A) to 1.6 (Level D). Looking at the boxplots in Figure 2, it is important to note that at nearly all levels, for both total research and aviation research, zero was within one standard deviation of the mean.

The implication of zero being within the standard deviation of the mean research output, as well as the presence of academics at all levels that did not publish any research outputs between 2017 and 2021, is suggestive of career progression without (or with minimal) research engagement. Further research should investigate this possibility; there may be a disparity between published position descriptions and operational expectations by universities. If universities value operational contribution differently from how positions are described for employment and promotion purposes, they should explore better aligning the two. It is also important to note that this study did not account for research impact or research quality. These may vary between or within academics and may play a role in career progression. Additionally, given the complexity of even defining aviation research, there may be other ways of evaluating research engagement that was not captured in the scope of this study (e.g., student supervision, non-peer-reviewed publications, industry collaboration, funding, etc.).

Within the scope of this study, research outputs appear to increase steadily across levels up to Level C/Level D and drop considerably at Level E. Future research should address why Level E research output (especially aviation outputs) is comparatively low. Factors that may help to explain this reduction might include a reduction of motivation to advance (as Level E is the highest academic rank) or the expectation of administrative and management duties at that level. The outlier identified in the Level E group of academics presents an interesting situation in that it represented a high level of research output that did not meet the criteria for aviation research for this study. Considering the low number of Level E aviation academics in Australia and New Zealand with comparatively low and/or inconsistent research output, there may not be a clear understanding of the university expectations of career advancement of aviation academics and the role of research in this progression. As such, further research may consider investigating the research performance/research career progression of Level E academics at the individual level to account for unique experiences. Future research can also address whether this phenomenon is consistent with other academic fields that incorporate significant technical training, licensure, and administrative oversight.

Further to this, regarding the ratio of aviation and non-aviation research, this study found that non-aviation outputs appear to be present consistently across levels and are the largest ratio of total publications at Level C and Level D. While this finding is consistent with the observation of multidisciplinary research across STEM by Li et al. (2020), future research should seek to unpack this phenomenon among aviation researchers. While interdisciplinary research might be valued, there may be elements of pressure or the need to conform to institutionally set academic promotion research output standards. If the pursuit of interdisciplinary research is not organic in nature for aviation researchers, this endeavor may be a distraction from engaging in more impactful research.

Regarding the journals targeted by aviation researchers in Australia and New Zealand between 2017 and 2021, the Journal of Air Transport Management was the dominant destination for aviation research. Beyond that, there appeared to be diversity in publication destinations, including book chapters/books, which were found to be the third most popular research output. While this study did not explore the decision-making behind publication destinations or whether there were failed attempts at publication prior to acceptance, it did observe no correlation between publication frequency and H-Index. The apparent absence of a relationship between journal popularity and publication frequency of aviation research is noteworthy.

An exploration of the emergent research disciplines based on the journal topic areas from aviation publications yielded noteworthy results. This study defined aviation research as "any research that supports the development, operations, and management of global civil aviation, excluding research that was reasonably considered part of an engineering discipline." Despite the specific exclusion of engineering-related research from this definition, engineering was still found to be an emergent discipline based on patterns of publication (with 17% of aviation research aligning to engineering areas). Further to this, the most dominant disciplines were found to be Transportation (28.4%) and Management (27.7%). While management was associated with a variety of business-related areas, what actually constitutes "transportation" remains elusive. For transportation to be a genuine discipline, its definition must be distinct from the definition of aviation research operationalized by this study as well as the other observed disciplines.

Regarding the other observed disciplines, there were some noteworthy findings. Tourism, which was distinct from the management topics as it tended to relate to human behavior patterns, may indeed have some overlap and could possibly be amalgamated into the management discipline. Safety and Human Factors appeared to be reasonably well-defined disciplines based on the associated research areas. However, there were two particularly remarkable findings associated with RQ2c. First, there were only two unique outputs associated with education. Considering academic work in the field of education itself and the magnitude of aviation training in this context, the near absence of scholarship in teaching and learning research is noteworthy. Along these lines, the other remarkable finding was that there was no observed discipline that captured aviation professional performance (pilot, mechanic, management, and other personnel) in either an operational or training environment. Research has been conducted in these areas. However, it is either not in a great enough volume over 2017-2021 to be captured by this study or is associated with inconsistent patterns of publication and is distributed across other disciplines. It is simply possible that the Scopus framework lacks the ability to distinguish this, similar to the challenges faced by the ANZSRC with its research classification frameworks. These findings are consistent with the challenges of defining the field identified by Li et al. (2019) and Mizell and Brown (2016).

Conclusions

This study sought to operationalize a definition for aviation academics and aviation research to better understand patterns of research outputs, including productivity and representative research areas and disciplines. Findings from this study suggest that, on average, productivity across academic levels increases but drops sharply at Level E, with non-aviation research contributing to total research output at all levels. For benchmarking purposes, average total research outputs per year based on a 5-year window of observation were found to be .2, .47, 1.28, 2.51, 3.20, and 1.0 for aviation academics at Level A, Level B, Level C, Level D, and Level E, respectively.

There remains confusion about the boundaries of aviation research as well as how aviation academics are identified. This presented significant limitations for this study and should be the subject of further research. The apparent disconnect between how research is positioned for publication, how aviation research contributes to the career progression of aviation academics, and how external entities (such as universities) quantify and make sense of aviation research appears to be an ongoing struggle.

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Do Compressed In-Person Classes Yield Student Performance Results Comparable to Traditional 16-Week In-Person Classes?

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Institutions of higher learning are offering an increasing number of compressed in-person classes with the goal of providing to their diverse student populations flexibility of instruction delivery. Southern Illinois University (SIU) and many other colleges are offering an increasing number of classes with compressed schedules to increase student enrollment (Krug et al., 2015). The increase in the number of compressed classes presents the challenge of ensuring that the same academic rigor and breadth of knowledge are maintained in comparison to the traditional 16-week semester. Therefore, it is necessary for the compressed courses to provide the same student learning outcomes and cover the same course material, requiring faculty to use the same textbooks and course content. The purpose of this research study was to determine any variance in overall student academic performance after two groups of undergraduate students completed the same course taught in two different modalities, as indicated by comparing students' final course grades. This study compared the performance of two groups of undergraduate students enrolled in the same Southern Illinois University (SIU) course that was delivered in two different modalities. An independent samples t-test was conducted in SPSS to determine if there was a significant difference between the on-campus and off-campus classes' final course grades. There was no significant difference found between the on-campus and off-campus classes. These results suggest that the delivery formats of the course, traditional 16-week format or compressed off-campus weekend format, did not result in meaningful differences in the final course grades for the participating classes.

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Institutions of higher learning are offering an increasing number of compressed in-person classes with the goal of providing to their diverse student populations flexibility of instruction delivery. Flexibility of instruction provides course schedules and formats that meet the needs of a diverse student population. This depends upon the institution of higher learning to provide the courses the students need, at the time the students need them, and in the desired modality (Kelly, 2008). Compressed courses are offered during a reduced schedule in comparison to the traditional 16-week college semester. Such arrangements provide students with increased flexibility by allowing the students to complete three eight-week classes, one after the other. It allows the student to concentrate on fewer courses at one time during the semester. Some students have life challenges, such as work and family obligations, and flexibility of instruction delivery can help students overcome some of these challenges.

The compressed courses offer the same number of student contact hours as the traditional 16-week courses. Therefore, it is necessary for the compressed courses to provide the same student learning outcomes and cover the same course material, requiring faculty to use the same textbooks and course content. In addition, compressed courses must require students to complete comparable student performance assessments such as writing-based assignments, quizzes, and examinations (Choudhury, 2017).

Statement of the Problem

Southern Illinois University (SIU) is accredited by the Illinois Board of Higher Education (IBHE). The Aviation Management (AVM) program is reviewed by the IBHE on an eight-year cycle (SIU-Provost and Vice Chancellor for Academic Affairs, n.d.). Because the AVM undergraduate program has two modalities, on and off-campus, SIU must provide evidence that assessment will be consistent across both modes of delivery and all locations (SIU- Provost and Vice Chancellor for Academic Affairs, n.d.).

SIU and many other universities are offering an increasing number of classes with compressed schedules to increase student enrollment (Krug et al., 2015). The increase in the number of compressed classes presents the challenge of ensuring that the same academic rigor and breadth of knowledge are maintained in comparison to the traditional 16-week semester. As an increasing number of students pursue classes with compressed schedules, it is difficult to ensure that these students are receiving the same quality of education as students who pursue a traditional class format. One method to validate the parity of the two modalities is to evaluate student performance. For this reason, it is necessary for the AVM program to compare student performance at the SIU AVM off-campus locations with those AVM students at the SIU main campus in Carbondale, Illinois.

Purpose of the Study

The purpose of this research study was to determine if students enrolled in off-campus classes with compressed schedules were receiving the same quality of instruction as students enrolled in traditional on-campus 16-week courses. This study compared the performance of two groups of undergraduate students enrolled in the same SIU course that was delivered in two different modalities. Data was collected from students enrolled in the *AVM 305: Aviation Industry Career Development* course taught in the traditional 16-week classroom setting on the SIU main campus in Carbondale, Illinois, and from the students enrolled in the off-campus compressed course taught at the Community College of Beaver County in Monaca, Pennsylvania. The courses used the same curriculum and were taught by the same instructor. The data consisted of course grades associated with student performance assessments.

Research Question

The following research question and stated hypotheses were addressed by collecting and analyzing performance assessment data from undergraduate students enrolled in SIU AVM coursework:

RQ: Is there any variance in overall student academic performance after two groups of undergraduate students complete the same course taught in two different modalities, as indicated by comparing students' final course grades?

a. Null Hypothesis *(H0)* - There is no variance in overall student academic performance, as indicated by students' final course grades after two groups of undergraduate students complete the same course taught in two different modalities.

b. Alternative Hypothesis *(H1)* - There is a statistically significant variance in overall student academic performance, as indicated by students' final course grades after two groups of undergraduate students complete the same course taught in two different modalities.

Significance of the Study

Research has compared the performance of students enrolled in compressed and traditional in-person classes (Sheldon & Durdella, 2010). However, no research has specifically analyzed the performance of students enrolled in an aviation management-related class offered in a traditional on-campus 16-week format as opposed to an off-campus six-week compressed schedule. The research is unique because it uses the same instructor, class lectures, assessments, and other course materials. The course format, compressed or traditional, is the only difference between how the two courses are delivered to the students. Moreover, the sample of students enrolled in each format is homologous as they are primarily traditional college students. The findings of this study will determine if students are receiving the same educational experience when completing the same class using two different modalities, on and off-campus.

Limitations

This study is limited based upon the voluntary participation of two groups of collegiate aviation students. One group consisted of collegiate aviation management students located at the SIU main campus in Carbondale, Illinois. The other group consisted of collegiate aviation management students located at an off-campus location at a community college in Pennsylvania. In addition, this study is limited by certain uncontrollable variables that cannot be accounted for, such as student motivation, commitment, and academic aptitude.

Literature Review

Many institutions of higher learning are offering more courses with compressed schedules to increase student enrollment (Krug et al., 2015). The compressed course format appeals to students who want to earn a college degree but cannot commit to the traditional course format due to family and work commitments (Krug et al., 2015). It is believed that compressed courses increase student retention, and student retention is needed to increase graduation rates. In 2019, almost two-thirds of jobs in the United States required a postsecondary degree or certificate (Bustamante, 2019). Compressed courses provide students with increased flexibility in comparison to traditional courses taught in a 16-week semester. Moreover, the compressed course schedules also allow students to reduce the time needed to graduate. In 2019, it took students in the United States an average of 52 months to complete a bachelor's degree (Bustamante, 2019). Furthermore, a study has indicated that students prefer compressed courses over traditional courses (Williamson, 2017).

Advantages & Disadvantages of Compressed Courses

Questions have been raised by the collegiate academic community regarding the relationship between course length and course success. Do students enrolled in compressed courses perform as well as those enrolled in traditional 16-week courses? Do students enrolled in compressed courses simply memorize the material quickly and perform well on examinations due to the benefits of short-term memory? Overall, student academic performance must be examined to determine if there is any variation between student success in the two-course formats.

There are many advantages associated with compressed courses. First, compressed courses provide flexible schedules that work best with the schedules of non-traditional students. Non-traditional students are those individuals who are over 24 years of age. This demographic is increasing as non-traditional students now account for approximately 40% of all college students in the United States (Battiste, 2022). According to the National Center for Educational Statistics, 73% of students enrolled at institutions of higher learning are considered non-traditional students (Battiste, 2022). This statistic is based upon a broad definition of a non-traditional student that includes characteristics such as employment and financial status. As stated earlier, institutions of higher learning are trying to attract and recruit a growing population of non-traditional college students. Institutions are trying to accomplish this goal by offering flexible hours to attend classes and rethinking the delivery of degree programs to accommodate those non-traditional students who have jobs (Battiste, 2022). Carman & Bartsch (2017) and Anastasi (2007) list other advantages to compressed courses: (1) the ability of students to quickly build a relationship with professors, (2) increased attendance, (3) decreased course drop rate and fewer incomplete grades, (4) increased graduation rates because the shorter duration of the course decreased the likelihood students would encounter schedule conflicts, and (5) institution's state funding is often linked to graduation rates.

There are also several disadvantages associated with compressed courses, and students need to mitigate these disadvantages to be successful in compressed courses. Krug et al. (2015) and Almquist (2015) list a few disadvantages of compressed courses: (1) some students reported increased mental and physical fatigue, (2) students can quickly fall behind in the course, and (3) not all students possess the motivation and discipline to be successful in a compressed course.

Overall, the study indicated students are more successful in compressed courses regardless of academic ability (Walsh et al., 2019). Again, the success may be attributed to students' ability to focus on fewer classes at one time and increased engagement with the instructor and their classmates. To sum up, institutions of higher learning are finding that compressed courses increase student success rates (Walsh et al., 2019).

Research on Student Performance

A study was conducted by Carnegie Mellon University that compared match-pair courses and student learning (Walsh et al., 2019). The primary difference between the match-pair courses was that one class was six weeks in length while the other was 14 weeks. The study used the final grades as the primary measure of student learning. The study also used student surveys, pre-tests, and post-tests to provide additional information. When the study used the final grades as the only indicator of student learning, the students in the compressed format performed better than their 14-week counterparts (Walsh et Al., 2019).

Several studies found that students of all ages who are enrolled in compressed classes have higher grades and lower withdrawal rates compared with students enrolled in traditional 16-week semesters (Carman & Bartsch, 2017). Several factors influenced these findings. First, the social presence of students in the classroom was more prominent during a compressed format. The students interacted more frequently with each other and the instructor during the compressed courses. Finally, students in compressed courses indicated they devoted more time and energy to their coursework (Carman & Bartsch, 2017). However, a study conducted by Brigham Young University indicated that, between the two-course formats, there was no significant difference in the amount of time students spent completing coursework outside of the classroom (Lutes & Davies, 2017).

Another study analyzed the relationship between course length and student success. Student success can be defined by varying metrics based on the goals of the student and institution of higher learning. The results indicated those students enrolled in the compressed courses experienced higher course success and completion rates when compared to those enrolled in the traditional 16-week course (Sheldon & Durdella, 2010). The results were the same when including demographic factors such as age and ethnicity. However, women were more likely to be successful in a compressed course than men, but the same results were true for the traditional 16-week course. Non-traditional students experienced increased student success in the compressed courses (Sheldon & Durdella, 2010). Overall, students of all ages performed better in compressed courses.

Southern Illinois University

Southern Illinois University (SIU) has a high success rate in the AVM off-campus program. There are several factors that determine an academic program's success; however, the graduation rate for students is one of the most important factors. Over the last two years, the SIU AVM off-campus program has experienced a high graduation rate. The off-campus AVM students complete all the required AVM courses utilizing the compressed format. The students complete three courses during the 16-week semester; however, they are enrolled in only one class at a time. Students meet on Saturdays and Sundays, every other weekend, from 8:00 a.m. until 4:50 p.m., for six weeks.

Methodology

The purpose of this research study was to determine if students enrolled in off-campus compressed classes received the same quality of instruction as students enrolled in on-campus traditional 16-week courses. This study compared the performance of two groups of undergraduate students enrolled in the same SIU course but presented in two different modalities. The collected data consisted of course grades associated with student performance assessments.

Research Design

The research design for this study is applied research. Applied research is a scientific method of inquiry that seeks to solve a specific problem or provide solutions to issues affecting an individual, group, or society (Ayanyemi, 2023). It is crucial that a comparable quality of instruction be received by students in both modalities. Parity concerning academic rigor and breadth of knowledge must be maintained for all students.

Population & Sample

Purposeful sampling focuses on a smaller sample to allow for a comprehensive analysis rather than a larger sample, which can provide more data and accuracy (Creswell & Creswell, 2018). Data was collected from two student groups; one group was enrolled in the on-campus traditional 16-week format, and the second group of students was enrolled in the off-campus course compressed six-week format. The total enrollment for both courses was 40 students. There were 14 students enrolled in the on-campus course and 26 students enrolled in the off-campus course. The selection of the students for participation in the research was based on their fall 2021 enrollment in the AVM 305 course taught at both locations. The students were not excluded from participating based on academic level or academic status. The study did not discriminate based on gender, race, religion, or ethnicity. All the students who participated were volunteers and received no compensation for participating in the study. Key attributes for the two-course modalities are provided in Table 1.

Table 1
Attributes of Two Modalities

Attributes	On-Campus Modality	Off-Campus Modality
Location	SIU Main Campus - Carbondale, IL	Community College of Beaver County - Monaca, PA
Student Enrollment	26	14
Schedule	Traditional 16-Week Semester	Compressed 6-Week schedule
Contact Hours	48 Hours	48 Hours
Instructor	Same	Same
Curriculum	Same	Same
Course Materials & Assessments	Same	Same
Semester	Fall 2021	Fall 2021

Research Instruments

Fourteen (n = 14) on-campus and 26 (n = 26) off-campus students participated in the research study. The student performance assessment data was collected by the researcher based on course assessments and assignments, including (1) three quizzes, (2) six discussion posts, and (3) four assignments.

Data Analysis

The data analysis consisted of an independent samples t-test conducted in Statistical Package for the Social Sciences (SPSS) to determine if there was a statistical difference between the overall academic performance of the on-campus and off-campus students (Bevans, 2023).

Using a t-test establishes a null hypothesis by assuming the means of the two groups are equal (Fernandez, 2020). If the t-test rejects the null hypothesis, then there is a statistically significant variance between the groups. The p-value is the probability that you would obtain your results by chance (Fernandez, 2020). The critical value for this research study is $\alpha = .05$ and will be compared to the p-value from the t-test results:

- *p*_value > α (.05): Fail to reject the null hypothesis of the statistical test.
- *p*_value ≤ α (.05): Reject the null hypothesis of the statistical test.

The critical value of 0.05 means that if an experiment is performed 100 times, 5% of the time, the null hypothesis will be rejected, and 95% will not.

Research Findings

The findings of the research study were analyzed to determine if students enrolled in off-campus classes with compressed schedules are receiving the same quality of instruction as students enrolled in traditional on-campus 16-week courses.

Results

An independent samples t-test determined there was no significant difference between the on-campus (*M* = 83.4, *SD* = 10.3) and off-campus (*M* = 86.3, *SD* = 10.2) classes; *t*(36) = -.820, *p* = .417. These results, Table 2 and Table 3, suggest that the delivery format of the course (traditional 16-week format or compressed six-week format) did not result in meaningful differences in the final course grades for the participating classes. Therefore, the null hypothesis was not rejected.

> Null Hypothesis *(H0)* - There is no variance in overall student academic performance, as indicated by students' final course grades after two groups of undergraduate students complete the same course taught in two different modalities.
>
> Alternative Hypothesis *(H1)* - There is a statistically significant variance in overall student academic performance, as indicated by students' final course grades after two groups of undergraduate students complete the same course taught in two different modalities.

Table 2
Group Statistics

	On/off campus	N	Mean	Std. Deviation	Std. Error Mean
Final Grade	On campus	14	83.4	10.3	2.7
	Off-campus	24	86.3	10.2	2.1

Table 3
Independent Samples Test

				Significance	95% Confidence interval	
	Critical *t*	*t*	*df*	Two-Sided *p*	Lower	Upper
Final Grade	2.028	-.820	36	.417	-9.797	4.154

The data analysis directly compared the final scores for the course between the students enrolled in the traditional on-campus 16-week course schedule and those enrolled in the off-campus compressed course schedule. There was only a small variation in the final grades for the course between the two student groups. The results indicate that there were no significant statistical differences between the two groups.

Conclusions

Conclusions Based on the Research Question

The research question stated, "Is there any variance in overall student academic performance after two groups of undergraduate students complete the same Aviation Industry Career Development (AVM 305) course taught in two different modalities?" An independent samples t-test was conducted in SPSS to determine if there was a significant difference between the on-campus and off-campus final course grades. There was no significant difference found between the on-campus (*M* = 83.4, *SD* = 10.3) and off-campus (*M* = 86.3, *SD* = 10.2) courses; *t*(36) = -.820, *p* = .417. These results suggest that the delivery formats of the course (traditional 16-week format or compressed six-week format) did not result in meaningful differences in the final course grades for the participating students.

Concluding Remarks

Although there was not a significant statistical difference between the two groups of students, several factors required analysis as they may inform researchers of the reasons for the small variations in academic performance between the two groups. First, the compressed course schedule allowed students to concentrate on fewer courses at one time during the semester. This concentration may have allowed students to engage in a deeper learning experience during the compressed courses. The compressed format provided a more concentrated and focused learning experience. A previous research finding indicated decreased procrastination with students in compressed schedule courses, and this appears to hold true with the compressed schedule students in this research (Krug et al., 2015).

The compressed schedule sample consisted of 26 students, and throughout the six-week course, only a total of 3% of all required assignments were not submitted by the students. Conversely, the traditional 16-week courses consisted of 14 students, and a total of 6% of all required assignments were not submitted by the students. It can be concluded, based on the research findings, that the students enrolled in the 16-week course had more opportunities to procrastinate during the semester.
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Next, the same student learning outcomes (SLOs) must be provided to both groups of students. The SLOs identify observable knowledge and skills acquired after course completion, providing evidence that learning has taken place during the course. The student performance assessments allow the instructor to determine if the SLOs were achieved. In contrast, grades evaluate student performance and the quality of a student's work. Based upon the findings, the SLOs were achieved with both groups of students, although the compressed schedule students, based on their grades, exhibited a higher quality of work.

Introducing large amounts of course content to students in a short amount of time may decrease the educational value for some students. Specifically, parity of academic rigor and breadth of knowledge must be maintained for all students. Academic rigor is a standard of quality that instructors expect of their students. The standards to measure academic rigor can vary in objectivity based on performance assessments. The breadth of knowledge refers to the extent or span of knowledge that a student possesses about a subject. The research findings indicated the students from both modalities performed similarly with the same standards of academic rigor and demonstrated comparable breadth of knowledge. Although there was no significant statistical variation regarding overall performance between the two groups of students, the compressed schedule students earned a slightly higher median course grade (M = 86.3), which may indicate a greater breadth of knowledge concerning the subject matter. The findings from this research study corroborate the findings of previous research that indicated academic integrity is the same for courses taught in traditional and compressed schedule formats (Williamson, 2017).

The compressed schedule itself may promote an increased quality of learning experience for the student. The student learning experience is influenced by the characteristics of the instructor, teaching methods, classroom environment, and evaluation methods. The faculty, teaching methods, and evaluation methods were the same for both modalities; however, the classroom environment was different. Courses offered in a compressed format promote the ability of students to quickly build relationships with instructors and other students, which increases student interaction and participation in the classroom. The researcher observed in the classroom setting that the compressed schedule students, as compared with the traditional schedule students, interacted more with each other, as well as with the instructor before, during, and after class. This interaction had a positive impact on the classroom environment for the compressed schedule students.

Recommendations

Based on the findings and conclusions of this research study, the following recommendations have been formulated:

All students must receive a similar quality of instruction and educational experience regardless of modality. To maintain parity between the student groups, a similar curriculum, including course assignments and quizzes, must be used in both courses regardless of course schedules. Academic programs that provide courses using different modalities need to ensure that one master syllabus is used for both courses. The syllabus must provide an accurate and concise course description and objectives. In addition, the SLOs need to coincide with the course objectives and the academic program's SLOs. Providing consistency with these key components within the curriculum and master syllabus is key to providing the same educational learning experience for all students regardless of modality.

The ability of students to meet or exceed academic standards is influenced by the quality of the learning experience received by the student. The instructor is responsible for the overall learning experience provided to the students. The quality of the student learning experience is influenced by the characteristics of the instructor, teaching methods, classroom environment, and evaluation methods. Courses offered in a compressed format promote the ability of students to foster relationships more quickly with instructors and other students. The findings from this study showed the compressed schedule students, as compared with the traditional schedule students, interacted more with each other and the instructor before, during, and after class. This interaction positively affected the classroom environment; therefore, it is imperative that instructors teaching compressed format courses need to establish relationships with students and engage with them early in the classroom environment.

Further Research

This research study concluded that there was no significant statistical variation between the two student groups. Both groups completed the course, with the only variables being the course schedule and location. It would be beneficial to compare the performance of two student groups, with one group completing the course in a classroom environment and the other group completing the course online. Another variable for analysis would be the delivery of the course using the synchronous or asynchronous online course models.

Next, further research with a more diverse student sample may yield varying results. This research study used a homogenous demographic sample. The student population in higher education is becoming increasingly diverse, so a more disparate research sample could provide additional findings concerning student performance in courses based on modality. Demographic diversity could include variations in age, gender, and race.

Finally, additional research is needed using the mixed methodology approach to analyze data, with the qualitative data providing clarity to the quantitative data. An analysis of how the students performed on specific performance assessments is needed, along with the calculation of correlations between variables such as grades on specific performance assessments, demographic data, and qualitative data collected through student questionnaires. Students' level of interest in the course content and career goals are two examples of qualitative data that may provide clarity to the quantitative data. The collection of qualitative data in future research will help explain why the students performed as they did and identify patterns and opinions that could explain the quantitative data.

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Strengthening the Understanding of the Context for Airport City Planning: A Case Study on Airport City Parafield

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Airport Cities have gained momentum all over the world in the last decades. However, Airport City planning often follows a one-size-fits-all blueprint approach, with many elements incompatible with the regional, economic, and cultural context. Using a general aviation Airport City in Adelaide in South Australia as the case context, we survey the retail choices of airport users and compare them with existing facilities and those retail facilities at Airport Cities of large commercial airports from the literature and industry examples. We found that desired retail facilities at Airport City Parafield are widely different from those at large-scale commercial hub airports and commonly promoted in the Airport City literature. The results indicate that preferences for retail facilities in the Airport City differ depending on the airport user groups, which are determined by the role of the airport. These findings suggest that the often practised one-size-fits-all approach in Airport City planning should be reconsidered. In summary, this study helps to augment both knowledge and practice by reinforcing the importance of planning retail facilities in Airport Cities in alignment with the airport role, the airport user groups, and the regional, economic, and cultural context.

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Introduction

Airport Cities are retail and commercial developments on airport land outside the terminals (Freestone, 2011). In Australia, Airport Cities are found in commercial airports, such as Brisbane and Canberra airports, and general aviation airports, such as Parafield, Jandakot, and Essendon (Walker & Stevens, 2008). The rise of Airport City developments in Australia is closely related to airport privatisation through the *Airports Act 1996* (Walker & Stevens, 2008). The *Airports Act 1996* is the only legislation governing land uses within airport land. It grants Airport Cities a wide range of development rights with minimal restrictions on land use types (Walker & Stevens, 2008).

Airport Cities are strategically located commercial sites with fast air connectivity that are intended to serve the ancillary, everyday needs of travel-intensive airport users (Kasarda & Appold, 2010). Not directing the business towards airport users but the demands of the wider urban area may deviate from the concept of an Airport City and will end up being an exchangeable business location and not worthy of the appellation ‘Airport City’ (Kasarda & Appold, 2010; Leeuw, 2019). Furthermore, it is suggested that Airport Cities could generate higher profits and enhance social welfare if they specialise in goods or services oriented toward airport users and avoid consumer goods for non-airport users (D'Alfonso et al., 2017).

An early conceptual paper on Airport City planning from Dr. John Kasarda in 2006 demonstrates a blueprint list of facilities that an Airport City should comprise, including restaurants, retail stores, hotels, and convention centres. This blueprint and similar variants from Kasarda gained massive popularity among Airport City practitioners to the extent that many Airport Cities directly imitated the blueprint (Wiedemann, 2017). If those Airport Cities that copied the blueprint are successful, it is questionable.

In the following years, some conceptual studies and best practices testimonials (for example, Alvendal, 2014; Kasarda & Appold, 2014; Wiedemann, 2014; Nikolova et al., 2018) have started to acknowledge that there is no such thing as one-size-fits-all. Instead, they emphasise the importance of choosing facilities that are suitable to the socioeconomic context of their respective airport users. These studies and industry examples were mainly written in the context of large commercial Airport Cities that serve high-income business employees in professional industries such as engineers, business consultants, and software programmers. These business employees are labelled as the ‘creative class’ by Florida (2012) as their work heavily involves using creativity for problem-solving and developing innovative artefacts. Based on interviews and focus groups, Florida (2012) discovers that self-expressive and experience-oriented cultural and active lifestyle amenities, such as discos and nightclubs, arts festivals and galleries, punk music venues, gyms, and health clubs, are preferred by the creative class. This is because the creative class enjoys being challenged intellectually and physically in these chic cultural and leisure amenities; besides, these chic amenities serve as stimulants for creativity and allow the creative class to structure themselves (Florida, 2012). Studies on the creative class conducted by other authors, such as Bille (2010), Bereitschaft (2017), Esmaeilpoorarabi et al. (2018), and Zandiatashbar and Hamidi (2018), confirm the same preference towards chic cultural and leisure amenities. Subsequently, apart from standard retail facilities such as restaurants, upscale cultural and leisure attractions are often suggested in the context-driven Airport City planning literature as they have unique importance in the daily life of their airport users, who are mainly the creative class.

One may wonder if tailoring facilities according to airport users' context should be an obvious principle to Airport City developers. However, Hirsh's (2019) recent study conducted in more than 50 Airport Cities worldwide finds that most projects remain obstinate in blindly copying common facility elements and do not plan facilities according to context. This suggests that the importance of context for Airport City facility planning still needs further investigation to gain wider acceptance. A case study methodology based on an extreme case of a single airport user group is well-suited to this purpose (Flyvbjerg, 2006). Hence, instead of the large commercial Airport Cities, a general aviation Airport City at Parafield Airport in Adelaide, Australia, is chosen as the study case.

Parafield Airport in Adelaide is one of Australia's busiest pilot training airports (Parafield Airport Limited, 2017; Airservices Australia, 2021). Flight training activities are the dominant aviation activity at Parafield Airport, and flight school staff and students are reported as the overwhelmingly largest group of airport users (Parafield Airport Limited, 2017), resulting in a clearly coherent airport user group that allows other factors to be controlled to a minimum. Thus, conclusions about Airport City Parafield can be easily drawn. This study investigates the retail facility preferences of flight school staff and students through a survey and interviews and compares the empirical case study results with the facility elements that are found in the Airport City literature and Airport City master plans globally.

The research question of this study is: When the airport context changes, should Airport City retail facilities change?

Since the context, defined as the job type and income of airport users, of a general aviation Airport City is different from the context in large Airport Cities at commercial airports (hands-on lower-paid jobs versus high-paid jobs of the creative class), the proposition is that:

If the *context* does matter, the retail facility preferences of airport users in general aviation Airport Cities will not be the same as in large commercial Airport Cities. This leads to rethinking the one-size-fits-all blueprint of Airport City master plans, thus contributing to broader implications to the Airport City planning literature and practice.

The rest of the paper is structured in six sections. The next section clarifies the concept of an Airport City by fencing it off against closely related business models. The third section reviews the literature on planning Airport Cities based on the airport user context. The fourth section describes Airport City Parafield and explains the methodology used in this case study. The fifth section presents the retail facility preferences of airport users of Airport City Parafield.

The sixth section discusses the need for context-driven Airport City development by comparing this study's findings to the literature on large commercial Airport Cities and giving recommendations for Airport City planners, architects, and owners. The paper concludes by highlighting the importance of context in Airport City planning and ideas for future research.

Clarifying the Airport City and its Related Concepts

In recent decades, airport land and near-airport land uses have become increasingly diversified. Real estate developments such as hotels, shopping complexes, office buildings, conference centres, logistics and distribution facilities, residential development, and industrial plants are common in airport areas (Stangel, 2018). As a result, various models have emerged since the beginning of the 21st century to describe airport-centred development of different spatial scales and functions, including Airport City, Aerotropolis, Airport Corridor, Airport Region, and Airea (Schlaack, 2010; Corrêa Pereira et al., 2023). Airport City and Aerotropolis, conceptualised by Dr John Kasarda have received the most attention in literature and practice (Mokhele, 2018). Sometimes, the terms Airport City and Aerotropolis are 'misused' interchangeably because of unfamiliarity with these two newly developed terminologies (Corrêa Pereira et al., 2023). This section aims to clarify and compare the key concepts of Airport City and Aerotropolis.

Airport City

An Airport City is an airport-linked commercial development on the landside or immediately adjacent to the airport property, anchoring aviation-enabled trade in goods and services (Kasarda & Appold, 2014). Typically, the airport develops the Airport City to increase revenue for the airport itself (Stangel, 2018; Wiedemann, 2020). Revenues from Airport Cities through retail, offices, car parking, restaurants, and hotel leases contribute 60%–70% of airport revenue on average (Baker & Freestone, 2012). An Airport City surrounding the airport terminal is analogous to a metropolitan central business district surrounding its urban central square (Kasarda, 2010). It often has no residents (Poungias, 2009; Wach-Kloskowska, 2020). The facilities in an Airport City have to be targeted at airport users and serve their daily needs (Kasarda & Appold, 2010).

Aerotropolis

When an Airport City evolves, it draws more aviation-oriented businesses toward the airport along the surrounding transportation corridors. Eventually, a larger airport-centred urban form with a radius of up to 30 km emerges (Aerotropolis Business Concept LLC, n.d.). The Airport City becomes 'the multi-modal, multi-functional commercial and logistics core' of the wider Aerotropolis (Kasarda, 2020, p. 36). Branching out from the Airport City core are 'outlying corridors and clusters of aviation-linked businesses and associated residential developments that benefit from each other and from their accessibility to the airport' (Kasarda, 2019, p. 1). In an Aerotropolis, there are industries dependent on airport accessibility, such as precision and time-critical manufacturing and high-tech industries, in which their workers travel by air 60%–400% more frequently than the general labour force (Kasarda, 2000). However, there are also all sorts of other regular commercial offerings like wellness and medical facilities and large mixed-use residential developments that serve a dual customer base of air travellers and locals (Kasarda, 2006). Hence, an Aerotropolis is usually more of a tool for wider regional economic development driven by the government (Wiedemann, 2020).

In summary, an Airport City is highly focused on airport-linked commercial facilities for airport users. In contrast, an Aerotropolis is a much bigger and diversified development with parts reserved for urban life and targeted toward both airport users and residents of the regional catchment area.

Airport City Planning Based on Context

Early literature on Airport City planning focuses mainly on generic advice, with little to no consideration of the geographical context. For example, Kasarda (2006) suggests that Airport Cities can successfully increase non-aeronautical revenue by establishing the following facilities:

- duty-free shops
- restaurants and specialty retail
- cultural attractions
- hotels and accommodation
- business office complexes
- convention and exhibition centres
- leisure, recreation and fitness facilities
- logistics and distribution
- light manufacturing and assembly
- perishables and cold storage
- catering and other food services
- Free Trade Zones and Customs Free zones
- golf courses
- factory outlet stores
- personal and family services such as health and child daycare (Kasarda, 2006, pp.2-3)

However, Kasarda (2006) does not provide an explanation regarding why such facility elements, but not others, are recommended.

Schaafsma et al. (2008) recommend four generic development directions for Airport Cities: shopping malls concentrated on terminals, corporate offices, air freight facilities, and facilities for tourism, leisure, and health. They do not directly link those recommendations to context, but they discuss the importance of market opportunities, pointing to the necessity of demand for those kinds of developments. These early conceptual papers provided practitioners with a ‘blueprint’ for Airport City facility planning without much consideration of the regional and local context.

Schlaack (2010) points out that almost every Airport City is homogeneous, featuring more or less the same generic components, such as hotels, conference centres, and offices. For example, Airport Cities of large international airports, such as The Square in Frankfurt and The

Circle in Zurich, have developed large-scale office buildings and hotels. SkyCity in Hong Kong has more than 90,000 square metres of retail, offices, and hotels and an exhibition and trade centre with 140,000 square metres. Airport Cities look alike because developers often copy the blueprint without considering the regional, economic, and cultural context (Wiedemann, 2017). Airport City developments filled with out-of-context facilities often fail to achieve a significant return on investment as they struggle to attract tenants (Hirsh, 2019).

As a result, in recent years, more academic studies and industry projects have started to realise the need to plan Airport City facilities according to the airport users' context. For example, it is proposed that an Airport City should incorporate high-quality schools, high-end shopping, upscale dining, bustling nightlife, and various cultural and leisure retail facilities to cater for the preferred lifestyle of creative class business employees (Kasarda & Appold, 2014).

Airport City Stockholm is one of the first movers in context-driven Airport City planning. Its management clearly recognises that too many 'Airport Cities have been planned with only aircraft, distribution, logistics, and other traffic in mind (and, on occasion, the passenger!). But very seldom are the people who actually work and spend almost every day there taken into consideration (Alvendal, 2014, para.6). To avoid the pitfall of its counterparts, Airport City Stockholm prioritises human aspects in its urban design strategy (Alvendal, 2014). Subsequently, Airport City Stockholm is targeted towards smart, metropolitan, educated, and rational creative class business employees who are looking for an engaging urban milieu with opportunities to socialise in public spaces and access convenient services during their lunch break or after work. Hence, Airport City Stockholm plans pedestrian-friendly streets, plazas, and parks lined with ground-level shops and eateries to create a high-quality urban environment for its airport users (Alvendal, 2014).

Based on recommendations and good practices identified by high-level Airport City professionals, The Base in Schiphol Airport City is used as an example to demonstrate facilities successfully planned to satisfy the demand of one main airport user group: The creative class (Nikolova et al., 2018). Its high-quality urban atrium space has a public library, a 24/7 childcare facility, a gym, a lounge, two cafes, and a restaurant, as well as events such as exhibitions, after-work get-togethers, and food trucks, which are expected to be attractive to the creative class in Schiphol Airport City.

The first empirical evidence comparing the facility preferences of airport users who work in Airport Cities in Germany and the United Arab Emirates (UAE) discovered that the perceived importance of facilities varies according to the social and regional context. For example, religious facilities in Airport Cities are very important to airport workers in the UAE but not to airport workers in Germany. However, the gym is frequently mentioned as an important Airport City facility in both countries, reflecting the typical needs of air-mobile, highly skilled, and higher-income creative-class employees working in large commercial Airport Cities (Wiedemann, 2014).

Most of the context-driven Airport City planning literature and projects focus on big commercial hub airports whose Airport Cities regularly try to attract knowledge-intensive firms and their creative class workforces. Consequently, their retail facility choices are more or less consistent because they have the same creative class airport user group. But for smaller airports, market intelligence has to be improved so they can effectively serve their airport users' needs (Kasarda & Appold, 2014). Little research has discussed the Airport City model in the general aviation context (Freestone & Wiesel, 2014). An exception is a case study on Essendon's general aviation Airport City, which suggests that supermarkets and small specialty stores in Essendon's Airport City serve airport employees mainly from transport and property groups (Freestone & Wiesel, 2014).

Summarising, the Airport City literature has morphed from a generic list of facilities for Airport Cities to recognising the importance of planning retail facilities according to its airport users' context. Nevertheless, the literature on context-driven Airport City planning is mainly conceptual or concerned with sharing industry best practices that understand airport users' facility preferences through predictions and assumptions. Very few studies have collected empirical data to understand airport users' preferences in Airport Cities. Moreover, studies on context-driven Airport City planning mainly concern large airports and key themes of attracting high-income, highly skilled business employees belonging to the creative class, who have a high standard of quality of life and are looking for chic, upscale lifestyle-oriented amenities in their daily life (Kasarda & Appold, 2014; Wiedemann, 2014). To our knowledge, only Freestone and Wiesel (2014) have provided some first findings on airport user retail facility preferences in the context of general aviation Airport Cities. Hence, the influence of airport users' context on Airport City retail facility preferences still needs further investigation to gain deeper knowledge of relationships and synergies. Subsequently, this study investigates the retail facility preferences of flight school staff and students at the general aviation Parafield Airport City through a survey and interviews and compares the empirical case study results with the facility elements that are found at Airport City Parafield in the Airport City literature and Airport City master plans globally to evaluate how much the socioeconomic context of airport users impacts retail choices in Airport City planning.

Case Study Methodology

This study was a case study that used Airport City Parafield as the single case context. A mixed-methods approach employing various data collection methods, including desk research, site visits, an online survey, and follow-up interviews, was conducted in Airport City Parafield to develop an in-depth understanding of the implications and limitations to inform Airport City planning practices. This study was conducted in late 2020 and early 2021 during the COVID-19 pandemic (but with no local lockdowns imposed) as part of a student summer research project at the University of South Australia. The study has been approved by the Human Research Ethics Committee (HREC) of the University of South Australia. The protocol number is 203557.

Parafield Airport in Adelaide is a major international-standard training airport (Parafield Airport Limited, 2023a). It has one of the largest flight movements among Australian airports, mainly because of the pilot-training activities (Parafield Airport Limited, 2017). Parafield Airport is a privatised airport on an operating lease located on Commonwealth-leased land operated by Parafield Airport Limited, a wholly-owned subsidiary of Adelaide Airport Limited (Parafield Airport Limited, 2023a).

Parafield Airport is 18 km north of Adelaide's central business district, within a 35-minute drive (Parafield Airport Limited, 2017). It is surrounded by the suburbs of Salisbury South, Parafield Gardens, Para Hills West, and Mawson Lakes (see Figure 1).

Airport City Parafield (see Figure 2) is the retail and commercial real estate within airport land, managed by Parafield Airport Limited. Airport City Parafield includes the Airport Business Precinct (68 ha) and Commercial Precinct (48 ha) and will eventually expand to the undeveloped Bennett Precinct (13 ha) and Enterprise Precinct (82 ha) (see Figure 3) (Parafield Airport Limited, 2017).

Figure 1

Location of Airport City Parafield

Note. Parafield Airport (labelled) is surrounded by residential suburbs of Salisbury South, Parafield Hills West, Parafield Gardens, and the transit-oriented Mawson Lakes precinct (Plan SA, n.d.).

Figure 2
The Logo of Airport City Parafield

Figure 3
Zone and Precinct Plan for Parafield Airport

Note. (Parafield Airport Limited, 2017, p. 65)

The Airport Business Precinct of Airport City Parafield mainly encompasses the office premises of the flight schools and aviation supply companies (Parafield Airport Limited, 2023b).

Most retail facilities in Airport City Parafield are located in the Commercial Precinct (see Figures 4, 5 and 6). They are dominantly bulky goods retail stores, including many home improvement centres, tool shops, automotive supply shops, and furniture shops such as South Australia's largest Bunnings (Bunnings is Australia and New Zealand's leading retailer of home improvement products) (Parafield Airport Limited, 2023b). Airport City Parafield has only a few retail stores outside the bulky goods category, including a petrol station with a convenience store, two restaurants, a liquor store, a tavern, a gym, a fast-food outlet, a suit store in the Commercial Precinct, and one cafe in the Airport Business Precinct (Parafield Airport Limited, 2023b).

A brand outlet centre development is planned for the Commercial Precinct (Devwest, n.d.). The development plans to have a 14,000 square metres gross floor area and 10,700 square metres lettable area, comprising 65 outlet tenancies and a food court.

Figure 4

Commercial Precinct's facilities facing Main North Road

Note. A shop selling vehicles and home batteries, a carpet shop, a curtain shop, a gym, a bedroom furniture shop, a signage featuring the Airport City Parafield logo, and advertisements for more furniture shops in the Commercial Precinct.

Figure 5
South Australia's largest Bunnings in the Commercial Precinct

Figure 6 *Commercial Precinct's facilities at the intersection of Kings Road and Main North Road*

Note. From left to right are a store selling air conditioners and heaters, a suit store, and a model plane showcasing the aviation theme of the Commercial Precinct of Airport City Parafield.

After the desk research and site visits to understand the composition of retail facilities at Airport City Parafield, an online survey created on SoGoSurvey was distributed via email to all staff and students at UniSA Aviation Academy, asking them to provide data about the range of their weekly income and retail spending behaviour.

Since the purpose of Airport Cities is to serve the ancillary everyday needs of airport users (Kasarda & Appold, 2010), this survey analysed the retail facility preferences of the main airport users of Airport City Parafield by studying their routine retail spending behaviour. Among the six flight schools at Parafield Airport, the UniSA Aviation Academy was chosen as the school from which to sample research participants as other flight schools at Parafield were operating at idle capacity at that time due to the COVID pandemic (Parafield Airport Limited, 2020a, 2020b). The Aviation Academy comprised 145 students, of whom 67.5% were domestic students and 32.5% were international students. The distribution of the students who answered the survey replicates this breakdown.

In total, 24 students (16.5%) and two staff members responded to the survey. Survey participants were asked to indicate the retail products and services categories they had consumed during the week before they completed the survey in all shopping places they had been to, including but not limited to Airport City Parafield.

Closed-ended options of retail products and services categories were:

- groceries
- meals, snacks, and drinks
- liquor
- aviation products
- clothes and shoes
- chemist products
- beauty, hair, and massage
- leisure and electric goods
- jewellery and accessories
- homewares
- medical services
- sporting goods and fitness
- movies, music, and events.

An open-ended option was provided to list other retail products that participants had bought. The only finding from the ‘other’ option was automobile parts.

Participants were also asked to think back how frequently they would typically spend on each retail product and service. The frequency was ranked on an ordinal scale. Options were:

- daily
- several times a week
- once a week
- several times a month
- once a month
- seldom
- and one-off purchase.

In addition to the survey, six follow-up interviews with UniSA Aviation Academy students were conducted, exploring the reasons behind survey answers. The interviews shed light on why certain retail facilities and types and pricing of products and services would be more relevant to airport users of Airport City Parafield than airport users at other Airport Cities.

Retail Spending Patterns of Parafield Airport's Users

This section presents the weekly income of surveyed flight school staff and students, i.e., airport users of Airport City Parafield, and findings on their preferred retail facilities obtained by documenting flight school staff and students' retail spending patterns. Qualitative results indicate that retail spending choices of airport users are linked to their socioeconomic context, such as having a low to average income versus being a high-income earner in professional industries, as is typically the case for the creative class in large commercial Airport Cities.

Survey responses showed that the cohort had low average incomes (see Figure 7). More than 60% of the survey participants earned less than $300 per week, and none earned more than $1,500 per week.

Figure 7
Weekly Income of the Surveyed Flight School Staff and Students (n = 26)

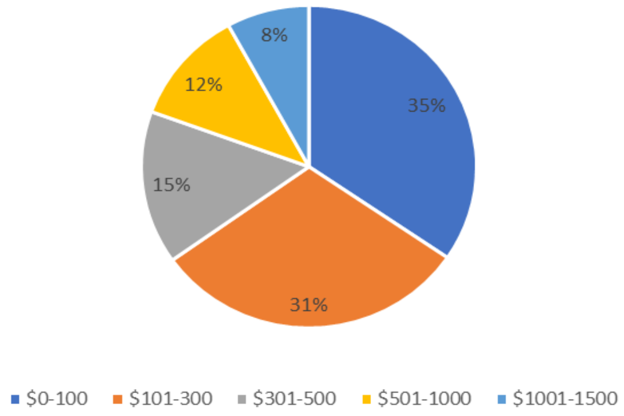
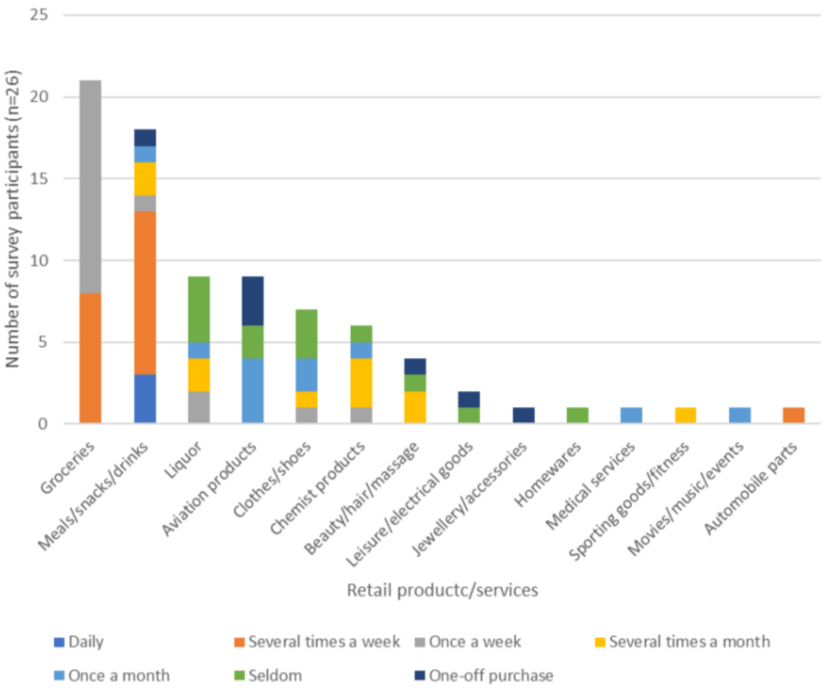


Figure 8 shows how frequently survey participants typically purchase various retail categories. Overall, survey participants purchase groceries, meals, snacks and drinks, liquor, aviation products, clothes and shoes, chemist products, beauty, hair and massage, leisure and electric goods, jewellery and accessories, homewares, medical services, sporting goods, and fitness, movies, music and events, and automobile parts.

Figure 8

Frequency of Consumption of Each Retail Product/Service in all Places at all Times



Note. Survey participants were asked to think back about how frequently they typically buy such products).

Surveyed flight school staff and students had the highest demand for groceries, followed by meals, snacks, and drinks. In addition, survey participants typically consume these goods and services very frequently: among the grocery shoppers, 62% buy groceries once a week, and 38% shop for groceries several times a week. This suggests an opportunity for a supermarket in Airport City Parafield, as also emphasised by one of the participants:

> *I generally have 2-3 flights per week in Parafield Airport. After training, I usually purchase groceries in Mawson Lakes. I do not spend in Parafield Airport [City] because there are no Woolies or Coles [Australian supermarket chains]. (Z4ACD)*

Of those who ate out, 56% consume food and drinks several times a week; 17% eat out daily (see Figure 8). However, currently, there is only one coffee shop in Airport City Parafield, and interviews with flight school students suggest that they might prefer fast-food chains:

> *My routine is to buy food in Hungry Jacks before flight … I will only find a good restaurant and dine out in Adelaide City if there are special events, such as a friend's birthday party. (Y6BCD)*

> *After flying, I usually buy food in McDonald's and Hungry Jacks if I don't have food at home. (Z3ACE)*

Four surveyed flight school staff and students purchase reasonably priced clothes and shoes regularly, and four regularly spend on chemist products (see Figure 8). Two participants consume beauty, hair, and massage services several times a month, while another 2 consume them less often (see Figure 8). However, retailers for clothes, shoes, chemist products, beauty, hair, and massage are absent in Airport City Parafield. Moreover, it was found that survey participants had very little interest in the home improvement centres, furniture shops, tool shops, or automotive supply shops that currently dominate the landscape of Airport City Parafield. Only one out of 26 survey participants consumed homewares, and only one participant bought automobile parts (see Figure 8).

Interest in fitness activities and entertainment was very low as well, in stark contrast to findings in the Airport City literature and availability at Airport City Parafield (see Figure 4). Only one participant spent on sporting goods or fitness, typically consuming them several times a month, and only one participant spent on movies, music, or events, typically engaging in entertainment once a month (see Figure 8). The following interview extracts illustrate the lack of importance of cultural and leisure retail facilities to the airport user cohort of Airport City Parafield resulting from low income:

> *I have not had entertainment, such as movies, for a long time because I want to save money for university. The last time I watched a movie was in November last year. (Z3ACE)*
>
> *I rarely visit the amusement arcades, cinemas, and bowling alleys in mega shopping complexes because I don't have money. (Y5ACD)*

In summary, surveyed flight school staff and students were most interested in consuming normally priced groceries, meals and drinks, liquor, clothes and shoes, chemist products, and beauty, hair, and massage services. Most of those products cannot be bought at Airport City Parafield. In contrast, they showed little interest in existing retailers in Airport City Parafield, such as fitness activities and home and furniture shops.

Discussion

The retail spending patterns from the previous section show that retail facility preferences at the general aviation Airport City Parafield of the sampled airport users are vastly different from the preferences of creative class employees in large commercial Airport Cities. Many retail facilities that creative class employees use routinely, thus being viable for big commercial Airport Cities, appear irrelevant in the socioeconomic context of Airport City Parafield. For instance, gyms (Wiedemann, 2014), exhibitions (Nikolova et al., 2018), and nightlife (Kasarda & Appold, 2014) have been found to be important to the creative class in large Airport Cities. Nevertheless, they were not important to the sampled airport user group at Airport City Parafield. Only one survey participant spent on fitness or sporting goods, and only one survey participant spent on movies, music, or events (see Figure 8). Moreover, instead of upscale dining targeting creative class employees in large Airport Cities (Kasarda & Appold, 2014), affordable food offerings like fast-food chains like McDonald's seemed to be more suitable for Airport City Parafield and its flight school staff and students, as seen in the interviews.

The difference in retail facility preferences between airport users in Airport City Parafield and those in large commercial Airport Cities could be explained by the differences in socioeconomic context in terms of their job types and income, and thus the different hierarchy of needs associated. The sampled flight school staff and students receive a lower income than high-income creative class knowledge workers such as engineers, business consultants, and software programmers in large commercial Airport Cities. Of the surveyed flight school staff and students, more than 60% earned less than $300 per week, and none earned more than $1,500 per week (see Figure 7). Several interviewees mentioned that they did not have much money to spare for leisure shopping, presumably due to lower income and the need to save up to pay the considerable amount of university tuition as well as the additional flight training course fees. Therefore, they only look for simple, ordinary retail facilities to ensure their basic physiological needs. On the other hand, creative-class employees in large commercial airports have obtained a higher socioeconomic status with more disposable income. The creative class has not only basic physiological needs but also higher-level pursuits in mind, body, and soul to achieve esteem and self-actualisation, so they engage in cultural and leisure facilities to challenge themselves intellectually and physically, as explained by Florida (2012). Hence, cultural and leisure facilities are important in the daily life of creative-class employees in large commercial airports.

The finding of *Airport City retail facility preferences changes with airport users' context* strengthens the message to Airport City developers that tailoring facilities for the distinct context is paramount and negates a one-size-fits-all approach. Retail consumers in Airport Cities should be airport users (Leeuw, 2019), but depending on airport functions, airports operating under the Airport City model can still have different airport user groups. Not all airports serve the creative class like the large commercial airports such as Amsterdam International Airport Schiphol. For instance, in our case context, Parafield Airport has a main airport user group of students studying aviation who have lower socioeconomic status and flight school staff with hands-on jobs with rather low salaries. Some other examples of airports with lower socioeconomic status include the logistics hub Memphis Airport in the USA, with blue-collar cargo handlers as their main airport user group (Antipova & Ozdenerol, 2013), and regional gateway airports in developing countries like Durban in South Africa with blue-collar manufacturing workers as their main airport group (Ngwenya, 2020). If Airport City developers use a one-size-fits-all approach and plan chic, upscale cultural and leisure facilities at Airport Cities with lower socioeconomic status like Parafield, Memphis, and Durban, it is not hard to imagine that little spending will occur in these Airport Cities due to the lack of purchasing power to consume in those cultural and leisure facilities, resulting in underutilised facilities and low return on investment (Hirsh, 2019).

Context-driven Airport City facility planning has clear benefits to both customers and businesses because airport users can have their ancillary needs well-satisfied at their favourite stores (Alvendal, 2014; Nikolova et al., 2018) and Airport Cities tenants and developers can thus also have sustained revenue (Wiedemann, 2014). Nonetheless, the organisational culture in the airport industry and the lack of government regulations might hinder the voluntary implementation of context-driven Airport City facility planning.

On the one hand, the psychological profile of airport management professionals might inherit a favour for copy-and-paste Airport City facility planning because Byers's (2012) mass survey on airport executives finds that they are dominantly categorised as 'divergers' and 'accommodators', meaning that executives across the airport industry are individuals with strong preferences of learning from others' concrete experience as passive observers.

On the other hand, the *Airports Act 1996*, the only legislation that governs land uses within airport land in Australia, lays minimal guidance on Airport City facility planning (Walker & Stevens, 2008), not to mention requiring developers to support their retail facility choices by documented market and demand studies. The same limitation appears in the better-known Airport-City-related legislations internationally. The United States *The House of Representatives Bill 658 Aerotropolis Act* is mainly concerned with defining an Aerotropolis and acknowledging its economic significance (Wang et al., 2018). The policy framework previously used by Bestuursforum Schiphol was mainly concerned with eligibility (airport-relatedness) assessment for companies' admission into Schiphol Aerotropolis (van Wijk et al., 2014).

Hence, to effectively promote context-driven Airport City development, it is recommended that instead of voluntary implementation, governments should consider amending the Airport-City-related legislation to explicitly regulate Airport City facility planning and requiring Airport City developers to submit thorough market and demand studies on the city's socioeconomic, regional and cultural context as well as the airport's role, function and form to justify their retail facility choices.

Conclusion

This study strengthens the importance of context-based Airport City planning by finding that low-income earning airport users of a general aviation Airport City have different retail facility preferences from creative class airport users of large commercial Airport Cities. A mixed-method spending behaviour study was conducted with the main airport users of Airport City Parafield, i.e., flight school staff and students. Data has shown that the sampled flight school staff and students have little interest in gyms, cultural and leisure retail facilities, or upscale dining; however, these retail facilities are considered to be attractive to the high-income creative class business workers in large commercial Airport Cities (Kasarda & Appold, 2014; Wiedemann, 2014; Nikolova et al., 2018). The difference in retail facility preferences between airport users in general aviation and those in large commercial Airport Cities might be due to the different socioeconomic contexts.

This finding strengthens the notion that a one-size-fits-all approach in Airport City planning should not be promoted because airport users' context changes and Airport City retail facilities should be selected.

We call on all practitioners to use Kasarda's blueprint or other existing benchmark references only as a first point of reference. The actual Airport City facility planning, however, should be based on a thorough understanding of the Airport City concept and thorough market and demand studies on the city's socioeconomic, regional, and cultural context as well as the airport’s role, function, and form. Substantial time should be spent on the strategic planning elements before any master planning exercise.

Despite being limited to one case, and results could have been impacted by the pandemic and small sample size, this study provides some empirical evidence of the importance of context-based Airport City facility planning. Future research could develop criteria and tools to analyse in-depth the relationship between different elements of the context of Airport Cities and their impact on successful Airport City planning. Future studies should also expand on sample sizes and explore different airport user groups, such as fixed-based operators and specialised aviation service operators, although there is a small presence of those in the airport of this particular study.

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Examining the Future of Automation in Commercialized Flight and its Impact on Airline Pilots

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The purpose of this study was to focus on the perceptions of an automated (unmanned) flight deck and its intended implementation in the U.S. airline industry. The objective was to understand fully autonomous aircraft's influence on commercial pilots, as well as investigate the effects on the U.S. airline industry and human-machine interaction. Commercial airline pilots, including ranks of both Captains and First Officers (FO) in Part 121 scheduled service, were the research population for this study. The sample population number was 15 U.S. airline pilots offering various diversity in age, gender, years of service, airline employer, and military or civilian flight experience. The semi-structured qualitative research consisted of developing a deeper understanding of the pilots' perceptions of the three-pronged approach: (1) the psychological barriers and motives of the pilot, (2) the differences in aircraft ground-based safety and training, and (3) pilots' understanding of the timeliness of entry for unmanned flight deck operations to reach FAA standards. The study consisted of participant interviews utilizing a series of ten structured and semi-structured interview questions. The findings concluded that pilots are aware of the workload changes that are present with implementing fully autonomous aircraft in the Part 121 category. Two themes became evident when discussing workload changes. First, the role of the pilot changes from a single flight focus to a multi-flight monitor. Secondly, as technology advances, the pilot's physical workload of hand flying an aircraft will constantly deteriorate. Furthermore, the advancement of a fully automated flight deck and its effects on the U.S. airline industry can potentially have significant impacts on the psychology of commercial airline pilots. While pilot responses varied based on individual experiences, attitudes, and adaptability, there were several psychological responses identified in this study, including (1) loss of control, (2) uncertainty toward technology, (3) job insecurity, and (4) adaptability. Last, the advancement of a fully autonomous flight deck will obviously create additional concerns for U.S. airline passengers. The most significant concerns for passengers included (1) safety, (2) trust, (3) passenger-pilot relationship, and (4) understanding of technology. Passengers will always question if modern technology has been thoroughly evaluated and if it can react to unexpected situations as safely and effectively as a human.

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Introduction

"I'm in a knife-fight with this plane. It isn't a fair fight; knife-fights never are," (Sullivan, 2019, p.2). Qantas Flight 72 experienced this war to stay alive on October 7, 2008. Over the West Coast of Australia, the flight deck realized their autopilot malfunctioned as passengers and crew members experienced roller coaster-like conditions, seriously injuring flight attendants and leaving many unconscious (Doran, 2020). What caused this erroneous malfunction in automation that lasted ten minutes? The answer to this question relies heavily on the industry's overruling machine trust and pilots' lack of ultimate control authority, resulting in the greatest growing concern in the commercial aviation industry (Borenstein et al., 2020). This dependency on automation raises a series of questions about the correspondence between heavily automated systems and pilots. These automated systems refer to the systems that manipulate the flight controls to simulate pilot input. The human-machine interface within the aviation industry has changed the relationship between humans and aircraft forever.

Automation already plays a massive part in commercial aviation. Even though automation has brought many benefits to aviation, the rise of automated technologies has eliminated many routine pilot functions. Today, most modern aircraft are controlled mainly by computers, with automatic flight management systems (Bertram, 2019). This broadened term *flight deck automation* now encompasses advanced systems such as aviation robotics, artificial intelligence (AI), programmed route monitoring, and calculation of judgment control (Prahl et al., 2022). Recent additions to flight deck automation include automatic route modifications, procedure warning systems, increasing flight management system (FMS) capabilities, automatic braking for smooth deceleration, advanced autothrottle control operations, and in-flight weather forecasting, all of which combine three sensors for judgment control related to AI (Prahl et al., 2022). This is described as the cluster of technologies that are essential to the modern flight deck throughout the monitoring and decision-making process for commercial flight (Prahl et al., 2022). Pilots can, of course, take over the controls – but flight management systems and processes are in place to allow aircraft to operate under considerable automation, and in fact, this has become the accepted norm for commercial aviation.

Within the commercial aviation industry, safety and pilot training remain the main concerns as automation technology continues to progress. Although flight deck automation rarely fails outright due to increasing reliability, issues are nonetheless encountered when the automation fails to adequately consider associated human factors and challenges or when it encounters situations that were not anticipated by its designers (Hart, 2020). As automation comes closer to removing pilots from the loop, it paradoxically generates more human factors and challenges, not only when it fails to function as designed but also when it does function as designed (Hart, 2020).

Statement of Problem

Although many factors prevent the advancement of aircraft automation, such as time necessary for technology innovation, increasing complacency of pilots, lack of funding sources, and slowness of market entry for manufacturers, the real problem is an extension of three barriers that limit its progression (Trop, 2023; McFadden, 2021). The three barriers that limit the advancement of aircraft automation are:

1. The human population is not ready to fly aboard commercial aircraft with no human pilots. The thought of having complete faith and confidence in a fully automated aircraft is daunting and ominous due to previous flight accidents.
2. Aircraft and ground-based safety automation procedures and training do not meet the needs of development, implementation, and maintenance standards for commercial flight.
3. FAA airworthiness certification for fully autonomous commercial aircraft is uncharted territory.

The combination of these three statements depicts the limitations restricting fully automated commercial aircraft, computer systems entirely replacing human pilots, and the barriers to entry. The impact of these barriers may include (1) a continuous decline in passenger confidence in automated systems, (2) a decrease in National Automation Programs, (3) a rising concern about policies, guidelines, and procedures for automation and information systems, (4) a decrease in priority for aircraft certification of automation programs, and (5) an increasing financial risk for airlines to offer fully automated flight.

Purpose of the Study

The purpose of this study was to focus on the perceptions of an automated (unmanned) flight deck and its intended implementation in the U.S. airline industry. The objective was to understand fully autonomous aircraft’s influence on commercial pilots, as well as investigate the effects on the U.S. airline industry and human-machine interaction. There have been many research studies that have been written about pilots' acceptance of automation, but few, if any, detail the pilot's perception of the future of fully autonomous flight and what implications this will have on their daily lifestyles.

Research Questions

The following research questions were addressed by interviewing 15 commercial airline pilots’ perceptions in Part 121 U.S. airline companies:

> RQ1: What are commercial airline pilots’ perceptions of how the implementation of fully automated flight decks will affect the workload, training, and scheduling of commercial airline pilots?
>
> RQ2: What are commercial airline pilots’ perceptions of how pilots will respond psychologically to the advancement of an automated flight deck and its effects on the U.S. airline industry?

RQ3: From a commercial airline pilot's perspective, how will the advancement of a fully autonomous flight deck affect the mindset of U.S. airline passengers?

Significance of the Study

Through the advancement of automation within the U.S. airline industry, the Federal Aviation Administration (FAA) has structured a new training regimen to help implement new automated systems that require workload, training, assignments, maintenance, responsibilities, and human resources for pilot training (Federal Aviation Administration, 2022). This advancement in policies results in an extended awareness of pilot training with automated systems and forces the U.S. airline industry to respond accordingly when tragedy strikes regarding automation malfunctions. Extended envelope training refers to the maneuvers and procedures conducted in a full flight simulator that go beyond the aircraft's limits of flight. Training for 14 CFR Part 121.423 - Pilots: Extended Envelope states that each certificate holder must conduct the approved extended envelope training in a full flight simulator to recover from loss or reliable airspeeds manually, slow flight, upset recovery maneuvers, bounced landings, and controlled instrument departure and arrival procedures (Federal Aviation Administration, 2020). This research study is significant because it has the potential to answer why this extended envelope training is required for airline pilots to override fully automated systems and the critical role U.S. pilots play in building confidence for fully automated commercial flights.

Another significance of this study is the psychological response of the pilots as the industry shifts toward fully automated flight. Many pilots choose this career path for the allure of adventure that is tied to their job description. However, how will pilots respond to flying a desk rather than flying the skies? A single-pilot cockpit is the next logical step in the road to total autonomy for commercial airline flights. This could save airlines as much as $60 billion annually in operational costs (Wyman, 2017). This emptying of the cockpit comes at a cost as pilots continue to juggle a redefined job description, role, and identity. From the passenger's perspective, pilots are the embodiment of trust with a responsibility to keep passengers and crew safe (Shahidi, 2019). People love stories of the heroic nature of pilots who turn a potential tragedy into a moment of triumph (Wyman, 2017). What happens to this comfort of trust as pilots move from reacting and responding to the aircraft in real-time from the cockpit to monitoring automation from a ground control center?

Limitations and Assumptions

Limitations for this study include any shortcomings or flawed methodology that impacts or influences the interpretation of the results. This can be a result of a lack of resources or limited information available for data collection. Every study, including this one, is not exempt from limitations that hinder and provide constraints to the methodology process (Sharpes, 2015). Assumptions provide another threat to the validity of data collection. Assumptions are defined as any influences the researcher has on any unexamined beliefs that we think without realizing it (Ekstrom, 2021). To eliminate both limitations and assumptions, delimitations are set in place to create boundaries for the research process. Delimitations help limit variables and guide choices for variables at play. For this study, the following limitations and assumptions were expected:

1. This study was restricted to the voluntary participation of commercial airline pilots to complete a qualitative interview.

2. The nature of the qualitative study was based on the pilot's personal experience and opinion on the implementation of a fully automated flight deck. These responses contained biases and subjectivity based on personal experience with airline procedures, company training, and personal exposure to automated systems.
3. It was assumed that each pilot would answer honestly and truthfully to the best of their knowledge on the set of questions asked when participating in the interview.
4. This study was limited to full-time pilots employed with a major U.S. airline operating under FAA Part 121 scheduled air service operations.

Literature Review

The Future of Aviation and the Increases in Automation

Do airline passengers know how much of a commercial flight is already automated? Chances are slim if passengers think pilots hand fly more than ten minutes each flight. On a Boeing 737, the primary airframe of Southwest Airlines, the dual autopilot system can be engaged 1,000 feet above the ground on takeoff and can land itself until all three landing gears are on the ground (ATP, 2016). Yes, the airplane can land itself; however, a research study conducted by John Cox, former US Airways Airline Captain, concluded that on an average 3,000-mile flight, the autopilot remains on over 90% of the flight with the exception of takeoff and just before landing, (Cox, 2014). Aviation faculty at Embry Riddle Aeronautical University (ERAU) expect fully autonomous flights to be common within the next few decades, starting with smaller private or air taxi companies (Rice & Winter, 2019). Both challenge companies and customers to reevaluate the risks and benefits associated with the advancement in automation technology. One must consider the safety, financial, and emotional hurdles needed to overcome the insecurities associated with fully autonomous aircraft for this inevitable future to happen (Rice & Winter, 2019).

Recent U.S. Major Airline Crashes Contributing to Automation Fear

The industry’s support for the automation of airline manufacturers generates competitive pressure for companies such as Boeing and Airbus to perform at accelerated rates. Boeing’s solution to this pressure resulted in the most tragic reality and possibly the greatest corporate disaster of the 21st Century: the 737 Max. After the tragic events of Lion Air Flight 610 and Ethiopian Airlines Flight 302, people have begun to think about how much of their commercial airline travel is controlled by automation rather than the pilot. Aside from the recent tragedy of flights 610 and 302 concerning the 737 MAX, other tragedies with automation malfunctions still linger within the aviation industry. Human error remains the leading cause of aircraft accidents (Federal Aviation Administration, 2022). An example of this unfortunate reality occurred on Asiana Flight 214 on July 6, 2013. This Boeing 777 was visually descending into San Francisco when the flight crew unintentionally deactivated the automatic airspeed control system and failed to monitor the airspeed to remain on a glide path (Gawron, 2019). This error resulted in a delayed action to initiate a go-around, causing Flight 214 to crash before reaching the runway threshold, killing three people on board. Factors contributing to this accident included (1) the pilot’s inadequate training on visual approach procedures, (2) complexities with the flight director and autothrottle systems and lack of pilot training, (3) inadequate documentation of these systems stated in Boeing's Asiana pilot training procedures, (Gawron, 2019). The FAA Human Factors Team Report (1996) reiterates these major categories of problems as the lack of mode awareness factors correlates to two-thirds of automation accident/incident reports (Gawron, 2019).

Psychological Aspects of Automation

Pilots are unlikely to use a system they do not trust. This narrative that humans and machines work, in contrast, needs to be broken for automation's advancement to occur. The perception that machines control humans gives automation a reputation of being happy and devoted to commanding the airframe toward its calamity (Mosier & Skitka, 1996), bringing 200-plus passengers along with it. This can result from automation bias through omission and commission errors resulting in the lack of intervention of pilots to erroneous automation data (Mosier & Skitka, 1996). The narrative analysis discussed in the Prahl et al. (2022) discussion post argues the same, stating that the only way to improve the reliance on automation is to eliminate human interaction. Here, it is argued that trying to make new pilots like old pilots is an expensive step, not just in monetary value but a costly decision for the safety and future of where automation is heading (Prahl et al., 2022). Humans are too unpredictable. This reality plays a heavy psychological factor in what the role of pilots will look like soon if that role still exists.

Current Success of Fully Automated Flight

Anthony Spencer, senior director of UAV & Unmanned Traffic Management at satellite giant Inmarsat, believes that by 2030, there will be over 10 million uncrewed vehicles flying in all spaces across the globe (Middleton, 2022). This future prediction is already a reality for private San Francisco-based company, XWing, as they conducted their first fully autonomous gate-to-gate cargo flight in 2021(Wolfsteller, 2021). While XWing successfully conducted its first hands-off flight with obstacle avoidance on both ground and air operations, the company is aware that the public has not yet been convinced that fully autonomous travel is trusted (Wolfsteller, 2021). Therefore, they will target the cargo feeder market while recognizing that proper pilot training in fully automated aircraft will be the key factor in getting the public onboard with pilotless travel.

Pilot Concerns Regarding Fully Automated Airliners

Regarding a study focusing on human factors concerns of UAV flight, one of the main consequences of the separation between aircraft and operator is the pilot's lack of sensory cues that help enable the pilot to interact with his or her environment. These sensory cues that are lost include kinesthetic/vestibular input, sounds of engine thrust, ambient visual information, and onboard sensory predictions, all of which can lead to the pilot operating in sensory isolation (McCarley & Wickens, 2012). Another major concern is the crew composition, coordination, selection, and training within the human factors-related issues regarding fully autonomous flight operations. Military reconnaissance missions currently operate with two pilots, one controlling the payload sensor controls, while the other is responsible for the airframe control and performance (McCarley & Wickens, 2012). If airlines continue to find ways to cut costs by eliminating the number of operating pilots, this could lead to an alarming perpetual work overload for pilots in the future.

Passengers' Acceptance of Fully Automated Aircraft

The ERAU study conducted by Rice and Winter (2019) identified that 30% of U.S. airline customers would be willing to fly on an autonomous aircraft with no pilot on board. Of this 30%, many were eager to fly air taxis and be the pioneers to show that this is possible for a safe means of transportation. However, most of the public is not ready for this trust in automation due to their lack of knowledge of automated systems. Some do not know that pilots only fly the aircraft between three to six minutes during the entire flight (Rice & Winter, 2019). A 2021 study explicitly targeted how consumers view advanced air mobility (AAM), including air taxis and cargo-delivery drones. This was an ambitious task, as they were asking people about a service that did not yet exist and involved a theoretical scenario that had not yet been marketed to the public. However, their research findings prove necessary discernment about the customers' psychology of placing their lives in the hands of machines (Kloss & Riedel, 2021). The survey population was approximately 4,800 customers from areas across the globe, including the United States, India, Brazil, China, Germany, and Poland. Across the board, commuting and running errands were the top reasons to adopt this AAM service, except in the United States. Here, business took the lead, with 26% of participants in the United States stating they would switch to an AAM vehicle for the convenience of business travel and short-distance leisure trips (Kloss & Riedel, 2021). Although this qualitative study offered an awareness of customer acceptance of the theoretical AAM service, the main concern among all countries was the safety of these vehicles. 60% of respondents stated they have concerns about flying in non-piloted small aircraft (Kloss & Riedel, 2021).

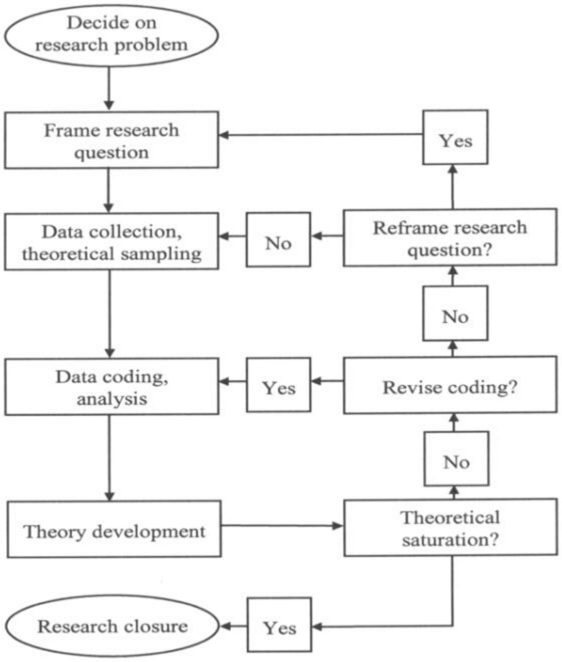
Industry Willingness of Autonomous Airliners

U.S. airlines and aircraft manufacturers say they would save money if they could reduce the number of qualified pilots flying the line. The status of the pilot shortage is another talking point for manufacturers to redesign the front of the aircraft, saving space for more seats available for sale, which is enticing for air carriers (Rice & Winter, 2019). A significant benefit of fully autonomous aircraft is the workload management for pilots. Allowing the FMS systems to lower the manual labor for pilots reduces operating costs, increases situational awareness, and increases efficiency, which seems to be the golden word in the airline industry. This increase in efficiency, in return, lowers ticket prices, increases customer loyalty, and generates greater profit margins for airlines (Beresnevicius, 2019). Airlines’ goal is fully autonomous flight (Bochard & Baggioni, 2017). This is an alarming statement to pilots as the reduction of personnel drops fuel consumption by six percent, reduces the space needed for cockpit operations, lowers the price tag for manufacturing commercial aircraft, and increases the flexibility of pilot scheduling. Computers do not need to adhere to sleep and rest regulations (Bochard & Baggioni 2017).

Methodology

Investigational in composition, this research study identified the commercial pilot's professional perspective of an *unmanned flight deck*. This research design primarily followed the Grounded Theory (Glaser & Strauss, 1967) methodology. According to Glaser and Strauss (1967), grounded theory is reached through the discovery of theoretical functions of research. Grounded Theory is developed from inductive theories that are grounded on the systematic data analyzed for this specific study (Figure 1) (Bitsch, 2005).

Figure 1
Grounded Theory Methodology



The Theoretical Sensitivity (Glaser, 1978) approach, which reflects the potential for data to be analyzed in theoretical terms, is integrated with what is already known about automation in airline operations while further developing the interaction between fully autonomous flight and the commercial pilot. Asking pilots about this theoretical scenario offers its own challenges to expand the imagination. However, pilots are already no strangers to the automation that exists in their everyday lives flying commercial aircraft. The semi-structured qualitative research consisted of developing a deeper understanding of the pilots' thoughts on the three-pronged approach: (1) the psychological barriers and motives of the pilot, (2) the differences in aircraft ground-based safety and training, and (3) pilots' understanding of the timeliness of entry for unmanned flight deck operations to reach FAA standards.

Sample Population

Commercial airline pilots, including ranks of both Captains and First Officers (FO) in Part 121 scheduled service, were the research population for this study. The sample population number was 15 airline pilots offering various diversity in age, gender, years of service, airline employer, and military or civilian flight experience. Gaining content comparison between the relationship and patterns in variations of the data, the sample reflected key individuals who identified as having significant professional knowledge (Patton, 2015).

The non-random sampling method used by the researchers was both purposive and convenient. In purposive sampling, the researcher selects participants who have the needed qualities of subject knowledge and topic understanding (Gay & Airasian, 2003). Convenience sampling indicates the selection of participants based on group availability (Gay & Airasian, 2003). The researchers established limits on participants to only those currently employed as U.S. commercial airline pilots, suggesting a purposive sampling process. The researchers also took advantage of selecting participants from personal contacts within the airline industry and referrals from other industry professionals, suggesting a convenience sampling process.

Research Instrument and Data Analyses

The collection of research data began by contacting U.S. certificated Part 121 airline pilots and asking for their willingness to participate in a research study involving their professional insight on the future development of aircraft automation within the airline industry. (Appendix). Regarding the interview process, the researchers asked several demographic questions to better understand the pilot's employment position and responsibilities with the specific airline. Next, the researchers asked a series of open-ended questions to develop a deeper understanding of the pilot's willingness to adopt fully autonomous aircraft and the amount of automation they are currently using in the cockpit. The last part of the interview process allowed the pilots to provide additional personal and professional comments regarding the future of autonomous commercial airline flights. These ten questions drove the initial conversation; however, the pilot was provided the freedom to diverge into other perspectives. Rather than taking notes, all interviews were audio recorded and transcribed by the researchers to ensure consistent data. These transcripts were generated through Zoom's formalized transcription process, and then the researchers used inductive coding to manually code each transcript and cluster common responses into themes (Creswell & Creswell, 2018). The collection of data began in November 2022 and concluded in January 2023.

Validity and Reliability

The validity of the research instrument was assured by forwarding interview questions to airline professionals representing the commercial aviation environment, as well as aviation faculty members knowledgeable of the U.S. airline industry and qualitative research methods (Robson, 2002). These nine aviation professionals and faculty members examined the set of questions, confirmed its focus on the research topic, and verified its clarity in wording and instruction. To ensure interview reliability, all questions were consistent across the administration of the interview and were asked the same way by the researchers. Also, the researchers summarized and restated the findings gathered from the interview and allowed the pilot to reflect on any additional feelings, views, or experiences regarding the responses shared with the researcher (Robson, 2022). This increased the authenticity of the findings and decreased any incorrect interpretation of the data.

Research Findings

The research findings were derived from interview data, which was transcribed and examined to develop themes related to each of the three research questions. Demographics of the fifteen participating pilots are displayed in Table 1.

Table 1
Demographic of Participants

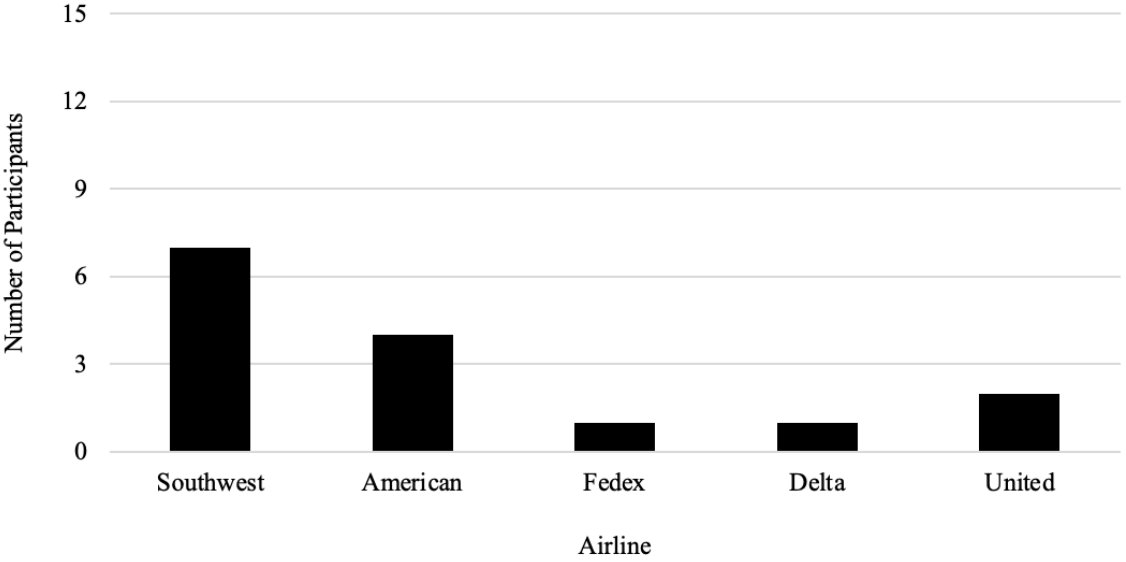
	Employer	Gender	Military Background	Rank	Years of Service
Pilot 1	Southwest	Male	Yes	Captain	32
Pilot 2	American	Female	Yes	Captain	22
Pilot 3	FedEx	Male	Yes	Captain	22
Pilot 4	Southwest	Female	No	Captain	24
Pilot 5	American	Male	No	Captain	35
Pilot 6	United	Male	No	First Officer	7
Pilot 7	Southwest	Male	No	First Officer	1
Pilot 8	Southwest	Male	No	Captain	30
Pilot 9	Southwest	Male	No	First Officer	9
Pilot 10	Southwest	Female	No	Captain	34
Pilot 11	United	Male	No	First Officer	4
Pilot 12	Delta	Male	Yes	First Officer	3
Pilot 13	American	Male	No	Captain	32
Pilot 14	Southwest	Male	No	First Officer	6
Pilot 15	American	Male	No	First Officer	26

Data Analysis of Interview Questions

(Q1) What is your professional flight background and current position as an airline pilot?

Figure 2 displays the employer demographic. The 15 pilots are represented across five U.S. airline employers. Within the interviewed group of pilots, seven (47%) were Southwest pilots, four (26%) were American pilots, two (13%) were United pilots, one (7%) was a FedEx pilot, and one (7%) was a Delta pilot.

Figure 2
Employer of Pilots



Of the 15 interviewed pilots, 12 pilots (80%) were male, and the remaining three pilots (20%) were female. Four of the pilots (27%) indicated they had served in the military, whereas 11 pilots (73%) indicated they did not have a military service background. Each participating pilot was asked about the current professional rank. Eight of the pilots (53%) were Captains, and the remaining seven pilots (47%) were First Officers. Last, three pilots (20%) had five or fewer years of service, three additional pilots (20%) had between 6-10 years of service, three pilots (20%) stated they had between 21-25 years of service, two pilots (13%) had between 26-30 years of service, and the remaining four pilots (26%) had between 31-35 years of service.

(Q2) From your experience as an airline pilot, do you believe passengers are aware of how much flight deck automation currently exists within commercial flights?

Although 80% of respondents believed that passengers are aware of how much automation exists, a common theme between responses was the lack of a passenger's understanding of automation levels that pilots encounter during flight. Pilot 2 believed that passengers are overly aware of how much automation currently exists, "They think we have more automation than we do because I get comments all the time like, 'Well, you do not really do anything. The autopilot does everything. You just sit there.'" Pilot 5 agreed, "I think there's a perception that we don't do anything out there. We just watch it fly."

The pilots who responded no to this question were consistent in their responses regarding automation. A commonality amongst this group of pilots was that passengers have a sense of awareness of automation within a commercial airplane but do not have a full understanding of the degree to which it exists. Pilot 1 stated, "I think some passengers are probably surprised at how much the autopilot flies the airplane. People know there are some phases of flight that require automation, but probably have no idea the purpose behind the automation." Pilot 6 felt similarly, "The public thinks that an autopilot in their Tesla car is the same as using an autopilot in an aircraft. They assume that we input a destination airport, and the plane magically takes off and flies us to our destination while we sit there and wait in case of an emergency."

(Q3) What will be some of your personal and/or professional benefits (if any) with integrating complete automation into commercial flight?

When asked to consider the benefits of complete automation in the industry, the pilots had similar responses. As a result, several themes emerged from the pilots' perceptions regarding the benefits of complete flight automation. The themes were (1) better home life, (2) personal safety, (3) minimizing fatigue, and (4) regular schedule.

Most pilots (73%) stated, at some level, that their home life would improve if they were able to fly fully autonomously. Pilot 9 described this benefit as such, "The benefit would be to be home every night. I would say the biggest resource that we provide to our companies is our time. And that is why sometimes I do not feel guilty about making the money that we do because I am missing time with my kids." Pilot 4 compared pilots to their friends who have a more standard work-life balance. "I think the comfort factor would be very appealing for pilots. You would have to look at it if you were the one traveling on the road, away from family, and missing day-to-day events that other people with 9-5 jobs get to go to."

Sixty percent of the pilots who identified personal safety as a benefit based their opinion on less exposure to radiation. Pilot 13 described his relationship with radiation exposure as this, "On the 777, you get a lot of radiation exposure. When you fly in the high latitudes, the higher north you go, and depending on the solar activity, the more radiation you get. So, a lot of people on the 777, which is highly automated, efficient, and can get up to these altitudes very quickly, get a lot of radiation."

Almost half of the pilots (47%) responded that minimizing fatigue and time zone changes would be a significant benefit. This is not surprising as seven of the 15 participants frequently fly internationally. Pilot 10 states, "Well, I would not have to travel through so many time zones to do my job, which sounds amazing." Pilot 8 combines a lack of fatigue and more home time into his response. "I think fatigue for sure. It is a big thing. Pilots are gone a lot. I like being home. The perk of flying allows you to experience a lot of things, but at the end of the day, I like being at home."

Three pilots mentioned a benefit of flying fully autonomous aircraft would be having a more regular schedule. Many of these responses were paired with having better sleep patterns, less task saturation, and boredom within the job. Pilot 15 correlates a more regular schedule when talking about flight delays and cancellations. "You would have more of an 8 to 5 schedule. When your shift is over, you are done." Pilot 13 agrees: "You have a set schedule to fly autonomously at some facility, and then you just go home. I would get more time with my family."

(Q4) What are some of your personal and/or professional concerns with integrating complete automation into commercial flight?

When the researchers asked the participants what concerns they may have with complete flight automation, several themes emerged, including (1) trust in automation, (2) task saturation, (3) communication gap, (4) software failure, (5) lack of aircraft control, and (6) terrorism.

Lack of trust in automation was a common response, as 47% of pilots addressed this as a primary issue when discussing the concerns with implementing fully autonomous flight. Pilot 1 stated, “I do not think people will trust it. I do not think that you are going to find many people who would be willing to get on an airplane where there is not a human flying the aircraft.” Pilot 13 had similar thoughts on the issue. “If I am down on the ground flying and they are up there, I would always worry about that link and pray not to lose connection or get hacked. I do not trust the overall safety of the whole thing.” Pilot 1 commented on the lack of trust from the passengers’ perspective. “There is a level of trust in pilots because passengers know they are not going to do anything that will put their own life in danger. Whereas if a pilot is not actually sitting in the cockpit, where is that level of trust placed now? I am not saying that somebody who is flying an airplane remotely would purposely be nefarious about it. However, the truth is people will not trust automation.”

Pilot 2 felt strongly about the concern of task saturation. Having military experience, she worked with many drone pilots who experienced task saturation and boredom. “For me, sitting in a box would be boredom. This would be the silent killer.” Task saturation was the outlier, as only one pilot spoke of this concern.

Forty percent of pilots addressed the communication gap as a concern with fully autonomous flight. Pilot 3 questioned the integrity of an autonomous system and his ability to override the automation if needed. “How will I communicate with ground operations? There are so many fail-safes with us being up in the sky, but what happens when something goes wrong? There must be safety nets in place because something is going to happen. It is only a matter of time.” Pilot 2 linked the communication gap to the lack of sensory cues present in the box rather than physically being in the cockpit. “You do not have the ability to hear what is going on in the cockpit. You do not have the ability to smell an electrical fire.” Pilot 2 posed the question of what happens when a pilot flying the box gets multiple emergencies at the same time. “How do you prioritize? Deciphering the emergency is hard enough being in the cockpit. If you cannot see or touch it or have somebody that is there to tell you what is going on, then how do you know what to do?”

Sixty percent of the pilot group expressed their concerns about software failures. Pilot 4 stated, “We all see problems with automation, computers, and software failures. If you had a software failure, it could cancel communication between the pilot and the automation itself.” Pilot 6 added, “My biggest concern is the divergence of two factors that make air travel unsafe: implementing more automation and deteriorating pilot skills. If I am not up there, and I do not see it, how can I react to certain things? Pilots are trained to think ahead, and the computer cannot see things like that right now within the cockpit.”

Sixty percent of pilots expressed the inability to physically control the aircraft as a major concern. Pilot 6 gave this scenario, “A lot of times, the controller gives me speed 180, and I can tell the computer is not adjusting for the differing winds. If I do not intervene, I am going to eat up the guy ahead of me." Pilot 7 added, "If something was to go wrong, then who is there to take over? Fully automated aircraft are a man-made product, and everything that is man-made fails."

Only 13% of participating pilots mentioned the threat of terrorism as a concern for fully autonomous flight. Pilot 7 questions the thought of terrorism if fully autonomous flight is achievable. "We have a locked cockpit door with two pilots up front that have control of the airplane. Who would want to trade anything for that? Whereas, if it is a Wi-Fi based or satellite-based system, anybody could hack into that system and technically override that aircraft and use it for a terrorist attack."

(Q5) What are your thoughts on losing the adventure of travel and the joy of flying?

Only one of the 15 pilots (7%) was good with this proposed change to their career expectations, with Pilot 9 stating, "This is going to sound horrible. I am not at the place in my career where I necessarily come to work for the fun aspect of it. I am in this growing family phase, so it is more important for me to be at home for longer times. Right now, I come to work to make money, and then I go home. So, I do my best to maximize my pay on the road, and then I get the heck out there."

While only one pilot saw losing the travel aspect of the job as a positive, 93% of pilots would miss the travel. Pilot 1 felt strongly about this issue, "I could not do the drone pilot thing. Sitting and learning in a little box, not actually flying around, and seeing new things does not entice me." Pilot 8 stated it this way, "I would hate it. It is a big reason pilots get into this industry because it is different from a 9 to 5 job. You are not sitting at a desk. You actually get to go out, see things, travel, and fly."

(Q6) From an airline company perspective, what are some of the benefits of moving toward complete automation? What are the threats and risks of complete automation?

When responding to question six, the pilots addressed three key factors of why the move toward fully autonomous aircraft would be a benefit from the airline's perspective. The three factors were (1) cost savings, (2) pilot fatigue, and (4) human error.

Of participating pilots, 87% stated that cost savings would be a huge attraction for airlines to move toward fully autonomous aircraft. This cost-saving would come from a reduction of fatigue and sick calls, pilot salaries, travel expenses, contract negotiations, and other ancillary costs required to operate an airline. Pilot 12 commented, "From a corporate perspective, you could make the case for more efficiency and cost savings because employees are the most expensive part of the system." Pilot 13 viewed this similarly, "I think they would save costs. They would not have those darn expensive pilots and would not have to negotiate contracts with them or pay health care costs."

Pilot 11 believed the lack of pilot fatigue, from a scheduling standpoint, was a major benefit from a company perspective. "A big benefit would be fatigue. If we were completely automated, that would take the human fatigue element out of it. And then, if we became systems monitors, our schedules would rotate from shift to shift every six hours. Then we are done for the day."

Twenty percent of pilots agreed human error would be a major concern when discussing safety amongst pilot operations. Pilot 6 had recently completed FAA training known as Pilot Professional Development (PPD), where each employee learns about his or her personality and characteristics and who they might work well within this environment. Pilot 6 saw this as a major benefit between the human-to-human interaction that causes friction within the workforce. "So that is eliminated, too, right? I do not have a 64-year-old pilot paired with a 24-year-old pilot and trying to mash two generations together. Or a grumpy pilot who just went through a divorce and does not want to engage with the other pilot. That does not work well, so that is all eliminated, which is a huge benefit for the airline."

The second part of question 6 asked the pilots to respond to threats and risks of complete automation from an airline's perspective. The researchers identified four themes based on the pilots' responses. These themes were (1) the public is not ready, (2) increased risk in operations, (4) cost of technology, and (5) terrorism.

Forty percent of pilots agreed that the public is not ready to move toward complete automation regarding airline profitability. Pilot 14 stated, "I personally do not think passengers will ever trust fully autonomous airplanes." Pilot 15 also recognized the reputation that US airlines must uphold in the future. "You know the U.S. has one of the best safety records for FAA regulations, and overall, we have done a good job of safely moving people from A to B. I do not know if the integration of autonomous flight is worth that reputation from an airline perspective."

Of the 15 pilots, five (33%) mentioned the increased risk in flight operations as a concern. Pilot 6 commented, "There would be huge operational risks from a company perspective." Pilot 13 described a scenario based on a passenger having a heart attack onboard and how the increased risk of not having a pilot in the cockpit could possibly result in loss of life without human intervention to divert the flight plan.

Twenty percent of participants identified the cost of technology as a barrier. With reduced overall costs being a benefit, Pilot 9 addressed the duality of the cost-benefit analysis many airlines would undergo to achieve complete automation. "I do not think it is enough of a cost-benefit to recoup the huge undertaking and investment that it would take to make complete automation a possibility. I think it would take decades to earn back the investment dollars. And I do not know if airline management is into getting returns on investments that would take that long."

While Pilot 4 was the only participant to identify the threat of terrorism as a risk of automation, she viewed this as an issue that supersedes any potential benefits, "You know I still have a major fear of terrorism. You have always been cautious of that. I think if pilots were all ground-based, it opens a new different level of terrorism and is not even worth talking about the cost-effectiveness that the company could be saving."

(Q7) What are your professional concerns about the employment of future pilot hiring? What will it take to get an entire customer base to trust automation?

Two-thirds of pilots (67%) did not find any concern regarding the future of pilot hiring. Pilot 9 used the current pilot shortage as part of his justification, stating, “With the current pilot shortage, I am not concerned about losing my job yet. We have not raised the pay enough to make it even a desired position.” Six pilots from this grouping stated their lack of concern for the future of pilot hiring stemmed from their doubt that fully autonomous flight would come to fruition within the near future. Pilot 2 remarked, “I do not think it will happen in the next 20 years, maybe in 30 years. But as for my employment, I am not worried.”

Three pilots (20%) addressed the accelerated hiring process within their airline operations and how this is a direct path to a shortage of proficient pilots in the future. Pilot 13 explained, “A lot of the pilots that we are getting, especially on the automated Airbus, lose their stick and rudder skills. They do not really know how the aircraft works. You are just a manager of automation, and you are following the pink line. There is a real concern about pilots losing stick and rudder skills and the knowledge of flying.”

Pilot 8 mentioned another concern is the lack of pilot proficiency in relation to pilot overreliance on automation. “Today, you can start at zero flight time and in four years be hired at Southwest. The lack of experience out there with actual real life and knowledge on issues is quite scary, and I see it all the time. From a human decision-making standpoint coupled with a fully autonomous world, this could be a recipe for disaster. If the computer is deciding for you, and you, as a pilot, have never been in a similar emergency, then I do not see any good outcomes from the situation.”

The second part of question 7 asked the pilots what it would take for the customer base to trust automation. The researchers identified three themes based on the pilots’ comments. The themes are (1) data evidence, (2) perception of safety, and (3) advanced technology.

Sixty percent of the pilots agreed that data evidence would help build consumer trust. Pilot 3 commented, “For customer trust, I think they would require a whole lot of data regarding successful flights.” In addition, two-thirds of this pilot group mentioned that cargo aircraft would be the first to help build data evidence for passengers. Pilot 14 stated, “I do not think trust is impossible. I think over time it will happen, but it will have to occur in areas like cargo first and then go to one pilot in the cockpit.”

About one-half of the pilots (53%) mentioned the increased perception of safety as an avenue to build consumer trust. Safety perception built through regulatory bodies such as the FAA and ICAO supports this theory as Pilot 10 felt confident about her opinion, “I would say there needs to be a lot of data and a lot of demonstrations as to what safety really is. Regulatory bodies like the FAA and ICAO would have to come together and establish standards in place to ensure this will work the way it is intended to work for the level of safety needed.”

One-third of the pilots stated if there was an increase in better technology, then public trust would increase as well. Pilot 8 commented, “We need technology that thinks and acts not only like computers but as humans.” Pilot 14 also saw the need for additional technological improvements as he compared the technological differences between Boeing and Airbus aircraft. “You look at the 737, and you compare it to an Airbus. The 737 is old, and it has not gotten any newer. The 737 is being marketed as a new airplane, but it still uses 1960s technology. So that means that everything the airplane does with hydraulics, air systems, or electrical systems demands human intervention. But for Airbus, they see rapid technological growth. There are only like four buttons in that airplane, now.”

(Q8) Do you believe that the human element of aeronautical decision-making will always mitigate risks and threats better than a computer?

An overwhelming 87% of pilots thought the human element within aeronautical decision-making would mitigate risk better than a computer. Pilot 1 added, “I do. I was just in a briefing the other day, and we talked about the concept of risk. Risk has no memory. So, just because you got away with something one time does not mean that your risk of an unwanted outcome is any less because you have seen it before. Also, we can never truly replicate all the exact conditions every single time that we do something. Whether it be flying an airplane or riding a bike, you are never going to exactly replicate everything. So, I believe that a human has a better propensity to help reduce that risk than a machine does. Machines try to replicate; humans try to investigate.”

However, pilot 7 believed computers could mitigate risk better than the human element. “You have done your accident investigations just like I have, and many of them are human error. However, I will say there have been a lot of automation failures where humans had to take over and save an accident. I do not think that computers are smarter than humans, but I do not think that humans are necessarily smarter than computers. They both have their own defined roles.”

(Q9) Would you choose a commercial airline pilot career path if you knew you were to fly a desk rather than flying the skies? Why or why not?

Only 20% of pilots would consider an airline pilot career as a remote pilot rather than physically flying the aircraft. Pilot 6 responded, “I would still choose it. With the increasing global population and more people rising out of poverty, there is a good chance we will have more flights requiring more pilots. So even if we reduce the number of pilots on the flight deck, we will need more individual pilots for the ever-increasing number of flights.”

The remaining 80% of pilots would choose a different career path if they knew they were going to sit at a desk rather than sitting in a cockpit. Pilot 1 responded. “No, I would not do it. It would not be the same job anymore.” Pilot 7 also commented similarly, “I would probably change careers. I could not sit at a desk. That is the reason I got into aviation, to begin with. Being confined to a cube or a building all the time is not something that I am wired for.” Furthermore, Pilot 10 stated, “No, it does not sound appealing to sit inside and operate a video game type control room. There is no longer a human element.” Last, Pilot 14 would choose a different career as well. He simply stated, “There is just something special about flying an airplane.”

(Q10) As an airline pilot, do you believe you will have the opportunity to experience a fully autonomous flight before your mandatory retirement age? Why or why not?

Despite their years of service, none of the pilots believed they would see fully autonomous operations before their mandatory retirement age. Pilot 2 said, “I hope not. I could be wrong, but I do not think we are there yet. If anything, air traffic control (ATC) will go autonomous before we do. There is a feature on the Airbus that allows us to communicate with ATC in a way like texting rather than talking on the radio. They type it in, it shows up, I accept it, and it gives me a new altitude. I go to the control panel, accept the altitude, and the aircraft climbs.” Pilot 10 mentioned the Boeing 737 MAX incidents as examples of why fully autonomous flight will not be achieved within her commercial career. “Just like in the B737 MAX crashes, systems failed, but the pilots had a fighting chance to bring the airplanes down safely. If a complete automation system fails, who is there to take over?”

Conclusions

Conclusions Based on Research Question One

As automation continues to advance within the aviation industry, the workload, training, and scheduling of pilots will begin to look different. The findings based on research question one are (1) the role of the pilot changes from a single flight focus to a multi-flight monitor, (2) the demand for a pilot’s stick and rudder skills will continue to diminish overtime, (3) there is a heightened sense of pilot awareness while physically flying the aircraft, and (4) pilots desire a better work-life balance.

The findings concluded that pilots are aware of the workload changes that are present with implementing fully autonomous aircraft in the Part 121 category. Two themes became evident when discussing workload changes. First, the role of the pilot changes from a single flight focus to a multi-flight monitor. As a result of airline cost savings, 87% of the pilots believed this would be a benefit for airline operations in the future. Pilots will pass along workload responsibilities rather than assuming full responsibility for each flight. Secondly, as technology advances, the pilot’s physical workload of hand flying an aircraft will constantly deteriorate. Therefore, the demand for a pilot’s stick and rudder skills will continue to diminish over time. According to the participating pilots, the aircraft’s autopilot is engaged, on average, between 95-99% of scheduled flight time. While it is no secret that the public knows automation exists within the airline industry, only a small percentage have knowledge of the various levels of automation capabilities and their purpose during different phases of flight.

The term having *skin in the game* was mentioned by several pilots as they believed their sense of awareness was heightened while physically flying the aircraft rather than being in a simulated environment during training exercises. This was evident when the participating pilots stated the removal of sensory cues was a professional concern. Would pilots still get the same sense of adrenaline or ownership if they were sitting in a box? Training pilots for situations in which they might not have control will create a major difference in situational management, having to understand how to override automation failures without humans physically being in the cockpit. This was a concern for 60% percent of the participating pilots.

The most predominant theme when discussing scheduling changes was the pilot's desire to be at home. This was significant as 73% of the pilots mentioned that a better home life would be a benefit in moving toward a completely autonomous industry. This was discussed through the benefits of less time commuting, less time spent in airports, less task saturation, less boredom, and less fatigue specifically related to long workdays or time zone differences.
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Conclusions Based on Research Question Two

The advancement of a fully automated flight deck and its effects on the U.S. airline industry can potentially have significant impacts on the psychology of commercial airline pilots. While pilot responses varied based on individual experiences, attitudes, and adaptability, there were several psychological responses identified in this study, including (1) loss of control, (2) uncertainty toward technology, (3) job insecurity, and (4) adaptability.

Pilots who have spent countless years gaining expertise in manually operating an aircraft may experience a sense of loss of control in their job duties with fully autonomous flight. This loss of control could lead to feelings of frustration, anxiety, or a diminished sense of job fulfillment. This was evident as 60% of pilots addressed their lack of control over the aircraft as a professional and personal concern. Automation is eroding their ability to physically override the aircraft, which, naturally, pilots will be resistant to. Pilots may begin to feel their skill set is becoming more obsolete and, as a result, are being pushed out of their profession.

The introduction of automation increases technological uncertainty for pilots regarding the reliability, safety, and vulnerabilities of automation. As evidenced in the study, most pilots (87%) believed humans can mitigate risk better than computers. This demonstrates the clear uncertainty toward current automation systems that currently exist within the US airline industry. Should the ability of automation continue to improve, pilots may change the way they view computers to manage emergency situations effectively. For now, however, it is clear there is an entrenched view to favor human aeronautical decision-making.

Increased automation creates insecurities within the pilot profession. The role of airline pilots may change from being a primary operator of an aircraft to simply monitoring and supervising an automated system. This leads to pilots feeling less valued regarding their careers. If automation proves to be safe, dependable and trusted among passengers, the U.S. airline industry could witness an overall decrease in the demand for pilots. While 67% of the pilots expressed no concern regarding future hiring, this could become a reality should the risk and/or benefit of implementing automated systems change.

Change is inevitable, and all must remain adaptable in this profession. However, increased automation would significantly change the aviation industry, and pilots may struggle to adapt to new lifestyles and technologies. Most pilots are not willing to accept this new lifestyle, as evident in that 73% of the participating pilots would choose a different career if they were required to sit in a box rather than physically fly the aircraft.

Conclusions Based on Research Question Three

The advancement of a fully autonomous flight deck will obviously create additional concerns for U.S. airline passengers. The most significant concerns for passengers will include (1) safety, (2) trust, (3) passenger-pilot relationship, and (4) understanding of technology. Passengers will always question if modern technology has been thoroughly evaluated and if it can react to unexpected situations as safely and effectively as a human. Before any autonomous technology is mentioned as a permanent replacement within the cockpit of a commercial airliner, passengers must feel comfortable with the overall reliability and safety of this modern technology. If automated flights become more common and can provide convincing evidence regarding their reliability, then perhaps passengers will have more trust in autonomous technology. Some of the pilots participating in this study mentioned how passengers have come to trust the auto-pilot systems currently in use. And that passengers will need to view autonomous flight as the natural progression in technological advancement onboard commercial aircraft.

It is entirely possible that the absence of pilots on board will create differing views among passengers. Some will have more trepidation about being in an unfamiliar situation without the perceived safety of a human sitting in the cockpit. For others, they may feel safer flown by a computer and not having a human error element onboard. However, 80% of the participating pilots agreed the human element of intervention is safer than relying on unpredictable and unreliable automation. There is little doubt the relationship between the pilot and passenger will look completely different if fully autonomous flight is implemented.

Final Summary

The purpose of this qualitative study was to interview 15 airline pilots to identify their perception of an unmanned commercial flight deck and its intended implementation in the U.S. airline industry. The objective was to better comprehend fully autonomous flight and the influence it will have on U.S. commercial airline pilots, as well as investigating the effects on the U.S. airline industry and the human-machine interaction. This research, through the personal life experiences and professional knowledge of the participating pilots, along with existing research, was able to identify those elements needed to make conclusions for each of the three research questions.

This study succeeded in providing a greater knowledge of pilot perception toward automation and the impacts that fully autonomous flight will have on the role of a pilot. This study also provided a knowledge base on pilots’ current lack of trust toward automation. Grasping this theoretical concept of fully autonomous flight within the airline industry was alarmingly foreign to the pilots participating in this study. This finding from this study will further educate the public and other pilots on the possible opportunities and obstacles with the integration of advanced technology in the cockpit.

Recommendations for Further Research

The findings from this study provided the opportunity for future research initiatives. Further research into current advancements in automation that exist specifically pertaining to flight operations would be beneficial in understanding current policies and regulations within FAA standards. Further research into Air Force drone operating units would assist in developing commercial standardization for fully autonomous flight in the airline industry. Although military drones are usually weaponized for combat and operate under different operating categories, a greater understanding of fail-safe procedures, training requirements, operating spaces, and communication between aircraft and ground-based systems would be beneficial.

Further research into the psychological element of human trust regarding automation would help articulate the complexities that seemed intangible to many of the pilots within this study. Automation was considered by many participants as just another tool used in the cockpit. How will automation go from being thought of as a tool to being dependent upon people's lives? Further research aimed at specific measures to gain public trust, other than from a pilot’s perspective, would assist in a more holistic approach to understanding the psychology behind how humans build trust.

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APPENDIX

Interview Questions

The following tentative interview questions will be asked to each participating pilot:

1. What is your professional flight background and current position as an airline pilot?
2. From your experience as an airline pilot, do you believe passengers are aware of how much flight deck automation currently exists within commercial flights?
3. What will be some of your personal benefits and/or professional (if any) when fully autonomous flight is in operation?
4. What are some of your personal and/or professional concerns with integrating complete automation into commercial flight?
5. What are your thoughts on losing the adventure of travel and joy of flying?
6. From an airline company perspective, what are some of the benefits of moving toward complete automation? What are the threats and risks of complete automation?
7. What are your concerns about employment for future pilot hiring? What will it take to get an entire customer base to trust automation?
8. Do you believe that the human element of aeronautical decision-making will always mitigate risks and threats better than a computer?
9. Would you choose this career path if you knew you would be monitoring a fully automated cockpit instead of piloting the aircraft? Why or why not?
10. Do you believe fully autonomous flight is achievable in your lifetime? Why or why not?

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Distinguishing the Job Market Across Aerospace and Aviation: A Natural Language Processing Approach

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This study dives into the intricate landscape of the aerospace and aviation job market. While these two markets are often conflated as being similar, if not the same, we propose that the differences are important to recent graduates of educational institutions and career programs. The research utilized a custom-written Natural Language Processing (NLP) software tool to distinguish the differences in 6,000 job offerings between the two industries with the hope of illuminating nuances to those in positions involved in placing professionals into careers. This research not only reveals the dynamic employment landscape of aerospace and aviation but also highlights the power of NLP in more clearly discerning emerging trends in job data.

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Although the U.S. Aerospace and Aviation industries are known to be highly bifurcated from those closely related to the field (Vasigh & Gorjidooz, 2016), they are largely seen as one singular entity to human resource and human capital professionals in the job market. In reality, the division between the two exists in two primary domains: the first being developmental (i.e., aerospace) and the second being operational (i.e., aviation). These divisions have a direct impact not only on the labor force skills required to operate within these specific industrial sectors but also have an impact on the evolvement of where these sectors are located (Rochon, 2011). For example, the aerospace sector is predominantly located on the Atlantic and Pacific Seaboard of the United States (Dancy, 2017), with more of the manufacturing portion of that workforce located on the Pacific Seaboard (Platzer, 2009). However, there are areas in the country that have been successful in gaining traction with Aerospace and Aviation manufacturing jobs, like Texas, Kansas, and New Mexico (Chang, 2020; Yazici & Tiwari, 2021).

While looking somewhat similar in name, each industry sector is distinctly different. Aviation is mainly focused on activities surrounding mechanical flight within the troposphere and stratosphere (Torenbeek & Wittenberg, 2009). This includes aircraft that are fixed-wing, rotary-wing, morphable wings, wing-less lifting bodies, and lighter-than-air craft such as hot air balloons and airships (Vinh, 1993). The newer field of urban air mobility (also known as Advanced Air Mobility) would also be included in the aviation sector (Reiche et al., 2021). In contrast, the aerospace sector has activities primarily surrounding mechanical flight within the troposphere, stratosphere, mesosphere, thermosphere, exosphere, and outer space (Anderson et al., 2015; Sirieys, 2022; Suthagar et al., 2022). In addition to aircraft, aerospace-focused organizations design and operate "mesospheric-plus vehicles" (i.e., rockets, missiles, spacecraft, satellites, probes, rovers, etc.) (Tewari, 2011).

The researchers conducted a systematic literature review in aviation and aerospace journals and found that existing research focused on the combined aspects of the aerospace and aviation industries without considering the multiple facets of each that make them unique for the workforce and job labor markets. For example, Lappas & Kourousis (2016) focused on new skills in the aerospace and aviation industries without marking differential aspects between the two. Additionally, in Rochon (2011), the focus of aerospace and aviation workforce strategy contained no differentiation of the terminology.

Our research goal is to determine if there can be clear delineations between the aerospace and aviation industries when examining job data from the employment market. This would be useful and timely for institutions of higher learning and educational programs that offer students career services to more directly help their alumni seek the most applicable jobs to their careers. Those involved in aviation research understand that these two industries are highly specialized with unique workforce needs (Bedialauneta et al., 2020). However, this research also seeks to further clarify the special workforce needs of those who would be involved in assisting graduates and future employees with their careers, such as advisors, career services professionals, and human resource departments of the company they ultimately choose. While some of our older notions of the workforce may remain the same, our goal for this research is focused on illustrating emergent trends regarding a) job title classifications between the aviation and aerospace sectors, b) classifying the human capital skills, and c) quantifying the demand for labor skills across these two industrial sector segments.

Methodology

This research is based on computational grounded theory. Traditional grounded theory is a research method designed to allow for the analysis of qualitative information, arriving at an underlying emergent theory via the categorization of information via unstructured phenomenon (Nelson, 2020). By contrast, computational grounded theory is a research method designed to quantitatively analyze qualitative information, arriving at an underlying emergent theory using a focused data-driven categorization of unstructured phenomenon (Glaser & Strauss, 2017).

As part of the computational grounded theory process, our unstructured data sets were codified by our research team and analyzed using a natural language processing (NLP) engine that we developed in-house. NLP uses continuous sequences of words or symbols called N-grams. These N-grams are processed through a systematic treatment, resulting in the breaking down of text into chunks of words (Guo et al., 2021). After the text has been converted into N-grams, it becomes useful to start categorizing relevant information using NLP (Dreisbach et al., 2019). These chunks of text are especially useful when planning on using word frequency models (Guo et al., 2021)

Each job record was labeled as being either ‘aerospace’ or ‘aviation’ based on our researchers' review of the company’s predominant mode of business. For example, when coding Lockheed Martin, it is a company noted for primarily being an aerospace-based company; a company like ‘United Airlines’ would be coded as being an aviation-based company. This is known as structure augmentation (also known as substructure augmentation); in our case, this form of data augmentation divides the research data into two data tree structures (i.e., aerospace and aviation). This structural data augmentation allows us to perform comparative NLP tasks such as text parsing, textual classification, and comparative token analysis (Shi et al., 2021).

Data Sources

Our data sources were then organized into two main categories: *market data* and *job data*. Market data is predominantly economic and financial in nature, and we leveraged two sources: Economic Modeling Specialists International and Fidelity Investments. These data sources were used to determine macro-level industrial segmentation metrics such as business sectors, market capitalization (market caps), sector performance, and industry growth. A visualization is presented in Figure 1 for market data and Figure 2 for job data.

Figure 1
Market Data

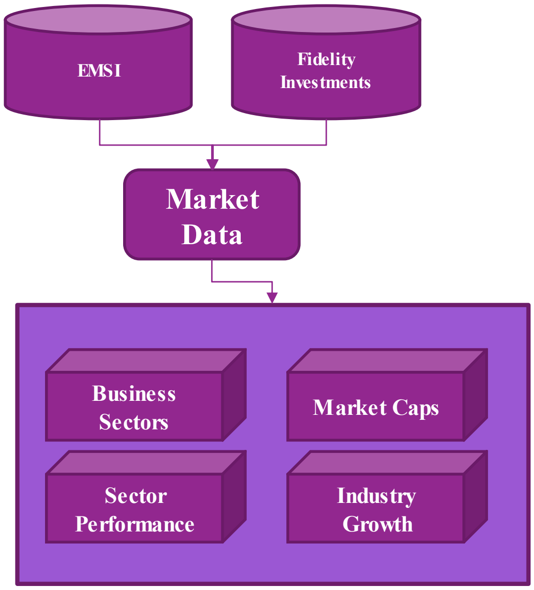
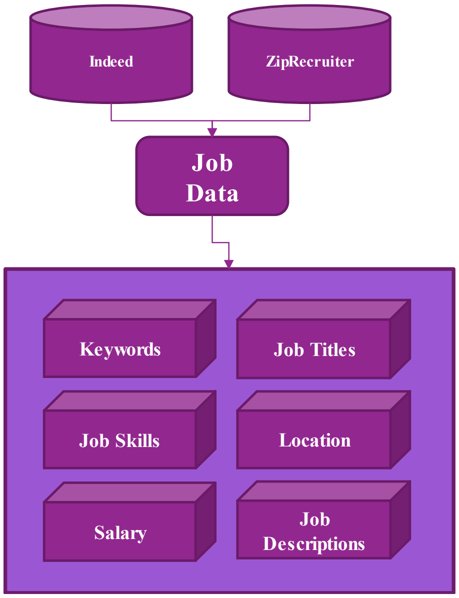


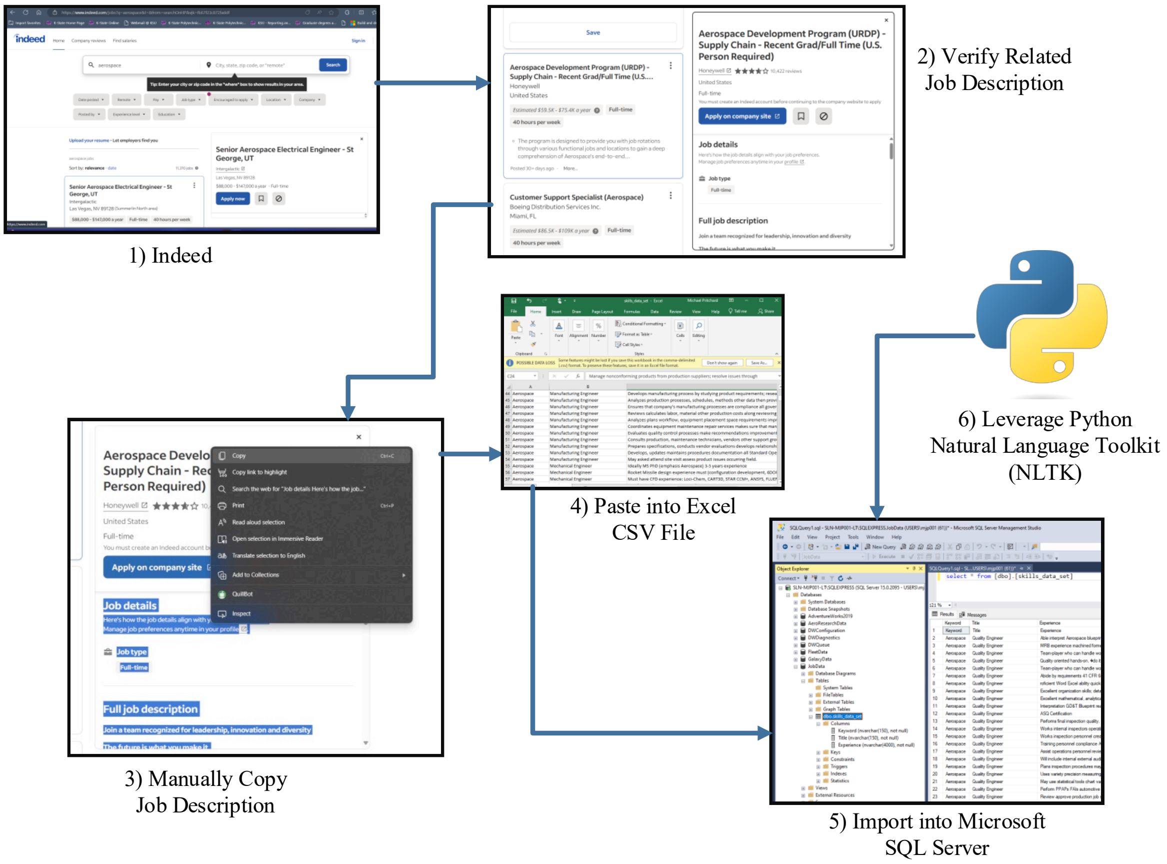
Figure 2
Job Data



Our job data comprises our secondary data source. This is composed of unstructured job board data that was manually scraped from the Indeed and ZipRecruiter job sites. Both websites have been used with success as a source of professional job data in defining job market demands (Eberts, 2023; Wang, 2020). To gather this data, we manually employed a systematic process between. First, the researchers searched ziprecruiter.com and indeed.com for all available aerospace job postings between May and June of 2021. This search range was substantiated by a report from Brazen (2015) that found that 43% of job openings are filled during the first 30 days, and conversely, 57% of job postings may still be active after a month. For each job posting, we manually copied and pasted the web page that contained all descriptors of the job (keywords, employer name, job titles, job skills, location, salary, and job description) into a .csv file. We repeated this process for aviation job postings. Next, we imported the raw text data into our Natural Language Processing engine. A visualization representation of this process is presented in Figure 3.

Figure 3

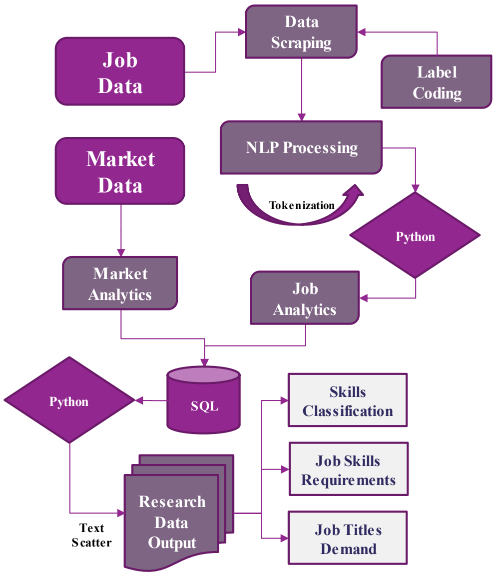
Initial Scraping of Data into Python for NLP



Data Process Model

While the market data provides macro-level market analysis, it does not by itself provide details regarding the job title classification between the aviation and aerospace sectors, the classification of human capital skills, or the quantification of labor demands across these two industrial sector segments. In this regard, we created the job data dataset to provide detailed insights into these three areas. A visualization is presented in Figure 4.

Figure 4
Data Process Model



Python was used to build our natural language processing engine. Python libraries included within the NLP engine include pyodbc, scattertext, nltk, pandas, and spacy. A SQL Server database was used to store and structure the job data. Python was also used to build the textual scatter plots seen in the results.

After completing our data process model (See Figure 3. Data Process Model), we were able to clean and distill 6,034 data samples across fifteen different organizations. A visualization of these companies and sample counts are presented in Table 1.

Table 1
Job Data Table (n=6,034)

Code	Organizations	Sample Count	Market Cap (Billion)
Aerospace	Lockheed Martin	2,841	$98
Aerospace	Honeywell	1,370	$144
Aviation	Textron	590	$16
Aerospace	Raytheon-Collins Aerospace	477	$130
Aviation	Alaska/Horizon	221	$7
Aviation	Delta	85	$25
Aviation	Spirit AeroSystems	78	$4
Aviation	Frontier	72	$3
Aviation	Flight Safety International	71	$1
Aviation	American Airlines	62	$11
Aviation	Bombardier	53	$3
Aviation	United Airlines	38	$14
Aviation	SkyWest Airlines	37	$2
Aviation	Mesa Airlines	31	$0.2
Aviation	Republic Airways	8	$0.0

In collecting the data, it was evident early on that the demand for aerospace jobs far surpassed that of aviation jobs. The demand difference was such that in our data collection efforts, we noticed early on a striking size differential between the aviation data tree and the aerospace data tree. A visualization of the two areas is presented in Table 2.

Table 2
Sector Data Tree Counts

Data Tree	Sample Count
Aerospace	4,688
Aviation	1,346

Using Fidelity Investments, we captured high-level macro metrics. Our data consists of domestic U.S.-based organizations that are publicly traded, where the industrial financial market data was collected and grouped according to industry classification and associated segments within the "industrials" sector (Fidelity Investments, 2021). Additionally, from a data sampling perspective, the individual tree sizes are more than twice what we needed to perform natural language processing-related tasks (Figueroa et al., 2012). The macro-level market data was used as a labor demand control group (i.e., when comparing the Sector Data Trees at a micro-level, we would get different results at a macro-level). While we can analyze skills within each data tree individually, we introduced a data ratio metric. This ratio was used as a control mechanism to a) standardize the data frames and b) enhance our analytical confidence when contrasting the labor demand differences between these two data trees.

As an industrial complex, the industry's sector market cap metric should, in theory, approximate the labor demand differences in the lower-level job data. A visualization of the market data is presented in Table 3. While there might be some slight variations, we should not see drastic labor demand deviations between the market data and the job data. As shown in Table 3, the market cap found in this study is within the data range of the overall market cap for each industry.

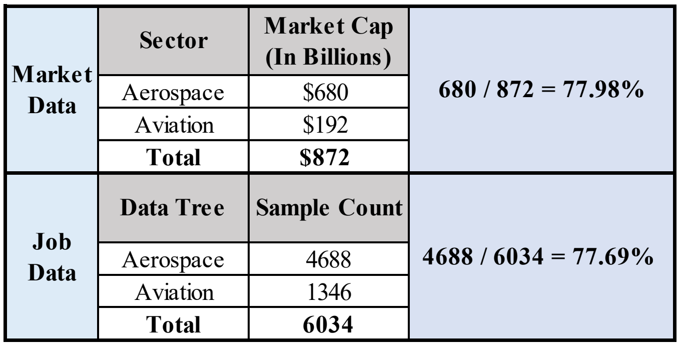
Table 3
Sector Market Cap

Sector	Market Cap Industry Total (in Billions)	Market Cap Within Study (in Billions)
Aerospace	$680	$372
Aviation	$192	$86

Results

The skills requirements within the job data exhibited a clear delineation of labor skill demands between aerospace and aviation-coded job descriptions. The types of jobs within the job data illustrated a market demand for labor largely in keeping with the higher-level market capitalization metrics found within the market data dataset. In analyzing our proposed data control mechanism, we found the sector data tree ratios to be similar. A visualization of the data is presented in Table 4.

Table 4
Data Control Group



Market Data	**Sector**	**Market Cap (In Billions)**	**680 / 872 = 77.98%**
	Aerospace	$680	
	Aviation	$192	
	Total	**$872**	
Job Data	**Data Tree**	**Sample Count**	**4688 / 6034 = 77.69%**
	Aerospace	4688	
	Aviation	1346	
	Total	**6034**	

The similarities are notable since, during our data collection process, we noted the need for more aviation data to help augment the job data disparity we were seeing in the data collection process. As it turns out, the job data disparity largely mirrors the macro market data metrics, and upon further review, we determined that our data sampling process remained intact.

Market Data

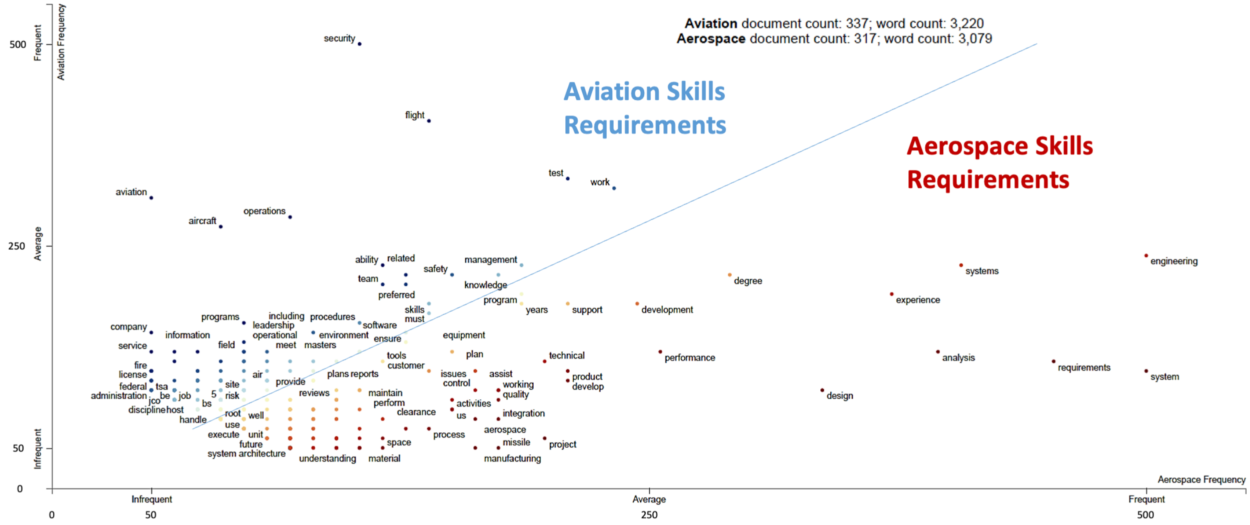
The total market capitalization of all firms in the industrial sector is roughly $5.21 Trillion (USD). The associated industries within the industrial sector specific to this research were "aerospace and defense" and "airlines." Additional sectors were captured as part of this research; however, our analysis was strictly focused on a standard data tree comparison between the two datasets (i.e., clearly defined aviation companies and clearly defined aerospace companies). The effects of COVID-19 really had a strong impact on the evaluated market sectors. Aerospace saw a decline of -21% growth from 2019 to 2020, with airlines seeing a decline of -17% over this same time period.

Job Data

The skills requirements text scatter data illustrates the variety of skills demanded by their respective industry sector assignment. The top skill requirements within the aerospace data tree are engineering, systems, analysis, and design. The top skill requirements within the aviation data tree are as follows: aviation, aircraft, operations, and security. The skills requirements text scatter does not illustrate a demand perspective. A skills requirement scatter plot visualization is presented in Figure 5.

Figure 5

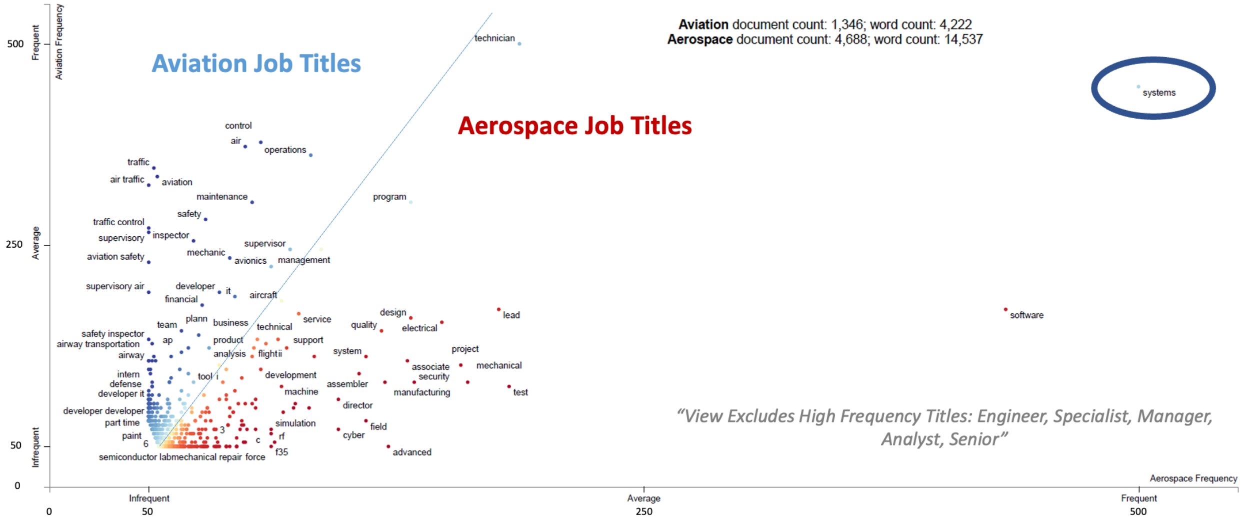
Skills Requirements Text Scatter Plot



It merely illustrates the skill breakdown between these two segments. However, a jobs demand perspective was included and illustrates the labor demand between aerospace and aviation. A jobs demand scatter plot visualization is presented in Figure 6.

Figure 6

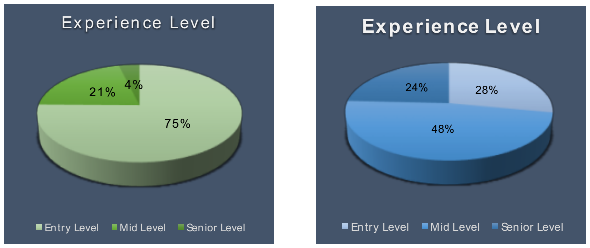
Job Titles Demand Scatter Plot



High-frequency terms such as engineer, specialist, manager, analyst, and senior illustrated a consistent theme within the data set that the demand for mid-to-senior level STEM-based jobs (Science, Technology, Engineering, and Mathematics) was a top priority in both sectors, yet, in higher demand within the aerospace sector. The demand for these mid-to-senior level jobs was so high that our initial job title scatter text was unreadable due to the high-volume frequency counts producing far-flung outliers that had the effect of shrinking the main scatter text to unreadable proportions. Thus, engineers, specialists, managers, analysts, and seniors were hidden so as to expand the scatter text view. In this view, we can see job titles that contain "systems" and "software" comprise not only the top two job spots in the aerospace sector but also the top job spots overall. Additionally, the job data illustrates an interesting trend regarding experience level. The aviation sector has a higher tolerance for hiring entry-level personnel; by contrast, the aerospace sector has a much lower tolerance for entry-level personnel. A visualization is presented in Figure 7.

Figure 7

Experience Level

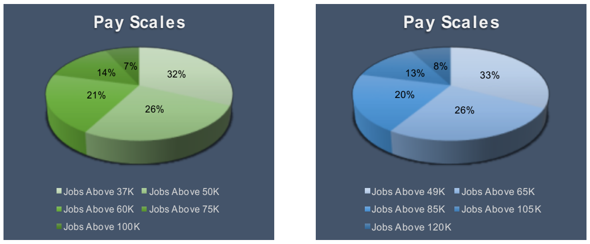

Aerospace Sector

Aviation Sector

Lastly, pay tends to be 11% higher on average in the aerospace sector versus the aviation sector. A visualization is presented in Figure 8.

Figure 8

Pay Scales


Aerospace Sector

Aviation Sector

Discussion

When discussing the human capital requirements as it relates to the aerospace or aviation sectors, often the conversation will focus on the workforce demand of 'pilots' and 'mechanics' (Caraway, 2020; Crouch, 2020; Lutte, 2018). While there has been a lowered demand for pilots and mechanics in the aviation sector workforce pipeline prior to COVID-19 (Bidaisee, 2021), this lowered demand for other skills was not exhibited across both the aerospace and aviation sectors. Systems thinking and systems-based skillsets dominated the data conversation within this research. Skills such as system analysis, systems architecture, systems design, and systems engineering all play a large part in this field. We believe that being able to think holistically – at multiple scales, both large and small – is something that comes with experience, and we see the demand for not only experience in the aerospace sector but we also see a high demand for systems-based skillsets. Aerospace companies see the value in "sustainability awareness," and much of their ability to be successful depends on their ability to be systems-focused (Scurati et al., 2020).

While the aviation sector has largely maintained its need for pilots, mechanics, and associated support personnel, the staffing needs of the aerospace industry are being progressively driven by integrative needs in science, technology, and engineering. Increasingly, this is leading many aerospace-based organizations towards the acquisition of 'systems-oriented' staffing requirements. This research helps to better align higher educational institutions with the current industrial staffing complexities within the broader aerospace sector. This research also highlights areas of demand that extend beyond pilots, mechanics, and engineers. For example, we found an increasing demand for artificial intelligence, cyber systems, and cyber security professionals, regardless of the industrial background. This highlights national emergent trends in this area seen across all industrial sectors outside of aerospace and aviation (Schuster & Wu, 2018).

Limitations

The market data discussed in section 2.1 was inconsistent in its segmentation, often creating overlaps where aerospace companies were tagged as being aviation companies and vice versa. This limited our ability to use the market data for detailed research at the micro level (i.e., its usage was predominantly relegated to macro-level insights).

In regard to the job data capture process, we were unable to gain access to their respective API frameworks. As members of a research institution and not a recruiting institution, our organization was considered “out of the market” to warrant access to their respective API frameworks despite our attempts. In light of this limitation, we were still able to capture a significant number of data samples using a manual approach: 654 skill-focused samples and 6,034 title-focused samples.

The “air freight and logistics” industrial sector was also evaluated as part of this research, but it was removed as we did not capture the market data at the same level as the job data regarding this metric. In other words, it was removed from our analysis to keep the comparison between job data and market data equal. We did not include the air freight sector in our analysis as we felt it was important to keep a cleaner delineation of job data and market data equal amongst the industrial sector segments. The air freight industrial sector itself is also part of the supply chain industry, which brings with it additional research parameters requiring a detailed expense analysis to separate out aviation expense as a ratio to market capitalization across all major air freight organizations. While outside the scope of this research, it is part of a future research agenda, especially as it relates to a global perspective of market and labor demand.

Lastly, our data capture was relegated to domestic U.S.-based publicly traded companies. While we recognize that there are significant aviation and aerospace labor demands in the government sector (i.e., NOAA, FAA, and DoD), we excluded them from this research to keep our research commercially focused. Additionally, we did not incorporate private entities. Private entities have more volatile valuations, making the prospect of including private entities more difficult. However, as more predominant space-based companies turn public, a new space-based data tree will be created for inclusion in future research.

The researchers plan for future research into NLP and job and market data by including more variables such as how long positions are posted, how quickly positions are filled, and other quantitative data. These concepts would further enhance our understanding of the labor demand in these two industries.

Conclusions

Our goal for this research in the aviation and aerospace industries focused on a) differentiating job title classifications, b) classifying the human capital skills, and c) quantifying the demand for labor skills across these two industrial sector segments.

Towards our first research goals, the research data collected in this study showed a differentiation between job classifications and human capital skills between the two industries. Prior to this research, we inherently understood job title classifications such as pilots and mechanics are predominantly in the aviation sector, whereas scientists, technologists, engineers, and developers are predominantly in the aerospace sector, with varying levels of overlap. Our research shows through the use of NLP the differences between these two sectors in more nuanced ways, such as differences in job titles, skills, pay scale, and entry-level hiring tolerability.

Towards our research goal c, quantifying the demand for labor skills, we know that demand as a function of market capitalization is well documented (Aghion et al., 2022; Solow, 1964). As a company grows in market capitalization, so does its demand for labor to meet that increased market share that the company captures (Solow, 1964). As the capital stock rises, the production function moves upward, leading to a simultaneous outward shift of the labor demand curve. This results in the hiring of more workers (Solow, 1964).

From a research perspective, the ratio metrics used as a data control were effective in this research. Using the market capitalization as a proxy control group for labor demand was an unexpected find in the research output. Future research may indicate that this style of analysis has the potential to generalize into other industrial sector analyses. We do suspect that the data tree ratio will change given the lens in use (i.e., global vs domestic, airline vs air freight, air freight vs aerospace). For example, the global aerospace market capitalization stands at \$873 billion dollars; the global aviation market capitalization is currently \$327 billion dollars. The difference between these two global segments currently sits at 72.75%. We hypothesize that this macro-level ratio would be somewhat consistent at the micro-level. We speculate that the job data demand ratio could swing +/- 2% of the market data metric. Of course, wider swings in this metric are possible, and in these cases, this may indicate increased market and labor volatility.

For future research, we hypothesize that the data tree ratio itself (micro-level, job data) would have only slight variation when compared to the macro-level, market data dataset (i.e., the ratio may change, but the ratio between the job data and the market data should remain somewhat equal). However, we speculate that there is another phenomenon at play regarding the directionality of an organization's market capitalization. As an example, if a company goes through market pressure via the loss of business, it will feel downward decapitalization (selling of public shares on the open market). This phenomenon will occur rapidly on the open market before it has a downward-facing effect on the labor within the organization, which may indicate why the labor job data ratio metric (77.69%) lags behind the market data ratio metric (77.98%) within our data. While additional research is required, we speculate that an inversion of this metric, where the job data ratio leads the market data ratio, may indicate a given job sector is becoming increasingly centralized (i.e., a broader movement of aviation jobs transitioning into the aerospace sector faster than the capitalization structure of the respective organizations in that sector).

In addition, higher education institutions should see that the data can be sensitized to educational frameworks for the demands of their respective industries. For example, aviation-based and aerospace-based education programs of higher learning should evaluate and understand that the labor force requirements are more nuanced between aviation (operation-oriented entities) and aerospace (development-oriented entities).

Using computational grounded theory and data structure augmentation proved to be useful for this style of research, and we look forward to expanding this research line further. Our primary goals for this research have illustrated various emergent trends regarding the skills classification between the aviation and aerospace sectors as well as the human capital requirements and labor demand movements within and across these two sectors.

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History of Aircraft Dispatchers in the United States: Improving Safety

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The aircraft dispatcher is an indispensable member of United States airline operations. The airline industry advanced from early attempts to transport mail and occasional passengers on a scheduled basis into a highly complex, tightly regulated, extremely safe means of transportation. Dispatchers have a key role that has expanded over time both in its scope and in its authority. The concept of operational control began with the desire to improve safety and enhance situational awareness for air carriers. Beginning with the earliest references to dispatchers, this paper explores the history of dispatchers from 1929 to the 1970s, operational control in the United States, and associated safety improvements. Drawing from both primary sources in the form of original aviation trade journals, aircraft accident reports, and books reviewing airline history, this paper examines how the dispatch profession has evolved and significantly enhanced aviation safety.

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Aircraft dispatchers have a crucial role in ensuring the safety of airline operations in the United States. The history of aircraft dispatchers and the changing role of dispatchers is not well documented, yet today, the United States airline industry relies heavily on the dispatcher's role in flight planning, flight following, and weather monitoring. After the airline industry established the dispatch profession, the operational control concept was developed. This concept employed both a pilot and a dispatcher with operational control over each flight. Utilizing a comprehensive review of books covering the United States airline history, aircraft accident and incident reports, and primary source aviation trade publications, this paper examines the crucial role of the aircraft dispatcher in airline operations from 1929 to the 1970s. This study begins with a historical overview of aircraft dispatchers and documents the establishment of the aircraft dispatcher certificate. Examining a series of accidents and incidents related to operational control, aircraft performance and loading, and other dispatch-related accidents demonstrates the critical role of the aircraft dispatcher in airline safety in the United States. Many accidents were examined during this research project, but ultimately, accidents with dispatch-related causes that improved aviation safety were chosen for inclusion in this paper.

Pre-Airline Dispatching

The emphasis on maintaining control, monitoring transportation progress, and issuing orders to moving vehicles originated with the railroad industry (Caisse, 2015). After the invention of the telegraph in 1830, railroads established lines along their tracks to pass messages and monitor train progress (Hardin, 2006, p.1). According to Hardin (2006), railroads recruited "thousands of young men for the lines – as young as 16" (p. 2). The station telegraph operator monitored and ordered train movements, handling railroad traffic as his primary duty. "Knowing the exact position of every train at all times was paramount in preventing a deadly train wreck or mishap" (Harden, 2006, p. 2). To maintain safety in railroad transportation, operators closely followed traffic conditions and traffic on the tracks.

Early Aircraft Dispatchers

Lawrence Sperry's October 1916 experiment explored the link between using Morse code and communication with an aircraft in flight. *Aviation and Aeronautical Engineering* (1916a) documented the use of three searchlights attached to the leading edge of the upper wing of the biplane so that "Morse code can also be used with these searchlights…which can be operated like a telegraph key" (p. 163). *Aviation and Aeronautical Engineering* (1916b) reported another test that successfully used a "wireless telegraph and telephone set invented by Dr. Lee de Forest for application to aeroplanes" (p. 197) at the United States Army Aviation Station on Long Island, New York. Less than three years later, a detailed article entitled "Wireless Telegraphy Applied to Aviation" by W. Knight (1919) appeared in *Aviation and Aeronautical Engineering* (pp. 572-575). Knight's article served to endorse the absolute necessity of positive communication with aircraft in flight. This need to communicate became especially important as Army pilots began flying mail in 1918 (Stroud, 1977, p. 235). By 1930, Boeing Air Transport pilots made required position reports to ground stations every 20 minutes through radiotelephone and received updated weather information (Garvey & Fisher, 2002, p. 76).

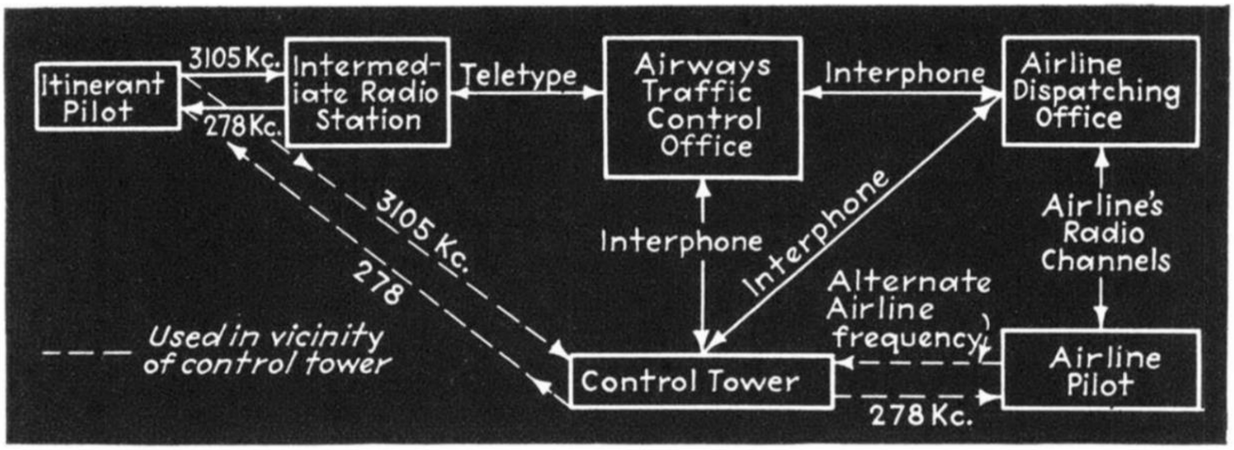
In 1929, the term "dispatcher" first appeared in advertisements in aviation trade publications in conjunction with more sophisticated means of communicating with aircraft. Advertisements in *Aviation* (1929) promoted the Western Electric two-way radio telephone system that "permits the dispatcher at the airport to talk at will with pilots in flight, advising them and receiving constant reports of their progress" (p. 4). In 1930, Boeing Air Transport installed the same system in its aircraft and 18 ground stations. Advertising text for Western Electric Aviation Communication Systems referred to Boeing Air Transport pilots as "always in touch with dispatchers and weather observers along their routes. Reports on weather and field conditions, guiding radio beacon signals, or instructions come in clearly, helping pilots to bring their ships through on time" ("Boeing Installs," 1930, p. 58). This description of the dispatcher includes similar responsibilities of modern dispatchers, which include issuing necessary information for the safety of flight (Holt & Poynor, 2016, p. 203) and maintaining communications with each flight (Holt & Poynor, 2016, p. 15). Willets (1931) noted that "the highest degree of reliability and safety can only be achieved with this mode of transportation when instantaneous communication with ground is available to the pilot throughout the flight" (p. 9).

The link between railroad telegraphers and early dispatchers is easy to understand, given how railroad telegraphers controlled train movements and monitored track conditions. Eventually, the dispatcher became an air traffic controller at busy airports. The March 1933 issue of *Aviation* documented dispatchers utilizing a light signal gun to aim a red or green beam at an airplane at "many airports where traffic is heavy" (p. 100). Another article in the August 1933 issue of *Aviation* described a tower at Allegheny County Airport in Pittsburgh where a dispatcher had a desk with:

> …almost finger-tip control of the arrival and departure of planes…Incoming and departing planes receive authorization to land or to take-off from a signal "gun"…All boundary, obstruction, and floodlights are also controlled from the dispatch board in the dispatcher's tower. (p. 240)

The role of dispatchers as air traffic controllers ended in 1935 when a new inter-airline agreement governed air traffic. This agreement included an experimental center for traffic control staffed by dispatchers from various airlines (Professional Airline Flight Control Association [PAFCA], n.d.). A July 1936 article by Jerome Lederer in *Aviation* described this system of Airway Traffic Control Offices (ATCO) controlling traffic separately from the airlines themselves (pp. 22-23). The system initially controlled traffic at Newark, and it required periodic communications of each flight's position between pilots and associated airline dispatching offices. The dispatcher communicated through an interphone system to Newark ATCO when the flight was over the last fix nearest the airport. If the flight was not going to be cleared to land imminently, ATCO informed the dispatcher and the dispatcher notified the pilot, who held the present position until cleared to continue. When each flight reported over the inner radio marker, the dispatcher notified ATCO who cleared the flight to proceed from the inner marker to the terminal. The pilot then contacted the control tower and proceeded to land. At that time, Newark had 64 closely spaced arrivals and departures per day. This generated concern for safety with the number of airplanes converging on busier airports (Lederer, 1936, pp. 22-23).

Figure 1
Relationship of Dispatcher and ATCO



Note. From “Go Ahead, Newark,” by J. Lederer, 1936, Aviation, 35, p. 22.

Dispatchers had the best interests of their respective airlines in mind, and each airline wanted its flights to arrive and depart on schedule. Obviously, conflicts of interest at busy airports occurred. The Bureau of Air Commerce established a permanent solution to separate the flight planning, flight following, and meteorology functions from controlling when airplanes arrived and departed. The ATCO solution previously described was not ideal; it involved direct communication and coordination between the aircraft dispatcher, the pilots, and the ATCO office.

On June 6, 1937, the Bureau of Air Commerce separated the dispatch and air traffic control functions by assuming control of airway traffic control centers (PAFCA, n.d.). According to Caisse (2015), the Bureau of Air Commerce certified several hundred existing airline dispatchers together as the Bureau created the new aircraft dispatcher certificate, grandfathering in these formerly uncertified airline employees.

The first documented educational program for training aircraft dispatchers appeared in the October 1936 issue of *Aviation*. The subjects covered included meteorology, dispatch practice, and airline operations. The course took 18 months to complete and required two years of college or nine months of accredited engineering college coursework prior to enrolling (p. 66). The 1947 vocational film *Your Life Work Series: Air Transportation* called the dispatcher a “flight superintendent.” The film describes a flight superintendent’s role in flight operations:

> He is the man who decides whether the planes will fly or not. He releases all planes on his division, follows their progress in the air, and keeps the captains…advised of conditions affecting their flight…He coordinates all flight operations to achieve these objectives: safe, swift, and dependable air transportation. (Twogood, 1947)

The flight superintendent position required a pilot certificate and a dispatcher certificate issued by the Civil Aeronautics Authority (Twogood, 1947).

Early Accident Rates

Despite the early airlines' best attempts to maintain an image of safe and reliable transportation, many accidents occurred. The public perceived aviation as a dangerous means of transportation. Rumerman (n.d.) states that in 1932, a $5,000 insurance policy for an airplane trip cost two dollars, while the same policy for a railroad trip cost just 25 cents. American Airlines President C.R. Smith authored a 1937 advertisement entitled, "Why Dodge This Question: Afraid to Fly?" (Allen, 1981, p. 98). This advertisement came after a series of accidents in the mid-1930s, several of which helped redefine the role of the aircraft dispatcher.

Increased passenger traffic led to more flights, and the increase in flights caused a corresponding increase in accidents. Sterling (1969) notes that the 1932 airline fatality rate was extreme, at 14.96 deaths for every 100 million passenger miles flown (p. 43). Between 1930 and 1937, 45 airline accidents occurred in the United States (PlaneCrashInfo.com, n.d.). This number included only the accidents involving three or more people; even more airline accidents involving only one or two people occurred during this period. The public viewed flying as a dangerous means of transportation; more than four significant accidents occurred each year during this period. Specific accident causes were not determined before mid-1934, but accidents were caused by maintenance issues, pilot errors, weather, and dispatcher errors (United States Department of Transportation, 2023).

Figure 2

Number of Airline Accidents Involving three or More Persons, Sorted by Year

Year	Number of accidents
1930	4
1931	4
1932	4
1933	5
1934	5
1935	7
1936	11
1937	5
Total	45

American Airlines Flight 166

A series of high-profile accidents in the mid-1930s led to formalized certification of aircraft dispatchers. The first of these accidents involved a Curtiss-Wright T-32 Condor II, NC-12363, operating as American Airlines flight 166 on December 28, 1934. Newman (2008) states that brothers Ernie and Dale Dryer crewed the flight. They were former barnstormers and friends of Amelia Earhart and Charles Lindbergh. Flight 166's trip sequence went from Boston to Albany, Syracuse, Cleveland, and ultimately, Chicago. One revenue-generating passenger and one dead-heading company pilot boarded at Boston, and ramp agents loaded the airplane with mail and packages (Newman, 2008).

At Syracuse, Ernie Dryer called the American Airlines dispatcher based in Albany. The dispatcher briefed Dryer about a blizzard to the west over Lake Erie and Cleveland. The dispatcher cleared the flight to return to Albany, but neither the dispatcher nor the crew realized that the winter storm had moved north. About 35 minutes into the flight, the aircraft lost its radio antenna due to ice buildup, and the right engine started to lose power due to excessive carburetor ice. The Condor II had no wing deicing system, but it did have propeller deicing capability. To manually de-ice the aircraft, the crew hand-pumped alcohol into the propellers. Chunks of ice slid off the propellers and slapped the fabric-covered fuselage. With ice building up on the wings, the aircraft crashed into a grove of trees, its impact cushioned by branches (Newman, 2008).

Newman's (2008) account describes the overnight survival of crew and passengers. By morning, they used the remaining aircraft battery power and a repaired aircraft radio to inform the dispatcher at Albany that they were alive but required immediate assistance. In the late afternoon, a search aircraft spotted the crash site. Dale Dryer suffered a broken jaw; no one else was injured more seriously (Newman, 2008). The Bureau of Air Commerce determined the probable cause to be "the failure of the company to have on duty in the Division Control Office a competent dispatcher in charge of flight control" (Aviation Safety Network, 2018). While the dispatcher did clear the flight to return to Albany directly into the path of a blizzard, it is doubtful as to whether the dispatcher intentionally sent the flight into the storm. More likely, weather reporting and forecasting in 1934 caused an erroneous understanding of the storm's position. Less than six months later, another weather-related accident sparked public outcry and generated a United States Senate investigation (Serling, 1983, p. 55).

TWA Flight 6 – The Bronson Cutting Accident

Serling's (1983) narrative of Transcontinental & Western Airlines (TWA) flight 6 discusses similarities with the American Airlines flight 166 accident, including weather reporting and forecasting errors and radio communication issues (p. 55). This first fatal crash of the Douglas DC-2 occurred on May 6, 1935, near Kirksville, Missouri. Five of the thirteen people on board died (Rimson, 1998). One of the fatalities was Senator Bronson Cutting of New Mexico (Serling, 1983, p. 55). Had it not been for Senator Cutting's presence on the flight, the accident would probably have been forgotten. The flight consisted of two airplanes flying the scheduled route together. The first flight departed approximately 30 minutes prior to the second (Serling, 1983, p. 54).

Senator Cutting boarded the second airplane of the flight in Albuquerque, heading for Kansas City. The DC-2's faulty radio transmitter received only the daytime company frequency, but the flight departed at night. The flight's captain, Harvey Bolton, elected to depart because Weather Bureau reports called for clear skies along the route. The radio's continual issues made it impossible for the flight to respond to the dispatcher, who finally told Captain Bolton to continue to Kansas City as the first airplane of the flight had just landed there despite poor visibility and low ceilings. In the 30 minutes it took for the second airplane to get to Kansas City, the weather dropped below landing minimums. Once the flight arrived in Kansas City, it had less than 45 minutes of fuel on board. TWA's worried meteorologist phoned a nearby oil refinery to ask them to "ignite extra gas so Bolton might spot the flames" (Serling, 1983, p. 54).

The TWA dispatcher, Ted Haueter, checked the weather at Kirksville, an emergency airport 120 miles northwest of Kansas City. Kirksville was below landing minimums, so Haueter advised flight 6 to proceed to Burlington, Iowa, the next available airport. Unfortunately, Burlington was 250 miles away, and flight 6 did not have enough fuel left. Captain Bolton headed toward Kirksville and attempted to descend through the overcast to make visual contact with the ground. Visual contact occurred only a few feet from the ground, and the DC-2 slammed into a 60-foot embankment and immediately flipped (Serling, 1983, p. 54).

Serling (1983) describes the chaotic investigations after the accident:

> The Department of Commerce…was literally investigating itself and proceeded to lay most of the blame on everybody but itself…The only criticism levied against the government was the Weather Bureau's inaccurate forecast and its failure to advise Flight 6 that Kansas City minimums had dropped below legal limits. (p. 55)

"Contributory causes" cited by the Board included "failure of TWA ground personnel at Kansas City to expeditiously redispatch the airplane to a field where better weather existed when it became apparent that the ceiling at Kansas City was dropping" (Rimson, 1998). Rimson (1998) states that TWA soon rebutted the findings of the Department of Commerce Investigation Board, and Senate hearings included testimony from R. W. Schroeder, Chief of the Air Line Inspection Service. Schroeder testified:

> …the accident started to happen when the pilot, still only a half hour out of Wichita enroute to Kansas City and knowing he was without two-way radio communication, first encountered instrument meteorological conditions. Yet both TWA's Captain and dispatcher sanctioned continuation into the weather and a fruitless attempt to land at Kansas City before attempting to continue on to a suitable alternate landing field. (Rimson, 1998)

The major outcome was the Civil Aeronautics Act of 1938, which established an independent Air Safety Board for accident investigation and an independent Civil Aeronautics Authority (Serling, 1983, p. 55). The accident highlighted the importance of better weather forecasting, resulting in more timely and accurate information flowing between both pilots and dispatchers.

The accident motivated TWA to improve its dispatch operations, and its president, Jack Frye, did not punish dispatcher Haueter, who allowed flight 6 to circle at Kansas City while wasting fuel. Instead, Frye promoted Haueter to flight superintendent (Serling, 1983, pp. 55-56). *Aviation* described TWA's dispatch system in a fascinating article, "Flying with One Foot on the Ground," published in August 1937. It opens with a story of two pilots, "Young Fellow" and "Old Timer." In a fairytale-like fashion, the article tells the story of the Bronson Cutting accident in a lighthearted, de-identified narrative. The story ends with "Young Fellow" making good decisions, having plenty of fuel, and heading toward a pre-determined alternate airport. "Old

Timer" lands at an emergency field after running low on fuel, but he still gets his passengers safely on the ground ("Flying with One," 1937, pp. 24-25). The article states that after this "incident," which is clearly a thinly veiled account of TWA flight 6, TWA President Jack Frye:

> made up his mind then and there that no pilot in the future would take off with a load of passengers without knowing exactly how he was going to get to his destination and what he would do if that destination was unavailable. Thus was born TWA's Flight Plan. ("Flying with One," 1937, p. 25)

TWA organized a flight control and navigation department. They equipped each pilot with a kit including routing information, charts, graphs, tables, flight computers, and a flight plan. Pilots made required checks of actual fuel burn at various checkpoints along the route versus planned fuel burn. The airline designated specific alternate airports in case the weather was not as forecasted and planned a direction to fly in case of total radio failure ("Flying with One," 1937, p. 25). Since the article only discusses TWA, it is unclear if other airlines adopted these policies prior to 1937. The article frames the new planning as innovative. It is plausible that this was the first major airline application of proactive fuel management combined with the development of contingency planning.

TWA made "a dozen or so" of the airline's best pilots into chief dispatchers. Many of its early dispatchers were "youngsters who had actually come along from clerical or other non-flying positions…[and] didn't know what they were talking about, or at least did not know how to interpret properly the information that was given to them" ("Flying with One," 1937, p. 72). Jack Frye was "among the first" to view the dispatcher as an additional crewmember ("Flying with One," 1937, p. 72). The modern aircraft dispatcher's role is remarkably like the article's description of TWA's aircraft dispatchers in 1937:

> A properly trained dispatcher, sitting apart from the immediate stress and strain of flying the airplane and with all possible forms of information at his disposal, has an opportunity to sit down and figure things out in a way that is not possible for the pilot with his many flying duties. Thus, the old joke about flying with one foot on the ground could become an accomplished fact. But the foot-on-the-ground must have the complete confidence of his flying crews. ("Flying with One," 1937, p. 72)

Clearly, the Bronson Cutting accident caused TWA to elevate the role of the dispatcher to that of a qualified and trusted ground-based crewmember. This concept is paramount to improved safety through operational control.

Operational Control

According to 14 CFR §1.1, operational control means "the exercise of authority over initiating, conducting, and terminating a flight." Holt and Poyner (2016) state, "Someone other than the pilot-in-command is involved in the decision-making as to whether a flight starts, how it is conducted, and how and where it terminates" (p. 42). An October 13, 1937 paper by Larry C. Fritz of TWA outlined the earliest record of this type of control:

> The pilot has decided whether the flight can be made with absolute safety, and if the flight dispatcher is of the same opinion, plans can be made for the flight…If [the pilot] is in doubt as to the safety of the flight, he may telephone the flight dispatcher and discuss the flight with him prior to making his decision. Thus, he has checked his own decision at least twice with his consultation with a meteorologist and flight dispatcher…The pilot reports any variation from normal routine in flight, and if the dispatcher believes a departure from the calculated flight plan is advantageous, such as landing at an intermediate field, he issues orders for the pilot to land…the decision of the pilot and dispatcher are identical. Their first consideration is the safety of flight. (pp. 279-281)

This new concept of operational control meant that the pilot-in-command was no longer the only authority on the operation of each flight. Through operational control, the dispatcher's authority became equal to the pilot's authority. By 1940, American Airlines' operational control policy required "the captain and the flight superintendent on duty…be in complete agreement regarding the procedure of each trip before an airliner can take off. Either man can cancel a flight on his single authority" (Gann, 1940, p. 88).

Although airlines introduced the concept of operational control in 1937, putting operational control into practice rested in the hands of dispatchers and flight crews. Through several additional accidents, airlines learned the necessity of establishing procedures to incorporate operational control.

United Air Lines Flight 6

On November 29, 1938, a DC-3 operating as United Air Lines flight 6 departed from Medford, Oregon, bound for Oakland, California. The flight landed in the Pacific Ocean near Point Reyes after complete fuel exhaustion (Civil Aeronautics Authority [CAA], 1939, p. 1).

The Oakland-based dispatcher initially concurred with the U.S. Weather Bureau forecaster's opinion that the flight should not be dispatched from Medford to Oakland due to poor weather. After further consideration and a three-way telephone conversation with Captain Charles Stead and the Medford station manager, Captain Stead, and the dispatcher agreed that the flight could be dispatched. The flight departed Medford just after midnight, estimating arrival at 2:14 AM (CAA, 1939, pp. 6-7).

Because of enroute icing conditions and interference from other radio range stations, the crew could not hear radio range beacons used for enroute navigation. The crew attempted and failed multiple times to establish their position. By 3:17 AM, the crew managed to intercept the Oakland radio range, at which time it was already over an hour overdue. At 4:08 AM, Captain Stead estimated fuel remaining at only 60 gallons. The crew still did not know their exact position. Captain Stead descended through the clouds, hoping he was over the water, and sighted a ship and the lighthouse at Point Reyes at 5:03 AM. The flight ran out of options and fuel, over the water at 5:25 AM (CAA, 1939, pp. 8-10).

The aircraft mostly survived the ditching, and the crew and passengers climbed onto the roof of the aircraft through an emergency hatch. Initially, "the aircraft rode the swells easily"

(CAA, 1939, p. 10). Captain Stead and one passenger survived the ordeal, but First Officer Lloyd Jones, Stewardess Frona Clay, and three passengers survived the ditching yet drowned after the fuselage broke apart on the rocky shoreline (CAA, 1939, p. 1).

The flight's first dispatcher, Thomas Van Sciever, cleared the flight from Medford to Oakland and went off duty at midnight. He was relieved by dispatcher Philip Showalter. Although communication logs showed that Showalter knew flight 6 had difficulty hearing Oakland radio range, these logs showed he did not attempt to determine the amount of fuel remaining on the flight until an hour after the flight was scheduled to arrive in Oakland. At 4:10 AM, Showalter received the following communication from Captain Stead:

> OK, I have been over 50 minutes from there, left of range???? (static) am 30 degrees off in my computations. There must be something wrong with the range. I have 60 gallons of gas, and I am (descending). Don't know exactly where I am???? (static terrible) I figure I should be over now. There must be something wrong with the range. I am going to come down slowly. (CAA, 1939, p. 13)

Showalter belatedly suggested Captain Stead reduce power to conserve fuel. It took Captain Stead's panicked communication at 4:10 AM to motivate a flurry of dispatch activity. Showalter finally began emergency activities nearly two hours after the flight's scheduled arrival time (CAA, 1939, pp. 11-12).

The *Journal of Air Law and Commerce* (1939) published CAB safety recommendations resulting from the investigation. Dispatch-related recommendations included:

1. Establishing a clear definition of an emergency condition and duties and responsibilities of personnel involved.
2. Requiring the dispatcher responsible for each flight to designate its minimum fuel requirement.
3. Increasing minimum competency requirements for dispatchers.
4. Defining duties and responsibilities of air carrier dispatchers.
5. Prohibiting dispatching of scheduled air carrier aircraft in flight by anyone not holding an Air Carrier Dispatcher Certificate of Competency.
6. Requiring dispatchers to be more thoroughly tested upon applying for an Air Carrier Dispatcher Certificate of Competency.
7. Requiring a standardized flight plan format, a standardized navigation log including fuel consumption calculations, and standardized position reports.
8. Requiring a standardized minimum training program, including both pilots and dispatchers. (pp. 225-227)

These recommendations resulted in major improvements to the dispatcher's role in exercising operational control authority. United Air Lines flight 6 demonstrated that, in general, dispatchers did not quickly recognize emergencies and act to assist flight crews. Inadequate emergency procedures existed for dispatchers to follow.

Operational Control Accidents of the 1940s

Despite these recommendations, accidents related to dispatchers and operational control continued. On November 4, 1940, a United Air Lines DC-3 crashed near Centerville, Utah, while on approach to Salt Lake City, Utah. The crew descended into a mountain due to the airport's radio range station malfunction and static electricity caused by St. Elmo's fire impeding dispatcher communications and radio range station reception. (Civil Aeronautics Board [CAB], n.d., pp. 111-112) After this accident, the CAB (n.d.) enacted regulations to:

> …authorize a dispatcher in charge of a flight to direct it to an alternate or take other indicated action in the event that his judgment leads him to believe that the flight cannot proceed with safety in accordance with its original clearance. This power of the dispatcher would be subject to the authority which is vested in the pilot to depart from regulation or from company policy when, in his judgement, an emergency then confronting him requires it. (pp. 119-121)

Even today, operational control and dispatcher emergency authority are key safety concepts used in airline operations.

To maintain adequate supervision of assigned flights, a dispatcher must be assigned a reasonable number of flights. Civil Air Regulations in 1940 required air carriers to "provide an adequate number of certificated dispatchers…located at such points as may be deemed necessary by the Administrator to ensure the safe operation of the air carrier" (CAB, 1941, p. 18). The loss of Eastern Air Lines flight 14 demonstrated that scheduled air carriers of the 1940s often did not employ enough qualified dispatchers to exercise operational control over all flights.

On April 3, 1941, flight 14 flew into severe turbulence in a squall line and crashed near Vero Beach, Florida (CAB, 1941, p. 22). Eastern operated a dispatch office in New York and relied on ground transportation agents in Florida to facilitate local flight communications (CAB, 1941, pp. 3-5). Eastern flight 10, flying nearby, told the transportation agent to warn flight 14 to stay out of the area due to severe turbulence. The transportation agent, who was not a dispatcher, told flight 14 to "stand by until [trip 10] is in the clear" (CAB, 1941, p. 5). The transportation agent did not communicate the existence of hazardous turbulence to flight 14. Flight 14 entered the area and was buffeted by updrafts, downdrafts, and rotational winds. The crew lost control and crashed into a field. Everyone on board survived, although 13 occupants sustained serious injuries. The CAB (1941) concluded that the accident was avoidable had Eastern Air Lines provided sufficient dispatch centers and qualified dispatchers to facilitate current weather reports to enroute flights (pp. 21-22). Two of the CAB's findings were directed at operational control functions:

> The company transportation agent at West Palm Beach did not relay to [flight] 14 a verbatim report of the weather conditions that [flight] 10 reported at 8:32 AM.
>
> Eastern did not provide an adequate dispatching system together with a trained number of certificated dispatchers on Route 6 so that aircraft could be informed of changing flight conditions as they progressed along the airway. The distance between New York and

> Miami is about 1,250 miles, and it was not possible for the dispatcher stationed at La Guardia Field to maintain adequate supervision and control over the numerous aircraft simultaneously in flight and nominally under his supervision. (pp. 21-22)

Shortly after this accident, Eastern established additional dispatch offices in Miami and Atlanta (CAB, 1941, p. 23).

Other dispatch-related accidents of the decade included Eastern Air Lines flight 14 (December 30, 1945, unrelated to the previous flight 14 from 1941) and American Airlines flight 9 (February 23, 1945). Both flights suffered from poor preflight planning by dispatchers. The dispatcher of Eastern flight 14 also failed to keep the crew informed of weather trends at both designated alternate airports (CAB, 1946b, p. 9). American flight 9's dispatcher approved the captain's plan to fly at night under visual flight rules at an altitude lower than that required for the terrain along the route of flight. The CAB (1946a) cited "a general laxity in dispatching and flight supervision and a need for continued training and checking of pilots in proper flight planning" (p. 3). The CAB (1946a) chastised the Civil Aeronautics Authority in its report for not maintaining adequate oversight of American Airlines' dispatching procedures (p. 4).

Non-Scheduled Air Carriers and Lack of Dispatchers

All scheduled air carriers operated under Certificates of Public Convenience and Necessity, and the CAB created this requirement to ensure safe operations (Stringer, 2015). The CAB required airlines to employ adequate numbers of dispatchers. The CAB checked this through operational oversight. But after World War II ended, many enterprising pilots started "non-scheduled" operations, carrying passengers on popular routes, with very little CAB oversight. According to Stringer (2015), newly formed "un-certificated" supplemental operators took advantage of a loophole allowing operations as non-scheduled charter flights without the requirement to obtain a Certificate of Public Convenience and Necessity.

> In 1946, all companies employing large transport aircraft in irregular service were informed they would be subjected to a safety inspection in order to obtain a letter of registration identifying them as an approved large irregular carrier. The letter of registration was not the Certificate of Public Convenience, and Necessity issued to the scheduled airlines but a document verifying that the company was registered with the CAB and in compliance with safety regulations. The Civil Aeronautics Administration (CAA)…initiated the carrier examinations but did not have enough inspectors to accomplish the job quickly. Meanwhile, the non-skeds [*sic*] that were already operating in August 1946 were allowed to continue operating until the CAA could get around to inspecting them. (Stringer, 2015)

To save costs and simplify operations, non-scheduled operators did not employ dispatchers. They relied on flight crews to perform all preflight planning and operational oversight. A series of accidents resulted from this chaotic environment. These accidents demonstrated the crucial role of dispatchers in facilitating safe operations.

On September 5, 1946, a Trans-Luxury Airlines DC-3 crashed near Elko, Nevada. In its accident report, the CAB (1946c) described the crew's planned route from Cheyenne, Wyoming, to Reno, Nevada, with an alternate of Sacramento, California (pp. 7-8). This plan was not feasible at the altitude filed with the available fuel onboard (CAB, 1946c, pp. 7-8). The flight crew landed to refuel at Elko and flew an approach in ground fog, continuing below authorized minimums hitting the top of a ridge. The CAB (1946c) cited the lack of dispatch facilities as a contributory cause of the accident (pp. 9-10). The crew could not access any weather observer at Elko or a dispatcher to designate a refueling airport with better weather.

Accidents involving non-scheduled supplemental air carriers continued through the 1940s and 1950s. None of these air carriers utilized dispatchers. Flight crews alone exercised operational control. These four accidents, plus the Trans-Luxury Airlines accident, resulted in 67 fatalities, all of which could have been avoided with adequate dispatch oversight and operational control.

Figure 3

Non-Scheduled Air Carrier Accidents, 1940s-1950s

Date	Operator	Dispatch-related cause(s)	Fatalities
September 5, 1946	Trans-Luxury Airlines	Inadequate preflight planning, lack of operational oversight while enroute	21
August 15, 1949	Transocean Air Lines	Fuel exhaustion due to lack of adequate preflight planning	8
May 27, 1950	Regina Cargo Airlines	Improper loading over maximum gross weight, no flight manifest	2
December 29, 1951	Continental Charters	Failure to obtain preflight weather information and inadequate preflight planning	26
December 22, 1954	Johnson Flying Service	Fuel exhaustion due to lack of adequate preflight planning	10
			67

In 1963, Harvard Law Review documented safety issues at non-scheduled supplemental air carriers (p. 1459). Between 1960 and 1961, seven accidents resulted in the deaths of 255 people (Harvard Law Review, 1963, p. 1459). The 1960 crash of an Arctic-Pacific C-46F killed 20 members of a college football team during takeoff in near zero visibility. The aircraft was over 2,000 pounds in excess of its maximum gross weight ("CAB Cites Early Liftoff," 1962, p.79). Lack of operational control, in addition to flight planning errors, contributed significantly. Just over a year later, the crash of an Imperial Airlines Lockheed Constellation in Richmond, Virginia, killed 74 army recruits. The crew's lack of training and systems knowledge resulted in the loss of power in three of the four engines (CAB, 1962, p. 1). Harvard Law Review reported that these two crashes caused "a national furor." A subsequent congressional investigation concluded that more regulation by the newly created Federal Aviation Agency (FAA) should result in safer operations for non-scheduled supplemental air carriers (Harvard Law Review, 1963, p. 1460). On August 22, 1962, the FAA proposed regulations adding flight following systems for these carriers "to maintain better operational control of their aircraft and thus conduct safer operations" (p. 3).

The FAA revised Part 42 of the Civil Air Regulations on July 8, 1963, with an effective implementation date of November 11, 1963. The revision included rules for the certification and operation of non-scheduled supplemental air carriers (FAA, 1963a, p. 1). Prior to the 1963 revision, Part 42 required no dispatcher oversight or operational control system for these carriers. Recognizing the safety advantages of dispatch systems, the FAA added regulations to Part 42 requiring "each operator…to establish a dispatch system using certificated dispatchers, or an approved flight following system" (FAA, 1963b, p. 7125). §42.38 listed the requirements for the flight following the system.

> An operator shall show that it has an approved flight following system…adequate for the proper monitoring of the progress of each flight taking into consideration the operations to be conducted…to ensure *[sic]* the proper monitoring of the progress of each flight…and to insure *[sic]* that the pilot in command is provided with all information necessary for the safety of the flight. (FAA, 1963b, p. 7134)

§ 42.381 further defined operational control for non-scheduled supplemental air carriers. "No flight shall be started under a flight following system without specific authority from the person authorized by the operator to exercise operational control over the flight" (FAA, 1963b, p. 7153). Under §42.350, the director of operations and the pilot in command shared operational control of supplemental air carrier flights. With the advent of flight following systems, the air carrier's director of operations could delegate the operational control functions to flight followers or dispatchers, but the director of operations retained responsibility for those functions (Federal Register, 1963b, pp. 7150-7151). Current 14 CFR Part 121 regulations still contain these rules for flight following and operational control for non-scheduled supplemental air carriers.

Lessons of the 1960s and 1970s

Though the expansion of operational control to all air carriers enhanced safety, the 1960s and 1970s brought important lessons related to performance planning, weight limitations, and thunderstorm avoidance. Dispatchers influenced all these areas during flight planning and operations. The result of these lessons meant an improved understanding of planning for airplanes that could now fly higher and faster.

14 CFR Part 121 regulations §121.189 and §121.195 require turbine engine powered airplanes to operate below weights designed to ensure safe operations in the event of an engine failure on takeoff or on approach to landing. Because dispatchers prepare dispatch releases for each flight, they have a direct role in ensuring flights remain in compliance with maximum weight limitations as defined in §121.189 and §121.195. The widespread introduction of heavier jet transports, such as the Boeing 707 and the DC-8, in the early 1960s led to several runway overrun accidents.

Serling (1969) described the problem:

> The FAA's original certification process theoretically required a jet to be able to stop at a certain distance on dry pavements, the distances depending on aircraft landing weight.

> The FAA itself admitted in 1965 that its requirements were on the unrealistic side… (p. 151)

In 1966, the FAA increased landing distance requirements for wet or icy runways by 15 percent (Serling, 1969, p. 151). Dispatchers began considering the runway condition expected at the time of arrival and planning flights below the maximum weight allowed, accounting for the newly required extra 15 percent of landing distance.

The 15 percent increase came into effect too late to save Continental Air Lines flight 12, a Boeing 707 that overran runway 18 at Kansas City Downtown Airport on landing on July 1, 1965. The aircraft landed in heavy rain 1,050 feet past the runway's approach end. The crew attempted to stop the aircraft but was unable to do so due to hydroplaning. The aircraft slid off the runway end and destroyed the ILS localizer antenna building, ultimately stopping on the airport perimeter road next to a levee. All sixty-six on board survived without major injury (CAB, 1966, p. 1).

Ironically, this accident occurred only six days after the July 7, 1965 publication of the Federal Register containing the FAA's (1965) revised regulation, including the extra 15 percent distance margin for turbojet airplanes dispatched to wet or slippery runways (p. 8572). In its explanation for the rule changes, the FAA cited ten incidents between 1960 and 1964 involving turbojet aircraft overrunning landing runways. Nine of these ten incidents occurred on wet or slippery runways (FAA, 1965, p. 8570). The FAA concluded that there had not been more overrun accidents because "most of the airports into which the large turbine engine powered airplanes have been operating have runways that are substantially longer…than the minimums required for landing" (FAA, 1965, p. 8570). The Agency worried that the number of turbojet aircraft operations into shorter runways would result in a significantly higher number of overrun accidents. The new rule became effective on January 15, 1966 (FAA, 1965, p. 8570–8572).

Pan American World Airways Flight 845

The Boeing 747, introduced in 1970 (Zhang, 2016), weighed significantly more than the Boeing 707 (maximum takeoff weight 333,680 pounds) or Douglas DC-8 (maximum takeoff weight 325,000 pounds), with a maximum takeoff weight of 713,000 pounds (Plane & Pilot, 2009). Only 19 months after the Boeing 747's introduction to passenger service, those onboard N747PA underwent a harrowing ordeal caused by dispatcher errors during preflight performance and maximum weight calculations (National Transportation Safety Board [NTSB], 1972, p. 1).

N747PA was a historic aircraft for Pan Am. It was the same aircraft Pan Am used for the first commercial service (Glionna, 2010). On July 30, 1971, dispatchers John Pepin, Francis Keithey, and Edward Anderson (NTSB, 1972, p. 36), stationed at San Francisco International Airport, prepared the dispatch release for the San Francisco – Tokyo flight (NTSB, 1972, p. 6). The dispatcher planned the takeoff on runway 28L, which measured 10,600 feet. He selected runway 01R as a planned alternate runway. He failed to check airport conditions; had he checked, he would have discovered runway 28L closed earlier in the day (NTSB, 1972, p. 7).

The crew radioed the dispatch office to request a departure runway change to runway 01R (NTSB, 1972, p. 7). The dispatcher needed to recompute the maximum available takeoff weight based on the new runway with a different length and obstacles at the runway end. Further reducing the available takeoff distance on runway 01R was a one-thousand-foot blast overrun area at the beginning of the runway (NTSB, 1972, pp. 7-8). Unfortunately, he did not realize the 9,500-foot runway distance listed in Pan American's Route Manual was incorrect. The distance available was only 8,500 feet because the first 1,000 feet were unusable due to the blast overrun. The dispatcher checked performance weight calculations against the clearway computations in Pan American's Route Manual and determined there were no takeoff limitations at the 708,002 pounds planned takeoff weight (NTSB, 1972, pp. 3-4). 14 CFR §1.1 defines a clearway as an area beyond the departure end of a runway that is free of obstacles protruding into an upward-sloping area of 1.25 percent.

Prior to communication with the dispatcher, the crew set takeoff speed "bugs" for the V_1 takeoff decision speed, V_r rotation speed, and V_2 takeoff safety speed. These speeds were set with the assumption of a flap setting of 10 degrees, correct for departure from runway 28L (NTSB, 1972, p. 3). During the runway change dispatch communication, the dispatcher informed the crew that the takeoff required a 20-degree flap setting (NTSB, 1972, p. 4). The crew reset the flaps to the appropriate 20-degree setting, but they did not recheck speed computations for the new flap setting. The speed "bugs" remained set for the initial 10-degree flap setting (NTSB, 1972, pp. 4-5).

The takeoff seemed normal until the first officer noticed the end of the runway "coming up at a very rapid speed" (NTSB, 1972, p. 5). He called for rotation to the takeoff attitude not at the appropriate V_r speed, but because the flight was rapidly reaching the runway end. The crew felt a sudden bump (NTSB, 1972, p. 5), and horrified passengers saw three metal pieces from the runway's approach lighting system shoot through the floor at the rear cabin. The pieces severely injured two passengers. One piece impaled four unoccupied seats. The third piece flew through rear seats and the rear lavatories (NTSB, 1972, p. 14).

The damaged fuselage led to hydraulic systems one, three, and four failing due to fluid leaks. The captain maneuvered the aircraft to check the remaining flight control systems and dumped fuel in preparation for an emergency landing (NTSB, 1972, p. 5). Dumping 180,000 pounds of fuel took about 45 minutes, after which the crew returned to San Francisco. The damaged hydraulic systems meant the aircraft lacked full elevator control authority, and the aircraft touched down hard and bounced. It finally veered off the right side of the runway and stopped at the runway intersection (NTSB, 1972, p. 6).

Chaos ensued during the subsequent evacuation. The flight deck crew did not make a public-address announcement directing the cabin crew to evacuate the aircraft. The evacuation commenced after the crew came down the stairs from the upper deck and shouted to the cabin crew to begin the evacuation (NTSB, 1972, p. 14). Several exit slides in the forward cabin failed, and passengers rushed to usable exits in the rear of the aircraft. The movement of the passengers to the rear, combined with partial landing gear failures, caused the airplane to seesaw back and forth, eventually settling on its tail with the nose gear completely off the ground (NTSB, 1972, p. 24). As the tail settled, the first exit slid in the forward cabin, pointed straight to the ground in a nearly vertical position. Eight passengers were seriously injured as they plunged down on these now-ineffective escape slides (NTSB, 1972, p. 15).

In its final analysis of the accident, the National Transportation Safety Board (1972) calculated that given the existing takeoff conditions, the maximum takeoff gross weight for the available 8,400 feet of runway with clearway should have been limited to 697,400 pounds (p. 18). The aircraft's loaded weight that day of 708,000 pounds required a runway length for takeoff of 8,675 feet plus clearway (NTSB, 1972, p. 18). The NTSB cited these causal factors directly relating to dispatching:

1. The dispatcher prepared a flight release for the longest runway in the airport without ascertaining the status of the runway (NTSB, 1972, p. 17).
2. The dispatcher was "lulled into a sense of complacency" (NTSB, 1972, p. 17).
3. There were no formal procedures for briefing the dispatcher on abnormalities of the operation in effect or expected to happen (NTSB, 1972, p. 17).
4. The Pan American Route Manual contained errors (NTSB, 1972, p. 21).
5. The dispatcher failed to propose the use of runway 28R to the flight crew even though the wind favored it. He simply reverted to his original alternate runway plan of 01R (NTSB, 1972, p. 20).

The probable cause determined by the NTSB (1972) was:

> …the pilot's use of incorrect takeoff reference speeds. This resulted from a series of irregularities involving (1) the collection and dissemination of airport information, (2) aircraft dispatching, and (3) crew management and discipline, which collectively rendered the air carrier's operational control system ineffective. (p. 1).

Aside from the previously described conclusions reached by the NTSB, additional lessons can be learned from this accident. Individuals involved in this accident repeatedly trusted each other, but through misunderstanding, miscommunication, or bad information, safety buffers broke down. We cannot know the exact cockpit sequence of pre-departure events, but the captain may have assumed the first officer or another crewmember had reset the speed "bugs" prior to departure. Airport personnel assumed that the FAA disseminated San Francisco International Airport flight safety information properly to dispatchers and flight crew. Dispatcher Kelthey assumed Pan Am's route manuals contained correct runway distance information. While not every piece of information can be verified prior to its use, crewmembers, dispatchers, and airline managers tasked with highly technical and safety-sensitive functions must confirm the use of correct procedures and information.

Additionally, Pan Am 845's evacuation encountered major issues. No one was killed, but many passengers sustained preventable evacuation injuries because of a lack of crew communication and poor manufacturer information about fuel dumping processes when combined with damaged hydraulic and landing gear systems. Pan Am 845 resulted in an evacuation where nothing went as planned. As a result, airlines now repeatedly practice emergency egress drills and stress crew coordination such that modern emergency evacuations typically result in few to no passenger injuries, provided there is no post-accident fire.

Pan Am 845's accident report notably listed the three Pan Am dispatchers' names and dispatcher certificate information. No previous aircraft accident reports included dispatcher names along with the flight crewmember names. Ultimately, dispatchers and pilots share a tremendous amount of responsibility for operational control and safe operations. This accident clearly illustrates the potentially fatal consequences that can occur when operational control breaks down even in the preflight planning process.

Thunderstorm Avoidance

Since the advent of commercial aviation, thunderstorms caused delays, diversions, and accidents. Airlines attempted to find ways to avoid enroute weather while maintaining scheduled operations. In 1949, American Airlines and the United States Navy conducted tests of an onboard weather radar system installed in a Convair airliner ("Flying Lab," 1949, p. 28). In 1956, American Airlines equipped its fleet of DC-7s with airborne weather radar ("AA to Equip," 1955, p. 20). Airlines quickly embraced the innovative technology, and Aviation Week (Christian, 1955) quoted a Northwest Airlines pilot: "We all wonder how we ever got along without it. Pretty soon the public won't fly in anything but radar-equipped airplanes" (Christian, 1955, p. 40).

Radar was life-changing for the crews who formerly navigated through areas of embedded thunderstorms by guesswork and prayers or significant routing changes. This new technology quickly became trusted by flight crews and dispatchers, and Job (1994) states:

> …since the advent of airborne weather radar, more and more aircraft were being dispatched in marginal weather, with the captain having the primary responsibility for avoiding severe conditions…too much reliance was probably being placed on an instrument that could not 'see' the turbulence itself. (pp. 58-59)

Several aircraft accidents in the late 1950s and early 1960s demonstrated this faulty reliance by dispatchers expecting pilots to avoid enroute thunderstorms and weather but failing to provide vital information on enroute weather conditions. These accidents included Capital Airlines flight 75 in 1959 (CAB, 1959), Mohawk Airlines flight 112 in 1963 (CAB, 1964), two different Braniff International Airways flights, flight 250 in 1966 (NTSB, 1968), and flight 352 in 1968 (NTSB, 1969).

One of these accidents that emphasized this misguided reliance on crews for inflight weather avoidance was highlighted by the NTSB (1968) in its report on Braniff International Airways flight 250 (p. 15). On August 6, 1966, a BAC 1-11 designated as flight 250 departed from Kansas City bound for Omaha. Prior to departure from Kansas City, the crew discussed the expected enroute weather with another Braniff flight crew that had just arrived from Chicago. The incoming crew described "a solid line of very intense thunderstorms with continuous lightning and no apparent breaks" (Job, 1994, p. 53).

Dispatchers were aware that another Braniff flight had delayed its takeoff from Sioux City because of weather at Omaha, and yet another Braniff flight between St. Louis and Omaha had diverted to Kansas City after its pilot elected to completely avoid the intense squall line of thunderstorms (NTSB, 1968, p. 14). Dispatchers failed to inform the crew of flight 250 of the other crews' decisions to avoid the weather. The dispatcher testified to the NTSB (1968):

> If he received a severe weather warning for an area through which company aircraft were operating, it was doubtful that he would forward this information to enroute aircraft. In his opinion, the crews in the area would be better able to evaluate the weather than he could. (p. 15)

Flight 250 continued ahead toward the line of thunderstorms, requesting a deviation to the left to avoid weather (Job, 1994, p. 55). It suddenly encountered a severe gust of wind in the turbulent shear zone near the line of thunderstorms. The gust broke the elevator and rudder from the tail, and seconds later, the right wing failed (Job, 1994, p. 56). Witnesses who had been outside watching the approaching storm saw the aircraft plummet to the ground, killing everyone on board (Job, 1994, p. 54).

The NTSB (1968) determined the probable cause to be "inflight structural failure caused by extreme turbulence during operation of the aircraft in an area of avoidable hazardous weather" (p. 59). The word "avoidable" in the Board's probable cause is tied directly to the dispatcher's error of omission. The dispatcher possessed weather knowledge but failed to provide it to the crew of flight 250. As a result, 42 people perished (NTSB, 1968, p. 1).

Conclusions

This research project successfully documents, in detail, the early development of the dispatcher and how dispatchers became inherent to safe and reliable air transportation. Dramatic improvements in airline accident rates are attributable to many causes. Fatality rates per 100 million passenger miles flown declined sharply with better operational control, communications, weather monitoring, and operational oversight. A comparison with 1932 rates – 14.96 deaths per 100 million passenger miles flown (Serling, 1969, p.43) – demonstrates this steep decline. Rates fell steadily from 0.50 fatal accidents per 100 million passenger miles in 1952-1956, fell again to 0.22 in 1962-1966 (Serling, 1969, p. 47), then to 0.121 in 1975, and finally dropped to 0.034 in 1980 (Department of Transportation [DOT], n.d.). Since 2009, the fatality rate has been near zero (DOT, n.d.).

The system of operational control exercised by dispatchers and flight crews contributes significantly to this excellent safety record. Today, dispatchers undergo stringent training and certification. All Part 121 air carriers require operational control systems, both for scheduled and non-scheduled operations. Modern flight position reporting technologies and weather reporting systems provide dispatchers with more real-time information than ever before. Today, the dispatcher is able to utilize a complete and comprehensive view that includes more information than flight crews can access. The *Aviation* article previously quoted in this paper, "Flying with One Foot on the Ground" (1937) described the then-novel concept:

> A properly trained dispatcher, sitting apart from the immediate stress and strain of flying the airplane and with all possible forms of information at his disposal, has an opportunity

> to sit down and figure things out in a way that is not possible for the pilot with his many flying duties. (p. 72)

This research project demonstrated how this early concept of a dispatcher’s role became a reality, examining the period from 1929 through the 1970s. As air transportation evolved in the United States, the dispatcher’s role also evolved. Dispatchers grew from glorified radio operators to trusted ground crewmembers, enabling flight crews today to fly with one very important foot on the ground.

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Challenges Faced by FAA CFR Part 147 Aviation Maintenance Instructors

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There is frequent discussion on the shortage of aviation maintenance technicians, but less frequent is the discussion on the instructors who will train these technicians. Most aviation maintenance technicians are trained at FAA-certified Part 147 Aviation Maintenance Technician Schools (AMTS) at the college or university level. What is less understood are the challenges faced by aviation technician instructors. What are some of the factors that make teaching difficult? How did those challenges change the instructor's approach to their career? The purpose of this study is to identify challenges faced by current aviation maintenance instructors and identify how those challenges affected the instructors' approach to their careers. This study surveyed instructors from FAA Part 147 AMTS on their background, the challenges they face, and their effect on the approach to their careers. The survey was sent to 172 programs with n = 44 respondents. Participants identified COVID, instructor shortage, incoming experience and knowledge of students, and lack of qualified instructors as common issues.

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Introduction

There is a shortage of aviation technicians. Boeing (2023) reports a demand for 690,000 technicians in commercial aviation alone over the next 20 years. While the entire reason for the shortage of aviation maintenance technicians is not completely understood, contributing factors point to an aging population, retirements, perceived benefits, and even qualified individuals who leave for other industries (Wyman, 2017).

A key component receiving less attention is a shortage of instructors needed to train that same workforce. As the population of students rises, so does the need for qualified instructors who also possess knowledge of the evolving industry, can effectively use physical lab spaces, can incorporate online learning environments, and are up-to-date on next-generation aircraft technologies to bring to the classroom. There is a growing and urgent need for qualified FAA Part 147 instructors who can teach the next generation of the aviation workforce. In addition to educational requirements, training aviation technicians at university or collegiate levels requires more than just a post-secondary degree. There are certification requirements and, frequently, industry experience requirements as well. Aviation maintenance technicians are trained under certification from the FAA under CFR Part 147 Aviation Maintenance Technician Schools (AMTS), requiring instructors to have their Airframe and Powerplant Certification. Additionally, if the program is at a college or university with research expectations, faculty may be in a tenure-track position. This means that they must also obtain a Ph.D. and pursue an academic career that includes research (Harl & Johnson, 2006). If research is not of interest to the instructor, this can become a significant barrier to entry. Some situations require instructors in a Part 147 maintenance program to have both a Ph.D. and an airframe and powerplant certificate. This combination of qualifications is not common. According to Motevalli et al. (2017), as of that year, only 490 people met that criterion.

The study data also indicated changes in technology tools being incorporated in maintenance tasks like Augmented and Virtual Reality (Borgen et al., 2021), data analysis from sensor-driven aircraft data systems (Boeing, 2023; Ropp et al., 2021) challenges instructors to stay current with new technologies. Even the expansion of online course delivery components was cited as a significant challenge. While the COVID pandemic that began in earnest in March of 2020 did not start the online education movement, it rapidly expanded its reach and pushed its limits. New technology can be difficult for some instructors to incorporate into classrooms. Before the COVID pandemic, the FAA did not generally allow for distance learning without a waiver, which is dependent on the local Flight Standards District Office (FSDO) to approve, and the FSDO did not always approve virtual instruction. During the pandemic, however, the FAA issued special waivers to allow for both synchronous and asynchronous learning. This forced many instructors to rapidly adapt their curriculum to an online format. For a program to switch from completely in-person to online was a seismic change and one that many instructors were not prepared to make. Questions on how to provide more online instruction in a program that requires 1900 hours of seat time is one that many instructors are not ready to answer. Recent changes to regulations allowed for the removal of the 1900-hour requirement with a switch to competency-based assessment, but the program still required significant hands-on experience. While core content and skill changes to Part 147 required areas may evolve more slowly, education and training organizations for aviation maintenance must still take evolving teaching and learning tools and professional development needs into account in order to support and retain qualified instructors in the future. Professional development should also include how to integrate curriculum to online and virtual reality technologies in the classroom and assess student performance.

With all the challenges facing instructors in an aviation maintenance program, the purpose of this study was to identify challenges faced by current aviation maintenance instructors and identify how those challenges affected instructors' approach to their careers.

Methodology

This study surveyed instructors of FAA CFR Part 147 programs, asking for their perspectives on the challenges of teaching in an aviation maintenance program. Participants were identified through a download of the Aircraft Maintenance Technician Schools (AMTS) listed on the FAA website (Federal Aviation Administration, 2021). In September 2021, the total number of schools listed was 185. The list included their designator, name, address, and phone number. The list was re-formatted to include only the name to help simplify the spreadsheet list. It was then used to review the web pages of the schools to identify a point of contact.

The contact information was normally from the school's webpage. Once a point of contact or multiple points of contact for an AMTS were found, they were added to the spreadsheet list. From this process, 184 school email addresses were collected. Some schools had multiple points of contact on the list based on the type of contact information listed. Nine AMTS were eliminated because they were high schools or contact information could not be located. The remaining 172 schools were contacted to participate in the survey.

An identical message was sent individually to each contact with a survey link and a brief message describing the survey and its goal. Due to each email being sent individually, the process was done in three batches in November of 2021.

There were 44 responses ($n = 44$) received between November 2021 and January 2022. Multiple types of data are reported, including demographics, descriptive statistics for Likert data, and qualitative thematic coding for open-text responses.

5P Thematic Framework Assessment

As this was not a typical interview process with the expected narrative response, but instead were short, focused responses, a typical qualitative coding analysis was not appropriate for this study. The responses were categorized according to the 5P framework for further exploration. The 5Ps are a piece of the Six Sigma quality process. The 5Ps are a framework that allows organizations to assess their culture and capacity.

There is inconsistency in the assignment of the different Ps. ISIXSIGMA defines the 5 Ps as purpose, participants, preparation, process, and progress (ISIXSIGMA, 2022). The 5 Ps are also identified as purpose, process, people, platform (tools and technology), and performance (Lewis, n.d.; Rousseau, 2018). Similar 5P models have been used in organizations where Quality Management Systems (QMS), Safety Risk Management, and Safety Management Systems (SMS) components are part of a systematic regulatory requirement of daily tasks, including aviation (U.S. DOT – FAA, 2012) and specifically used as part of education and training aeronautical and piloting risk management tools (FlightStudy, 2021). Other 5P assessment framework methodologies have been validated in organizational Six Sigma applications in manufacturing and the medical industry (Huber, 2006).

For this study, the 5P model used was:

People	Both the creators and customers of the task, whether it be curriculum, university-level requirements, or FAA requirements.
Parts	Equipment or electronic tools used in the delivery of curriculum or daily tasks of the instructor job.
Processes	The sequence of tasks required to perform the duties of the instructor.
Placement	Geographical or physically within a learning organization’s campus.
Performance	How well the program or course meets its objectives.

To assess the survey with open-ended/open-answer responses (survey items 13 – 16) with more precision, two researchers independently reviewed the textual responses and analyzed them using the 5P framework. This analysis was completed using one of the built-in tools in Qualtrics, Text iQ. The first researcher reviewed all the responses and reviewed them for alignment with the 5Ps. For instance, one of the questions was, “Please briefly describe a problem or challenge you faced in your career in the last three years.” The response was, “Teaching in the last three years has become more demanding and time-consuming. The amount of work required is becoming so great I am concerned future educators will be hard to find. Personal time vs. professional time is way out of balance.” This response was coded “People” for alignment with the 5P framework. A second researcher then performed a second review for alignment with the first researcher. Any conflicts were resolved through discussion between the two researchers. This study examines only two of the questions from the instrument beyond demographic information: 1) Describe a problem or challenge you faced in your career in the last three years, and 2) How did that problem or challenge change how you approached your career?

Instrument

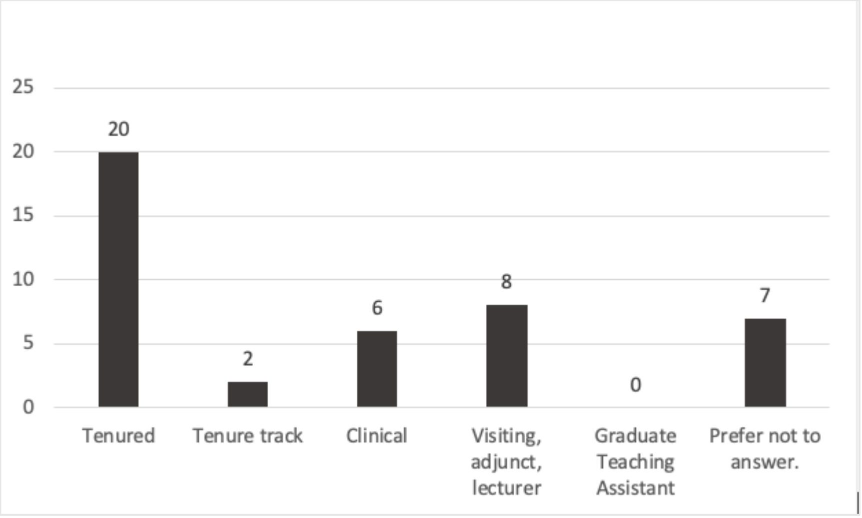
The survey was built and distributed through Qualtrics, see Appendix A. There were three major sections, consisting of 16 questions, to the survey: 1) questions related to the individual and the institution (6 questions), 2) questions related to their interaction with the aviation industry (6 questions), 3) and finally, questions about a recent challenge or problem they have faced in their career (4 questions). In the first two sections, all questions were answered except for a question where the participants were asked to describe their position, which was open text. The final section, questions on a recent problem or challenge, were all open-text responses.

Analysis

Participants

In the first section of the survey, the researchers collected data on the participants and their institutions. Most participants were in tenured positions and had taught for over fifteen years, *n* = 20. See Figure 1 for a breakdown of the positions held. Of the 43 participants who answered, 20 were tenured professors. 41 had an airframe and powerplant certificate, one had a powerplant-only certificate, and the remaining participants preferred not to answer. Forty participants were male. Two participants preferred not to say, and the remaining one did not answer the question.

Figure 1
Position Held by FAA Part 147 Faculty



Thirty-two of the participants had more than 15 years of industry experience, see Figure 2. When it came to the program where they were teaching, most of them were in a two-year program as part of an associate's degree, see Figure 3. Two respondents identified themselves as teaching at a high school program. One clarified in the question of roles that they were an adjunct at a university, but their responsibilities were to teach high school students. The second appears to be an instructor at a high school. Even though high schools were not intended to be part of this study, their responses were kept in the data. Most participants had some background working in the aerospace industry, and most of their backgrounds were in aircraft maintenance or maintenance, repair, and overhaul (MRO).

Figure 2
Teaching and Industry Experience of FAA Part 147 Faculty

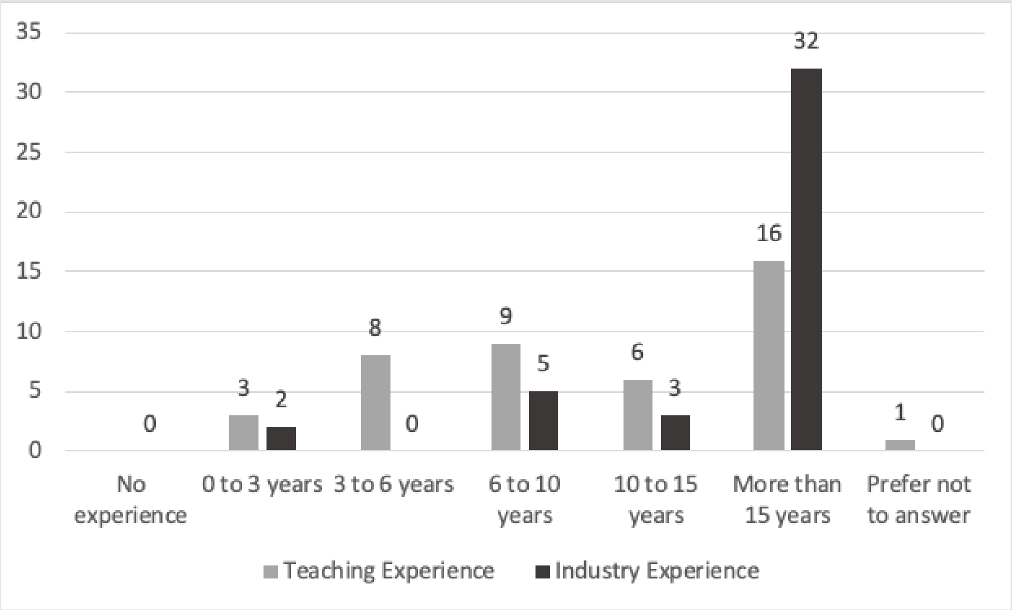
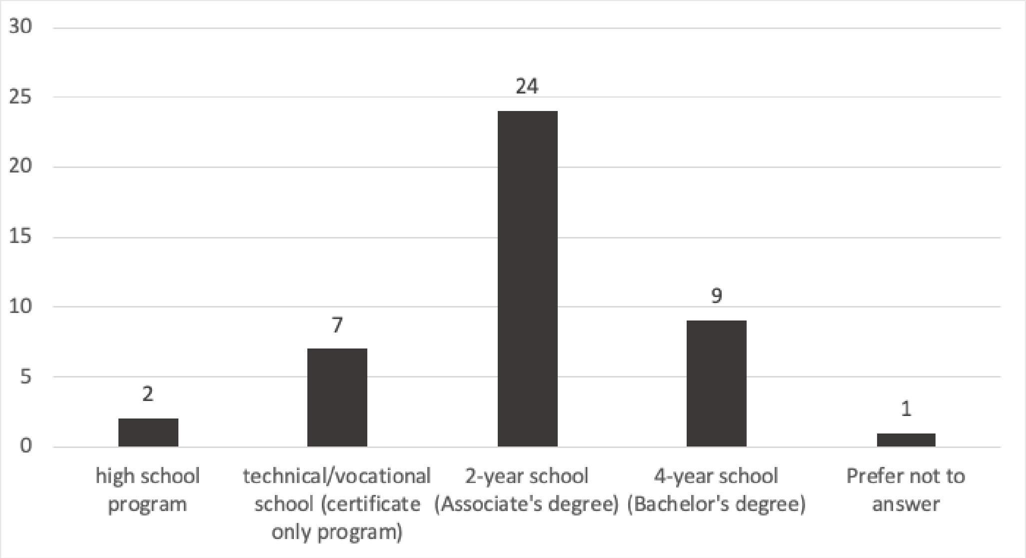


Figure 3
Program Type of the Participants



After the preliminary questions on the participants and their institutions, the survey questioned them on the challenges they faced and how their administration responded. Responses were coded using the 5P model of people, parts, process, placement, and performance using the TextiQ tool in Qualtrics.

Describe a Problem or Challenge You Faced in Your Career in the Last Three Years

Once the responses from the participants were coded using the 5Ps, the data showed that people were the key finding for most of the responses. Figure 4 is an illustration from TextiQ of the 5Ps, how common the responses are, and the tone of the responses, positive or negative. Since the question is asking about a problem or challenge, it is not surprising that the responses were negative overall.

Figure 4
Challenge Responses

The breakdown of responses is detailed in Table 1. There were 34 respondents who answered this question. Each response could be included in more than one category.

Table 1
Challenges responses for each category

Category	Number of Responses
Parts	7
People	24
Performance	14
Placement	5
Processes	13

Respondents identified three major areas as challenges faced in the last three years. Those are the following:

- COVID-19/Online instruction (Process)
- Qualified instructors (People, Performance)
- Student preparedness (People, Performance)

Due to the timeframe of when participants responded, in November 2021, COVID-19 was a common response for a recent challenge they faced. One participant replied that they quit teaching full-time after the spring of 2020: “Teaching A&P online during the initial stage of the pandemic. Retired from full-time instruction prior to the following (Fall) term. Would avoid repeating that experience. Feel terrible for current faculty that have to function in the current COVID environment.” Another participant also discussed their challenging experience with the pandemic.

> Transitioning from lecture/lab-based program delivery to a synchronous online lecture-only course delivery in response to COVID. I only had a few weeks to prepare and had to transition class presentations, tests, and projects to remote delivery. I then had to develop a plan in which the hands-on projects could be done in a compressed format upon returning to in-person classes.

Another issue cited was instructor shortages to meet the needs of the program. Many participants had comments on the ability to find and hire qualified instructors. Multiple respondents specifically mentioned instructor staffing as a challenge.

> "Finding instructors to fill positions when they become vacant. Current teacher pay isn't exactly strong compared to what we can make working in the aviation industry."
> "Short on teachers, having to fill in when necessary."
> “Adequate faculty staffing.”
> “The biggest challenge of the last few years has been finding qualified faculty.”
> “…limited number of availability [*sic*] of qualified AMT professors.”
> “Also, extremely difficult to hire and keep qualified instructional staff.”

Other concerns focused on the preparedness of the students with regard to both expectations and skills. Some students do not realize the composition of the program.

> They come to class understanding that as an A&P, they will make big money from day one. They either are not told or do not understand that they will need to read and take quizzes/tests. They think they will spend their time working on aircraft. I must try to help them learn to study and understand that to be an A&P, they will be reading tech manuals and filling out paperwork.

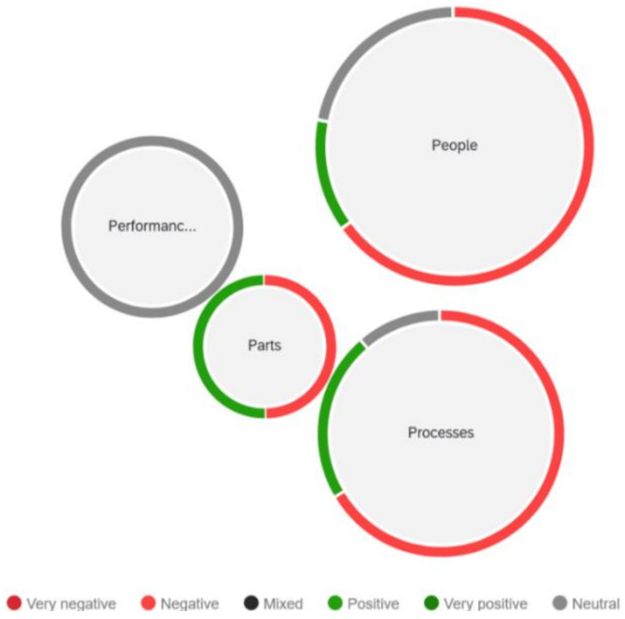
Students may not have the education strength they need for a collegiate level program, “Mainly incoming students not being properly prepared for higher education. Lack of sufficient math and English skills.” Or they are missing mechanical skills, “Students are less mechanically prepared than in the past (but more electrically capable).” With the increase in international students, communication becomes a greater concern, “The problem that we run into the most is the foreign students that English is their second language. It's very difficult for them, especially in a technical field.”

How Did That Problem or Challenge Change How You Approached Your Career?

This question is a follow-up to the previous question about a challenge the participants faced. After coding responses against the 5Ps, the responses were primarily people and processes. The results of the coding are found in Figure 5. While the responses to the challenge were universally negative, the responses to this question were still primarily negative, but in this case, they included positive responses.

Figure 5

Changes in Career Approach Due to Recent Challenges



The breakdown of responses is detailed in Table 2. There were 33 respondents who answered this question. Each response could be included in more than one category.

Table 2

Response to challenges breakdown by category

Category	Number of Responses
Parts	2
People	23
Performance	8
Placement	0
Processes	18

Overall, respondents focused on two major areas that changed their approach to their careers. Those are the following:

- Incorporation of distance learning (Processes)
- Leave teaching or retire (People)

Considering when this survey was sent to participants, it was not a surprise that many focused on the challenges and recovery from the COVID pandemic. Many instructors found a positive response to the review and adaption of the curriculum. A common response was around the use of technology in the delivery of material. One respondent said, "… their *[sic]* are different opportunities to use technology in the classroom…." Another said, "The curriculum that I taught had to be converted to something appropriate for Canvas and distance learning." "… how curriculum can be presented in multiple formats. I have developed contingency plans for my class if instruction is disrupted again."

Others responded that the changes forced them to adapt or modify outcomes. "As a program, we have learned to adapt *[sic]* and supply needed supplies and equipment…." "It stretches all of our faculty and makes us look for other options to keep classes running." "Have to spend more time teaching basic mechanical skills instead of teaching aircraft-specific skills."

> I decided that instead of constantly fighting with the college over when we would enter grades, I would try to change the program to fit their requirements while still meeting the Part 147 rules. Looked over a sequence of units and determined that I could reorder them to get the desired results of everything fitting into the semester guidelines.

Not all responses were positive. Many found that either they or other instructors in their program left their positions. "Encourages me to retire" was one response. "This problem was significant and nearly caused all the tenured staff to leave the program" was another. "It actually has me looking to retire at the end of this year." Another said, "I questioned my decision to accept this position and questioned my broader career choice."

Discussion

Evolving Challenges in Aviation Education

Educators at the collegiate level face increasing challenges to remaining current and relevant in a changing consumer-focused learning landscape and changing learner needs that follow industry hiring and training practices (Bok, 2020; Crow & Dabars, 2020). Additionally, the aviation industry itself continues to evolve tremendously in technology, as well as demands for a more agile, cross-trained workforce (Garret, 2017; Hedden, 2020). Changes in technologies and processes outpace many traditional educational institutions. While experienced instructors have the competencies, data in this study suggests perhaps there is associated frustration at a perceived lack of being trained and upskilled in new technologies. This frustration could arise in the delivery of instructional material, such as teaching out of online learning management systems. As well as introducing students to new technology, such as electric propulsion. Typically, investment into these areas is required at School/Departmental levels and competes with other capital needs expenditures such as upgrading older facilities or hiring to fill instructor shortages.

Instructor Education Pathway

Instructor shortage is an issue many of the respondents identified, but it is not an easy task to hire more. Aviation maintenance instructors must meet many requirements before they can teach. Because the requirements to be an instructor are so unique and varied, many of the instructors in aviation maintenance programs come from the programs themselves. This means that in addition to training future aviation technicians, which is a challenging process, these programs also have a secondary purpose: to train the next generation of instructors. Johnson (1999) surveyed faculty members of the University Aviation Association (UAA) about their perspective on their program's ability to prepare the next generation of faculty members. While the responses could range from "poor" to "excellent," no respondent ranked their program as excellent. Sixteen percent responded that their program was doing a good job in training the next generation of faculty members. 39% of the respondents said their program was doing average in faculty training. 28% responded with below average 28%. 16% responded poor.

There are multiple challenges in developing aviation maintenance instructors, including professional development, changing technology, and evolving curricula. The need for professional development is not unique to instructors in aviation maintenance training or even all instructors but includes all workers. Professional development could include multiple avenues, including a) maintaining currency in the field, b) faculty renewal, and c) improving instructional techniques (Johnson, 1996).

Future Work

Future work building Part 147 education and training systems that support development and instructor retention can go in many directions. Critical areas would include evaluating advances in:

- Innovation in online course delivery
- Programmatic and instructional delivery methods and professional development of instructors
- Curriculum content

A conversion to online education did not start in the spring of 2020, but it did accelerate it. Aviation maintenance programs have a significant amount of hands-on education that is difficult to convert. In the future, studies could explore the ways activities that have been traditionally seen as restricted to in-person instruction could be modified, possibly to virtual or augmented reality. Rapid changes in technologies both in the aerospace industry and teaching methodologies are challenges for existing instructors.

Additional professional improvement could include online teaching techniques. Knowing that many future instructors are initially trained in a technician program with minimal or no instruction in teaching skills, the curriculum could be revised to include student outcomes focused on teaching and training to better prepare them for a day when they might find themselves in front of a classroom. This extra instruction would need to be in addition to the FAA ACS requirements. The inclusion of teaching techniques could be challenging for programs without much additional space in the curriculum for additional material.

Future work could also include how new teaching techniques could be used to increase flexibility in programs. Can instructors be virtual, with some instructors teaching at multiple locations? Can the sections that must be hands-on be covered by a reduced number of instructors?

Conclusion

With the shortage of aviation technicians, there is a need to increase the number of technicians trained. A consequence of this gap is the need to develop additional instructors to train the new technicians. The purpose of this study is to identify challenges faced by current aviation maintenance instructors, identify ways to improve the academic environment in the future, and encourage new people to become instructors. The instructors surveyed identified multiple major challenges, which include COVID, instructor shortage, incoming experience and knowledge of students, and lack of qualified instructors. Recommendations to address these concerns include further training and professional development for instructors. Training for future instructors could begin during maintenance technician training if schools or programs have the space in their curriculum to include basic instructor knowledge. Additional courses or seminars focused on building a common and higher experience level for incoming students will help bridge the gap between what students know and what they are expected to know.

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Appendix A

A&P Faculty Challenges Survey

Researchers at XXX invite you to participate in this research study.

The title of this study is Assessment of Challenges in Teaching for Instructors/Faculty in Part 147 Airframe and Powerplant education programs. The purpose of this study is to gather your perspectives and challenges teaching in an FAA Part 147 program and other experiences you have had with or in the industry.

Your participation in this study will involve taking an online survey through Qualtrics. First, we'll ask you a few questions about yourself, your certifications, the areas you teach in, your professional background, and the area in which you teach. You will then be asked to complete a 12-question survey about your experiences teaching within your program. The estimated time to take the survey is approximately 20 minutes.

The risks to you as a participant are minimal. This survey is designed to be anonymous, but there is a slight risk of loss of anonymity. This risk is minimized by designing the survey in a way in which no identifiable information will be collected. The researchers have taken additional data security measures, minimizing the chance of personally identifiable information being disclosed. This includes ensuring the online survey has been developed to make responses anonymous and password protection to the survey results available only to the researcher.

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 anonymous.

Participation in this study may help develop and improve approaches to preparing and mentoring existing aviation educators. Additional benefits may come from the assistance in equipping and hiring future educators as well.

You can choose not to participate. If you decide not to participate, there will not be a penalty to you or loss of any benefits to which you are otherwise entitled. You may withdraw from this study at any time.

If you have questions or wish to withdraw from this study, call XXXXX.

Reference IRB-2021-1320.

These questions are related to you and your institution**.**

1. What is your current rank?
   - ○ Tenured
   - ○ Tenure track
   - ○ Clinical
   - ○ Visiting, adjunct, lecturer
   - ○ Graduate Teaching Assistant
   - ○ Prefer not to answer.
2. How long have you been teaching in a Part 147 A&P program?
   - ○ 0 to 3 years.
   - ○ 3 to 6 years.
   - ○ 6 to 10 years.
   - ○ 10 to 15 years.
   - ○ More than 15 years.
   - ○ Prefer not to answer.
3. Which certification do you have?
   - ○ Airframe only.
   - ○ Powerplant only.
   - ○ Airframe and Powerplant.
   - ○ Neither.
   - ○ Prefer not to answer.
4. Please describe your position, including the most important characteristics of your job.
5. What is your gender identity?
   - ○ Male
   - ○ Female

○ Non-binary/third gender
○ Prefer not to say

6. Is your Part 147 program part of a:

○ High school program.
○ Technical/vocational school (certificate only program).
○ 2-year school (Associate's degree).
○ 4-year school (Bachelor's degree).
○ Prefer not to answer.

The following questions are related to your interaction with the aviation industry.

7. How many years of industry experience do you have?

○ No industry experience.
○ 0 to 3 years.
○ 3 to 6 years.
○ 6 to 10 years.
○ 10 to 15 years.
○ More than 15 years.
○ Prefer not to answer.

8. If you have industry experience, which best describes your primary prior area of professional experience?

○ Aircraft maintenance/MRO
○ Pilot (Airline, Corporate)
○ Airline Operations (Revenue management, planning, etc.)
○ Commercial Manufacturing
○ Military Manufacturing
○ Aircraft finance/leasing/acquisition
○ Government/Regulatory

○ Air Traffic Control
○ Training
○ Airport Operations
○ Commercial Space
○ NASA
○ Military
○ Other ____
○ Prefer not to answer.

9. Do you currently connect with the industry as part of your class? Examples could be coordinating student projects, company site visits/tours, special speakers in class, or internships.

○ Yes
○ No
○ Prefer not to answer.

10. Do you concurrently connect with the industry doing consulting, technical assistance, or research?

○ Yes
○ No
○ Prefer not to answer.

11. Please indicate your level of agreement to the following statement.

The institution in which I teach, I am encouraged to stay updated on current industry advances and trends.

○ Strongly disagree
○ Somewhat disagree
○ Neither agree nor disagree
○ Somewhat agree
○ Strongly agree

12. Please indicate your level of agreement to the following statement.

At the institution in which I teach, I am provided time and funding for continuing education and learning.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree
- ○ Prefer not to answer.

Please answer the following questions about a recent experience you have faced in your career.

13. Please briefly describe a problem or challenge you faced in your career in the last three years.

14. How did that problem or challenge change how you approached your career?

15. What did your administration do that was helpful / not helpful in this situation?

16. What would have made this problem easier for you to manage?

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The Use of Industry Advisory Boards in Support of Collegiate Aviation Programs

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Abstract-Research problem: Aviation Accreditation Board International (AABI), the organization that accredits aviation degree programs, requires that programs seeking accreditation work with aviation industry professionals in the development and assessment of their programs. (AABI Accreditation Criteria Manual, February 24, 2023). There is no formal directive regarding how aviation programs and industry partners must work together, however, and no best practices relating to the use of industry advisory boards have been researched for aviation degree programs as they have been in other academic fields. Research questions: (1) How do aviation degree programs incorporate industry feedback? (2) How are industry advisory boards being used in support of aviation degree programs? Literature review: Literature in other fields regarding the use of advisory boards in the development and assessment of academic programs has offered insights into stakeholder benefits and suggested best practices, but research on the use of industry advisory boards in collegiate aviation programs is significantly lacking. Methodology: A survey link was shared with all current UAA and AABI members with the goal of determining how common it is for programs to have an industry advisory board. If the programs reported having an industry advisory board, additional survey questions sought to identify the benefits and challenges of having an industry advisory board, as well as the common characteristics of the boards. Findings: Advisory boards are commonly used to support aviation degree programs. However, there is a wide variation in terms of how they operate. This study offers a beginning framework for learning how industry partners and aviation programs are currently working together and suggests areas of additional needed research in order to identify best practices.

Recommended Citation:

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Introduction

In contrast to general studies degrees that prepare graduates for a wide variety of post-graduation opportunities, specialized degree programs tend to focus on preparing graduates for employment opportunities in a particular career field. Aviation degrees are examples of specialized degree options that tend to be career-focused; other examples might include engineering, information systems, business, and technical communication.

Due to this stronger focus on immediate post-graduation employment in a student’s chosen career, many specialized programs and schools have found value in collaborating directly with the industry-specific organizations that employ their graduates in the form of an advisory board, advisory committee or other similarly named working group.

These working groups, referred to as advisory boards or industry advisory boards (IAB) throughout this paper, serve to “provide feedback with the goal of enhancing students’ academic experience and preparedness for future careers” (Soderlund, 2017, p. 76).

This paper offers a foundational overview of advisory boards within several specialized degree programs, summarizes relevant literature, and identifies two research questions: how do aviation degree programs incorporate industry feedback, and how are industry advisory boards being used in support of aviation degree programs? This paper also explains the methodology used in administering a survey, discusses survey results, and offers suggestions for continued research in this area.

Literature Review

Selection of articles

In learning more about research relating to the use of advisory boards in collegiate aviation programs, peer-reviewed journal articles that included the search terms “aviation” and “advisory boards” were first considered. These search efforts yielded no applicable results, so the search terms “academic,” “advisory,” and “boards” or “committees” were considered instead. This strategy resulted in a much larger number of resources upon which to base our research. Notably, the lack of research specific to aviation validated a need for research in this area.

In order to focus on the most relevant findings, the scope of the literature review was limited to those studies that looked at the use of advisory boards where the primary and limited purpose was to advise a particular academic program, department, school, or center within a university. Excluded were articles that looked at boards with decision-making authority or boards that had a broader scope of influence, such as at the college or university levels.

The resulting articles appropriately limited the scope of this particular research and informed the survey design.

Background

Industry professionals have influenced academic programs in the form of boards or working groups for decades. Researchers reviewing information systems (IS) programs, for example, report evidence of IS programs working with industry experts as early as the 1960s (Mandviwalla et al. 2015).

An early example of how researchers have examined the use of advisory boards in a more generalized way is a paper that was presented at the annual meeting of the American Association for Adult and Continuing Education, "Using Advisory Boards in Academic Administration" (Silver, 1988). This same author went on to publish a related paper four years later, where they described the benefits of working with advisory boards (1992).

Another article published around that same time appeared in the Journal of Marketing Education, where professors Kress and Wedell promoted the use of advisory groups as a way of "bridging the gap between marketing academicians and marketing practitioners" (1993, p. 13). This article explored the purposes, benefits, and challenges of using advisory boards in support of a particular department or program within a university.

Research that followed focused on how advisory boards were developed to support academic centers and other specialized programs within a university, and since the late 1990s, we find research that focuses on several types of centers and specialized degree programs.

Centers and programs represented in the literature

Academic centers represented in the literature include entrepreneurship centers (Zahra et al., 2011) and learning centers (Craig et al., 2018). Academic programs represented in the literature include actuarial science (Query, 2018), marketing (Andrus & Martin, 2001; Kress & Wedell, 1993), engineering (Coe, 2008), communication (Benigni et al., 2011; Dorazio, 1996; Soderlund et al., 2017; Penrose, 2002), information systems (Watson, 2012; Mandviwalla et al., 2015), and sport management (Lawrence et al., 2018).

While studies have examined the use of advisory boards in several different academic settings, as listed, studies exploring the use of advisory boards to support aviation programs are entirely lacking.

Existing articles in these non-aviation subject areas, however, suggest a number of topics to examine. Topic areas include the purpose of advisory boards and benefits to the programs, benefits that board members receive by being on an advisory board, how to form and operate an advisory board, and how advisory boards are used to meet accreditation standards.

Purpose of advisory boards and benefits to the programs and students

Having an advisory board can bring a number of internal and external benefits related to credibility and prestige. Industry advisory boards help academic programs avoid the critique of being too inwardly focused, too theoretical, or too out of touch with current industry trends. Programs also establish credibility within their own institutions by working with an advisory board because board members serve as knowledgeable, respected external consultants with access to resources and wider professional networks (Maxwell, 1997).

Specific resources provided by advisory boards might include monetary funding in the form of donations to the program or university and the networking connections they have that give them the ability to promote the program within the larger community. These are described by Zahra et al. as actions that are “legitimizing [the program’s] operations among various external stakeholders” (2011, p. 115).

Additional research discussing benefits focuses on how advisory boards can directly impact the educational experiences of students by providing feedback on curriculum development and program review, assisting with student recruitment and retention, and providing students with opportunities to work with professionals in their field (Mandviwalla, 2015; Dorazio, 1996).

Dorazio’s research provides even more specific examples by discussing how board members can suggest case studies or projects for classroom use, they can serve as student mentors or evaluators in capstone courses, and they might be used to conduct mock interviews and offer resume critiques. Then, as students near graduation, advisory board members can be instrumental in terms of job placement and internship opportunities (1996).

In addition to the research highlighting the benefits that advisory boards bring to programs and students, a number of articles also point out the ways that board members benefit from serving on advisory boards.

Benefits to the board members

Members of boards with decision-making authority are frequently compensated for their work. Advisory board members, however, generally are not, so some research explores why advisory board members choose to serve voluntarily. Motivations cited in the literature list intrinsic benefits such as a “sense of duty, contribution to the education and learning of others, and community responsibility” (Zahra et al. 116).

Dorazio’s work also cites intrinsic satisfaction as a motivating factor and notes that board members often enjoy learning from each other. Their service on a board also promotes their own company, allows them to expand their own professional network, and the work is considered valuable volunteer work or community service (1996, p. 102).

Articles that address the logistics of forming and operating an advisory board can be instructive for programs that want to maximize the benefits that advisory boards can provide.

How to form and operate a board

Operational logistics described in the literature include how to set up an advisory board, how and how often to communicate with board members, and the differences between engaged and ceremonial boards (Zahra et al., 2011).

Additional articles suggest how to define board missions and objectives, how to recruit and select board members, how to manage advisory boards, and describe the importance of board members having a “diversity of thought and experience” (Mandviwalla et al. 1996, p. 28). Others suggest ways to handle the removal of board members, suggest roles of administrators and alumni on the board, and summarize additional best practices (Penrose, 2002).

Presumably, many suggestions about how to form and operate advisory boards in other academic programs would be applicable to aviation programs as well, but without research and evidence, that assertion would be made without validating evidence.

As programs decide how to formulate their own advisory board, they should be aware that while some articles discuss the use of alumni as ideal board members (Penrose, 2002), other research suggests that non-alumni members can be just as engaged and beneficial to a program as alumni members are (Nagai & Nehls, 2014).

How advisory boards are used to meet certification and accreditation standards

An added motivation for academic programs or schools to work with industry advisory boards is meeting accreditation and certification standards.

Learning center certification standards

University learning centers seeking certification through the National College Learning Center Association (NCLCA) must utilize an advisory board and describe how the board is used (Learning Center of Excellence Application, 2018). The importance of advisory boards in support of learning centers is described in Craig’s learning center research (2018).

Business education accreditation standards

There are several ways business schools can use advisory boards to meet Association to Advance Collegiate Schools of Business (AACSB) accreditation standards, which are described in the 2020 Business Accreditation Standards document provided on the AACSB website. Throughout the published standards, for example, there are multiple directives that describe the need for external stakeholder input, namely, in developing a strategic plan, as described in standard 1.1 (p. 23); in monitoring its progress towards meeting goals, as described in standard 1.2 (p. 23); and in reviewing assurance of learning processes, as described in standard 5.1 (p. 46).

Additionally, schools seeking AACSB accreditation must demonstrate they are collaborating with “a wide variety of external stakeholders...[and] that informs...theory, policy, and/or practice of business,” and systems must be in place to support external stakeholder engagement in a way that enhances the school's reputation, as described in standard 8.2 (pp. 56-7).

AACSB also includes standards to ensure that business schools are contributing positively to society in ways that are supported by external stakeholders "through [their] core activities," as described in standard 9.1 (p. 62).

Engineering education accreditation standards

Engineering is another specialized program that has recognized the importance of advisory boards for at least twenty years. Proceedings from an engineering education conference in 2001 noted that with the Accreditation Board for Engineering and Technology's (ABET's) shift to outcomes-based assessment at that time, industry advisory boards could do much more than simply ensure that programs were keeping up with industry trends; they could also be used to directly support the accreditation process (Schuyler et al., 2001).

ABET standards that were met, at least in part, through the use of the advisory boards included providing evidence that students were being effectively advised and monitored and providing evidence that the curriculum was being evaluated on a regular basis (Schuyler et al., 2001).

More recently, the use of advisory boards in ABET-accredited programs is now mandated. Engineering technology programs seeking ABET accreditation must use an "advisory committee" as part of the curriculum review process, as outlined in criterion 5 (ABET criteria manual, 2021).

Aviation education accreditation standards

The Aviation Accreditation Board International (AABI) also recognizes the importance of academic and industry collaborations, as expressed in its accreditation standards.

Current standards for "relations with industry" are outlined in the 2023 AABI Criteria Manual for associate degree programs (Criteria 2.9), baccalaureate degree programs (Criteria 3.9), and graduate degree programs (Criteria 4.9).

Similar to standards expressed by other specialized accrediting agencies, aviation programs seeking accreditation through AABI must show "evidence of a relationship between the aviation program and... practicing professionals in the industry" (pp. 13, 23-24, 34).

Additional program-specific criteria related to industry relations are described in expectations that apply to aviation management degrees and aviation maintenance degrees (pp. 37-38); aviation electronics (pp. 38-39); aviation studies (p. 39); flight education (p. 40); aviation safety science and air traffic control (pp. 41-42); and unmanned (sic) aircraft systems (pp. 43-44).

Unlike ABET standards that require an advisory committee, AABI standards do not. In order to meet the "maintain relations with industry" requirement, though, an unknown number of

AABI-accredited institutions have elected to utilize an industry advisory board to help them fulfill many of these industry relations requirements.

Commonplace but under researched

As evidenced by the survey results described in this article, all respondents reported that their aviation program has an industry advisory board. Even though aviation advisory boards are common, they have not been well researched.

A similar observation was made by learning center researchers Zahra et al. (2011), who describe learning center advisory boards as being "…ubiquitous…, [yet] we do not know much about the role of academic advisory boards in promoting the teaching and learning mission of business schools" (114).

Based on this literature review, the same statement could be made about collegiate aviation programs. As common as they appear to be, there is much to learn about how they operate, how they are structured, and how they most effectively contribute to successful program outcomes.

Methodology

This exploratory study's purpose, then, was to determine how faculty and program directors perceive how their aviation program utilizes industry feedback and, if they have an advisory board, how it operates. A survey was determined to be the best way to collect this information.

Survey design and data collection

This research utilized a qualitative research approach to determine the faculty's perception of their industry advisory boards (IAB). Qualitative studies support answering more open-ended questions and are most appropriate in exploratory case studies (Creswell & Poth, 2018; Yin, 2018). Additionally, an article from Soderlund et al. (2017) that researched technical communication programs was influential in the survey design. Additional questions were provided for faculty who work within programs without advisory boards, though no responses indicated that was the case.

This exploratory case study will support and improve the reliability of these questions through transferability and dependability as described as key aspects by Yin (2018). Upon completing the data collection, as described next, the validity of the data was ensured through bracketing. Once the data was collected, each researcher evaluated, coded, and found themes of the data independently before meeting together to find overlap. Researchers focused first on the Likert scale type questions to find themes, then the open-ended questions, and then combined both to overarching themes of the data. By asking similar types of questions in different manners, this serves as triangulation (Yin, 2018).

In administering the survey, an informational message with the survey link explained the purpose of the survey, assured participants that the survey was anonymous and voluntary, and noted that the ideal survey participant would be anyone who had an awareness of "how your aviation program works with industry professionals."

Not knowing the extent to which aviation programs work with advisory boards, the first survey question asked how the aviation degree program stays apprised of current events and issues in the aviation industry. An answer that indicated they *did not* have an advisory board would take the respondents to questions that asked why they did not have an advisory board, how they otherwise receive industry feedback, and if they would be interested in receiving best practices guidance in terms of developing an industry advisory board.

If the answer to the first survey question indicated that the program *did* have an advisory board, additional multiple-choice survey questions asked how long it had been in existence, how membership on the board is determined, details about the roles and demographics of board members, how board members are on-boarded, the main purpose of the advisory board, the extent to which board members interact with students, the size of the board, how often the board meets, and whether the meetings take place in person, virtually, or a combination of the two.

Additional open-ended questions followed, asking how board feedback is shared, whether or not program or curriculum changes have been made as a result of board recommendations, what are the benefits and challenges of having a board, what advice they would give others who want to start an advisory board, what strategies have been most successful in sustaining productive working relationships with board members, and how satisfied the respondent was with the advisory board and how it functions.

In determining how to administer the survey, we initially felt as though limiting one response from each institution would be ideal. That would prevent a program from submitting multiple responses and skewing the results. Also considered was that respondents from the same program might have answers that contradicted each other. One option considered was to accept only the first respondent's answer, but the decision was made to accept all responses. Inconsistent answers might provide additional and potentially useful information. Ultimately, there were no restrictions placed on how many responses could be received from the same degree program.

In order to reach as many collegiate aviation program representatives as possible, the survey was distributed via email to all University Aviation Association (UAA) and Aviation Accreditation Board International (AABI) members. Additionally, both researchers posted the survey link to their LinkedIn feeds. The survey remained open for six weeks.

Results & Discussion

A total of 31 surveys were submitted; 12 were incomplete, and 19 were complete. The 19 completed survey responses came from 19 unique institutions, and all the respondents indicated they had an advisory board-type group.

Note: Because all respondents indicated they had an advisory board, that might indicate that programs without one declined to participate in the survey, suggesting a potential flaw in how it was administered. Alternatively, the use of advisory boards in aviation programs may be even more pervasive than the researchers considered. Either case suggests opportunities for further research.

Names of the advisory groups

In addition to the “advisory board,” other names used for the working groups included industry advisory committee, program advisory committee (PAC), workforce council, and aviation partnership council. As the survey results are discussed in this section, all of these groups will be referred to as an IAB for Industry Advisory Board.

Programs represented

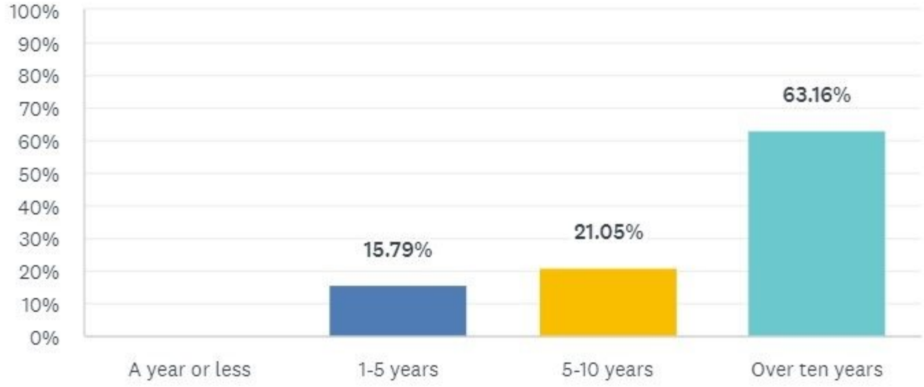
Respondents indicated they represented aviation degree programs that included flight, maintenance, and aviation management, with some respondents indicating they represented more than one program. Seventy-four percent of the respondents indicated that their programs were accredited by AABI.

History and composition of the IAB

When asked how long their IAB had been in existence. Over 60% stated that it has been over ten years, while just over 20% stated that their IAB is between five and ten years old, and 15% were between one and five years old. No respondents indicated that their IAB was less than a year old. The general makeup of the board members was also requested. All IABs included working professionals in the aviation industry; almost 90% of them included graduates of their program, and just over 70% included retired aviation industry professionals. Additionally, 31% of IABs include program faculty, and 26% include program staff. No respondents indicated that current students serve on their IAB.

Figure 1

How long the Industry Advisory Board has been in existence



Industry representation and other membership requirements

In all cases, IAB members are selected based on ensuring that a variety of industry specialties are represented. The majority of respondents stated that industry representation is a key component of the IAB makeup. One respondent also explained that "they also need to be supportive of our programs and faculty." When requested to provide information regarding the qualifications or requirements of board members, several respondents indicated that a portion of members are alumni, with up to 50% reporting that was a requirement. Only one respondent indicated specific requirements, including the number of years of industry experience required (seven) and the education background requirement (undergraduate degree). Outside of a general goal to have a variety of industry representation, respondents of this survey did not report more formal requirements of board members.

Onboarding and diversity

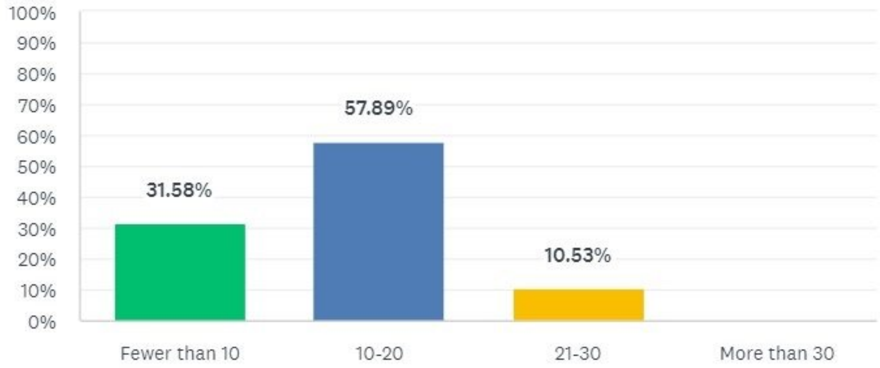
Survey responses indicated that IABs did not have a structured onboarding process for new members. Survey respondents also reported no demographic considerations when selecting IAB members. However, improving diversity was mentioned by 26% of the respondents when they were asked what they would like to see change regarding the IAB at their institution.

Size of the IAB

The size of IABs can vary from institution to institution. However, nearly 60% of the respondents stated their IABs were between 10 and 20 individuals. Slightly over 30% have less than 10 members, and about 10% have more than 30 members. Most respondents indicate that keeping the board smaller, especially initially, is a key to success. Unfortunately, there was no explanation provided as to why they felt this was desired. This would be something to explore in future research.

Figure 2

Size of Industry Advisory Board

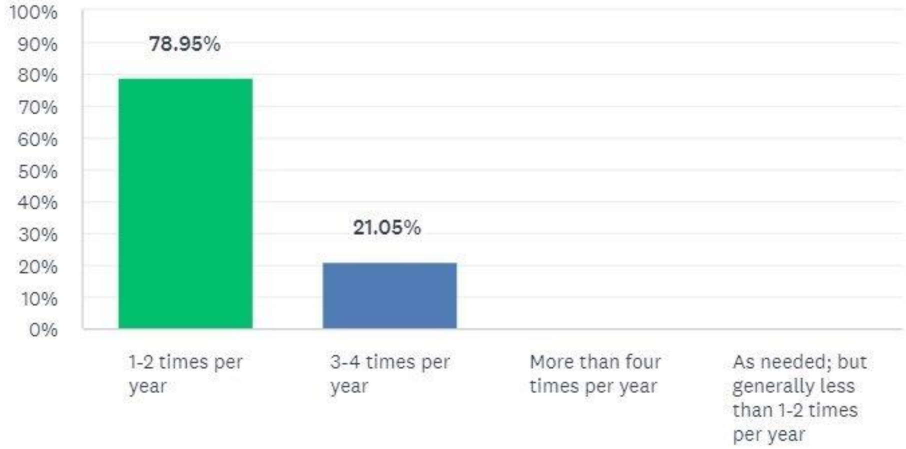


Frequency of meetings and meeting format

Almost 80% of IAB meetings take place one or two times per year, and the remaining 20% meet three to four times a year. No respondents indicated the IAB meets more often than four times per year, nor did they respond that the IAB only meets as needed. The most common meeting format (63%) is a mixture of in-person and virtual. Always meeting in person or always meeting virtually were much less common at 21% and 16%, respectively.

Figure 3

How often the Industry Advisory Board meets



Purposes and benefits of an IAB

Almost 90% of respondents expressed satisfaction with having an IAB, with statements expressing that having an IAB is “one of the best things we’ve done” and “the people are wonderful.” The top three main purposes of the IAB included networking opportunities (95%), curriculum development (79%), and internship or employment opportunities (74%). Respondents stated that the curriculum was improved by “staying connected with industry trends” and “learning how to mirror curriculum with industry best practices.” One respondent combined the importance of curriculum management with financial benefits by stating that their IAB helped keep “the curriculum current, [which] provides new opportunities for our students and increases the potential for scholarships and other funding sources.” These sentiments were echoed by several respondents, as well as addressing the fact that the aviation industry has “developing needs” and that having a healthy relationship with industry partners helps ensure programs are aware of the need for change.

Additional responses included scholarships (32%), resource planning (26%), and financial or budgeting factors (11%). Almost all respondents indicated that learning about current industry perspectives was a primary benefit of having an IAB, and they also found a benefit in hearing about future trends and how industry trends could impact the curriculum. One respondent stated that “[h]aving current industry professionals to guide how we run our academic program” was a great benefit to their degree program.

Tangible influence on program and curriculum

Based on these survey responses, IABs that support aviation programs have direct impacts on program changes and/or curriculum development. A large majority of respondents (84%) confirmed that their IAB influenced the program and/or curriculum.

Interactions with students

For those whose IAB members interacted directly with the students, we asked what that interaction looked like. Two respondents did not complete this question, which led the researchers to believe that their IABs did not interact with students. Additionally, one respondent indicated they were not sure, and another stated that student interaction was minimal unless the interaction was unrelated to the IAB. The remaining 16 respondents listed classroom speakers, career fairs, and mentorship. Fewer than 40% of the responses indicated small group networking events, mock interviews, and feedback on student work. An open-ended response prompted one respondent to share that their IAB members attend social gatherings, and another stated that their IAB members attend open house events for new students.

Challenges of an IAB

While IABs provide many benefits to aviation programs, maintaining an effective IAB includes a number of challenges. About half of the cited challenges relate to the difficulty in finding good times for everyone to meet and the amount of time it takes to plan and conduct board meetings. Respondents understood that having strong members of the aviation community means that they are busy professionals and schedules are challenging to coordinate, which led to respondents stating that the frequency of meetings is insufficient. While virtual meetings have become more commonplace to accommodate busy schedules, consistent attendance remains a concern, with one respondent stating that “[e]ven using virtual means are difficult because of the number of schedules we are juggling.”

Other responses indicated challenges with board members understanding the advisory nature of their roles, keeping the meetings on task, and helping board members understand that changes in university systems take much longer than they do in the industry. Some respondents expressed concern that members of their IAB “think that we are obligated to take their advice and implement it into the curriculum” and do not fully understand the advisory role versus having “oversight of the program.” Change sometimes happens slowly in academia, and one respondent expressed that IAB members can be impatient when their suggestions cannot be immediately implemented.

Suggested improvements

Even though about 90% of respondents are happy about having an IAB, approximately 30% indicated that they would like to see IAB improvements made. When asked what they would like to see change regarding their program and board interactions, the statements relating to challenges were reinforced. Respondents indicated that their curriculum needed additional industry perspectives and meeting topics should “include more interaction regarding curriculum." Additionally, improved communication and structure of the board meetings to be "better organized" were mentioned. Three comments indicated the need for more demographic diversity of the board members.

Sustaining a productive relationship

The most cited strategy to sustain a productive relationship with IAB members was related to communication, such as holding more frequent meetings, holding more in-person meetings, keeping IAB members informed of how their feedback was implemented, or explaining why it was not. Communication regarding the agenda well in advance of the meeting was also listed as a key strategy for a productive relationship, as well as inviting board members to other events on campus beyond the board meetings.

Advice to other programs who want to form an IAB

Respondents were also requested to provide advice to aviation degree programs who were considering developing an advisory board. Many suggestions were shared about how to best form an IAB, and in all cases, forming an IAB was considered to be a good idea despite the challenges. Initial suggestions suggested in this survey included starting small, finding an "influencer" in the industry or a "champion" of the degree program in order to recruit more board members, focusing on diversity across industry perspectives and university experience, and setting clear goals.

Conclusion & Future Research

The foundational work of this exploratory research appears to confirm the pervasiveness of IABs in collegiate aviation programs and validates the many benefits they provide to faculty, staff, and students in terms of curriculum development, program guidance, networking, professional development, and the sharing of industry news. This research also confirms that the use of IABs in other areas of study, namely engineering, information systems, business, and technical communication, can provide us with guidance in terms of how to learn more.

As we learn more through additional research and the further consideration of research from other disciplines, we may be able to suggest how to utilize board expertise most effectively, how to maintain effective communication, how to manage expectations, and how to find solutions to common logistical challenges.

Additional research directedly related to this initial article should include a multi-case study review, research validating the pervasiveness of IABs in collegiate aviation, and research that focuses on the perspectives of IAB members. In order to draw more accurate conclusions and overcome the limitations of having such a low response rate in this phase of research, it will be important to find ways to increase the sample sizes in our future research. The results of the planned research are expected to provide the additional information needed to allow for the creation of a comprehensive best practices guide that collegiate aviation programs could use in establishing and working with industry advisory boards for the benefit of their programs.

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Appendix A

Survey Questions

For the purposes of this survey, an Industry Advisory Board (IAB) refers to any formal grouping of aviation industry professionals whose purpose is to serve the university for the benefit of the aviation department, program, or school. Often, these groups have different names, such as Advisory Committee, Industry Workgroup, and the like.

1. How does your aviation degree program learn about current events and issues in the aviation industry? (Select all that apply)
    a. Faculty or staff members have current industry experience through their work or consulting efforts.
    b. Faculty or staff members regularly attend off-site or remote professional conferences or meetings that provide opportunities to interact with industry representatives.
    c. Faculty or staff members regularly participate in on-site or local professional development meetings or workshops that provide opportunities to interact with industry representatives.
    d. Faculty or staff members read about current industry topics and events via print or online publications such as industry newsletters or press releases.
    e. Faculty or staff members receive regular feedback and information from an Industry Advisory Board or similar entity.
    f. Other
2. Open-Ended: Please elaborate on any of the above responses.

3. Do you have an IAB?
    a. Yes
    b. No

<u>If yes, IAB Questions:</u>

4. Knowing that your program utilizes an IAB or similar entity, what is it called within your organization?
    a. Industry Advisory Board
    b. Industry Advisory Committee
    c. Other: ____
5. As an estimate, how long has your aviation degree program had an IAB?
    a. A year or less
    b. 1-5 years
    c. 5-10 years
    d. Over ten years

6. Open-Ended: How purposeful is your board member selection? Are there key areas that you attempt to ensure are well represented, including but not limited to gender, race, levels of education, and experience within the aviation industry (pilots, management, operations, maintenance, etc.)?
7. What is the make-up of your IAB? (Select all that apply)
    a. Alumni
    b. Work in Aviation Industry
    c. Has previous community and professional ties with the board administrator
    d. Faculty
    e. Students
    f. Staff
    g. Works for a company partnered with the university in a cross-campus program
    h. Other: ______
8. Open-Ended: What is your process to bring in new board members? Are there specific requirements for them to join (experience, qualifications, financial, etc.)?
9. What would you say is the main purpose of your IAB? (Please select up to 3 purposes)
    a. Financial/Budget
    b. Curriculum development
    c. Resource Planning
    d. Internship/Employment Opportunities
    e. Scholarships for students or graduates
    f. Networking Opportunities
    g. Speaker Series
    h. Other: ________
10. If your IAB members interact directly with students, how so?
    a. Mentorship
    b. Providing feedback on student work
    c. Small group networking events
    d. Career Fairs
    e. Mock Interviews
    f. Other: ______
11. How many members serve on your IAB on average?
    a. Fewer than 10
    b. 10-20
    c. 21-30
    d. More than 30
12. How often does the board meet?
    a. 1-2 times per year
    b. 3-4 times per year
    c. More than four times per year

    d. As needed
13. How do they meet?
    a. Always in person
    b. Always virtually
    c. A mixture of in-person and virtually
14. Open-Ended: How does the feedback from the board get shared, and to whom?
15. Open-Ended: Have you made changes to your program or curriculum as a direct result of IAB?
16. Open-Ended: What would you say are the benefits of having an IAB?
17. Open-Ended: What would you say are the challenges of having an IAB?
18. Open-Ended: What advice would you give to an aviation degree program that is considering starting an advisory board?
19. Open-Ended: How satisfied are you with your IAB and its function?
20. Open-Ended: What strategies, if any, have you found successful in sustaining a productive relationship with advisory board members?
21. Open-Ended: Would you like to see something regarding your program and board's interactions change?

<u>If No, Non-IAB Questions:</u>

22. If your aviation degree program does not have an IAB, could you elaborate as to why not?
    a. Not required
    b. Too complicated
    c. The program is too small
    d. No one is able to take the lead
    e. Too much faculty turnover
    f. Unknown
    g. Other (explain)
23. Open-Ended: Who do you solicit feedback from with regard to industry information in order to guide your degree program?
24. Open-Ended: How do you otherwise ensure that you are incorporating industry feedback into your program?
25. Open-Ended: Can you provide an example where you sought out industry feedback in order to guide your degree program and what was the result?
26. Would a best practice guide for aviation degree program IABs positively influence your decision to develop an IAB?
    a. Yes
    b. No

Collegiate Aviation Review International

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Book Review #1

12-14-2023

Book Review *Women of Color in the Aviation Industry*

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Women of Color in the Aviation Industry takes a gallant position on the contemporary state of Diversity, Equity, and Inclusion (DEI) initiatives within U.S. aviation through the lenses of several women of color working in the industry. The exploration of their experiences as women of color aviation professionals provides a compelling and nearly irrefutable backdrop for the many inequities, challenges, and barriers they face as a function of their race and/or gender. The author contends these inequities persist because aviation entities are engaged in “performative DEI” measures rather than reflecting upon their extant structures and systems to ascertain what is causing the inequities and why minoritized groups, particularly women of color, are adversely impacted. The text strives to encourage readers to critically reflect upon the reason(s) why minoritized groups, specifically women of color, continue to have low participation rates in an industry that proclaims to be committed to DEI to make a more just workforce. Such a conundrum is explored through semi-structured interviews with numerous women of color who hold various aviation positions. This approach was most apt to obtain first-person accounts of the challenges women of color and presumably other minoritized groups experience. Consequently, industry leadership can leverage these experiences and focus efforts on making equity-centric change instead of concerning themselves with remaining on the “right side” of DEI. The author provided several robust examples of how current DEI efforts, coupled with a lack of reflection, do more harm than good because they propagate a “diversity that maintains Whiteness.” Combined with the six commonly used controlling images, these examples help refute the state of social equity many believe the U.S. is in. The primary messages are written to make it easy for the layperson to understand, but the text falls short of providing actionable recommendations leadership can implement. Despite this limitation, the text may benefit a broad audience, especially for leadership overseeing commercial airlines, government, and collegiate aviation programs. Further, the experiences described have some transferability to sectors and industries external to aviation, meaning they can be incorporated within the public, private, and nonprofit sectors to enhance public administration and social policy to make a more just society.

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Introduction

Women of Color in the Aviation Industry provides enthralling insight into the lived experiences of minoritized women, referred to as women of color by the author, working in various capacities within the aviation industry. From the very first pages of the text, a critical analysis of the multifarious reasons why U.S. aviation continues to be an underrepresented industry for minoritized groups, especially for women of color, despite intentional outreach efforts to these groups through the implementation of robust Diversity, Equity, and Inclusion (DEI) initiatives within the industry (Morrison, 2023). The rather stagnant participation of minoritized groups and in particular, for women in aviation, should be of concern for industry, government, and congressional leadership because it is indicative there are other factors at play that are deterring these groups from entering and/or making it less appealing to remain in aviation (Lutte et al., 2023). This text sounds an alarm that has been silenced by the aforementioned leadership for years, drawing attention to these factors and explicitly outlining what they are while situating their gravity, frequency, and impact on minoritized groups through profound examples. These issues are rooted in inequity and are irrefutable through interviewees' quotes that highlight the issues in real-time from the lenses of those experiencing them. If history has shown us anything, it is that the issues stressed are not new, as evidenced by 20% of women comprising the aviation workforce (Lutte & Morrison, 2022) or the 0.5% of airline pilots identifying as Black women (Sisters of the Skies, 2022). Such abysmal participation rates further underscore the aviation industry is not doing enough to cultivate and maintain a diverse or inclusive workforce predicated upon equity.

The text aims to forcibly encourage the industry, specifically its leadership, to consider actions that will result in lasting change rooted in equity to rectify systems of inequity (Morrison, 2023). These long-standing systems hinder minoritized people, especially women of color, from pursuing careers in aviation and/or make them more inclined to leave the industry. This text contains insightful definitions, nuanced concepts, and prominent examples that orient readers to visible and invisible issues extant within aviation. These issues are salient to the industry's ability to develop a diverse workforce across various sectors, within government (e.g., the Federal Aviation Administration [FAA]), and even aviation higher education, bolstering its utility and applicability within public administration contexts. Given the worsening of the workforce demand shortage across a variety of occupations that is impacting the aviation industry currently, the spotlight this book places on the inability of aviation entities to effectively retain and recruit minoritized groups and, in particular, women of color, casts a large, dark shadow on contemporary efforts made by the industry to foster an inclusive workforce through DEI. As such, the salience of this scholarship is inexplicable because it forces industry leadership to critically reflect upon their lackluster DEI efforts and ascertain how they can utilize the guidance encompassed within this text to initiate change that will redress inequity at the root (e.g., within systems, processes, protocols, etc.). The text also places a new sense of gravitas on the current state of DEI and its impact on the diversification and development of the aviation workforce. This gravitas accentuates the urgency that if swift and intentional action is not taken by industry leadership to make concerted efforts to abandon their over-reliance on performative measures and instead focus on removing systems that propagate inequity, then minoritized participation rates will remain low and potentially worsen the industry's continuity, productivity, and longevity (Johnson, 2023b; Lutte, 2021; Lutte et al. 2023).

Book Summary

The core theme of this book is equity, specifically racial and gender, both of which have not received the attention necessary within the aviation industry by its leadership. The current DEI efforts made by the industry, specifically within commercial airlines, are performative at best, which is a crucial argument Morrison repeatedly makes throughout the book (Morrison, 2023). This performative diversity does more harm than good because it is ingenuine, provides entities with an "out" to lean on when challenged about their efforts to make a more equitable workforce, and does nothing to address the root issues outlined by the interviewees. It is not enough for entities, Morrison contends, to create DEI-centric programming and/or participate in heritage months (e.g., Black History or Pride Month) because these activities alone do not address the institutional structures that hinder the recruitment and retention of minoritized groups (Morrison, 2023). This type of counterfeit diversity allows organizations to circumvent the critical self-reflection that serves as a precursor to foster change that would positively impact the experience(s) of minoritized groups.

The purpose of the book is two-fold. The first is that it seeks to engage readers in meaningful self-reflection to ascertain why DEI efforts challenge an industry that proclaims to be developing an equitable workforce. This leads to the book's second purpose: to encourage readers to question how DEI efforts within aviation continue to diminish the lived experiences of women of color (Morrison, 2023). Such encouragement and reflection were facilitated through the qualitative methodology underpinning the book. Semi-structured interviews allowed for rather informal conversation with the interviewees, all women of color who held various positions (e.g., administration, pilots, collegiate aviation students, etc.) within the industry. Consequently, there was skillful leverage of the lived experiences of these women to explain their challenges and barriers in great detail. This enables readers to place themselves in the shoes of the minoritized women and begin to understand the incessant bouts of workplace inequity they face daily. An exciting element of the methodology was the author's positionality statement. The author listed and explained all her identities, recognizing the innate privilege and power that is incumbent on these identities. This shows a deep understanding of reflexivity and aids in not obscuring or diminishing the lived experiences of those interviewed.

The book consists of four chapters plus a conclusion; these chapters are prefaced by the positionality statement, which serves as an example and reminder for readers to think about their identities, positions, power, and privileges before immersing themselves in the shoes of several women of color. The first chapter provides a brief history of U.S. aviation. It comprises several sub-chapters meant to contextualize many of the claims proffered in the text that center barriers for minoritized groups. The second chapter furnishes an assessment of recent DEI efforts in the industry and outlines the reliance on performative diversity measures aviation entities have, which ultimately maintain "Whiteness" (Morrison, 2023). The third chapter explores how women of color are misidentified or presumed to be out of place within aviation spaces through the use of controlling images and other stereotypes (Morrison, 2023), both of which maintain oppression. The fourth and final chapter details the importance of community and coalition building for women of color pursuing aviation careers (Morrison, 2023). It identifies critical elements (e.g., mentorship and advocacy) that aid in retaining these women. The conclusion coalesces the prominent points made in the previous chapters, acknowledges the emotional and general labor the book is predicated upon, and provides a parting reminder to readers of what they can and ought to do to assist in making U.S. aviation a more socially just workforce.

The Four-Pronged Trident: A New Tool to Combat Inequity

Strengths

This book possesses four innate strengths, aiding in its applicability and relevance to the aviation industry regardless of the sector, audience age, or identity. The first is the provision of critical definitions of the terms “women of color” and “minoritized” (Morrison, 2023, pp. 37-38). These definitions are integral to the text and necessary for readers to understand the nuances of social, racial, and gender equity within the context of aviation. By including definitions for such contentious terms, the author supplies the reader with a detailed description of the terms and breaks them down in a palatable way for readers of any age, race, education or knowledge level, and/or experience with DEI. It also allows the reader to situate the terms properly in the context of aviation and their respective lives. Such explicit definitions are necessary when discussing something as polarized and politicized as DEI to help convey what is precisely meant by the author rather than leaving it up to the readers’ interpretation, especially since DEI and social justice are not partisan issues.

The second strength is the explicit overview of barriers women of color encounter as aviation professionals. Morrison specified three main challenges women of color faced in the industry due to race and gender. These challenges include 1) Extant diversity efforts reinforcing the status quo, 2) Assumptions about what position they hold because of their identities as women of color, and 3) The need to find mentors and advocates in the industry (Morrison, 2023). The aforementioned are derived from the lived experiences of these minoritized women; these challenges stem from inequity that is embedded within institutional structures that are upheld by “diversity that maintains Whiteness” (Morrison, 2023, p. 50). More importantly, the inclusion of these challenges connotes the U.S. is still not in a place of social or racial equity (Berry-James et al., 2020; Evans & Feagin, 2012) despite the professional advancements made by minoritized groups in sectors of the U.S. workforce such as aviation (Johnson, 2023b; Lutte, 2021; Lutte et al. 2023). The belief the U.S. is in a state of (social, racial, or gender) equity is a false maxim that intentionally ignores the lived experiences of minoritized groups, as cited by the women in the book.

The third strength is the discussion of controlling images and elaboration on how they are used by organizations to oppress minoritized women through stereotypical narratives. According to Morrison (2023), controlling images are designed to be harmful and maintain the subordination of minoritized groups and have become a tool to support the minoritization of Black, Indigenous, and Persons of Color (POC). The six controlling images outlined include the

Mammy, Matriarch, Jezebel, Angry Black Woman, Illegal Immigrant, and Model Minority. The author leverages the profound narratives connected to the images to convey the historical and contemporary social, racial, and gender inequity that exists in the U.S. It is through these examples that explanations are rendered to detail how controlling imagery is used to oppress women of color, perpetuate stereotypes, and most importantly, elucidate how the stereotypes translate or connect to positions in aviation. This benefits readers who may not be familiar with aviation operations or occupations in the industry, helping them understand the gravitas of the controlling images and their incumbent narratives as they pertain to aviation.

The fourth strength is the methodology that undergirds the book, specifically the methods used to garner the unique insight, perspectives, and experiences upon which the text is built. The qualitative nature and use of semi-structured interviews provided a platform for interviewees to furnish their experiences within aviation (Tracy, 2019). This allowed the author to learn of ethical issues negatively impacting the retention and recruitment of women of color from women who possessed experience with the issue. Additionally, the conversation-based interviews provided information and pertinent context on issues that cannot be easily observed or efficiently accessed (Tracy, 2019). In the context of this book, being a woman of color in the aviation industry is not something that can be easily observed nor accessed, and as the literature suggests (Johnson, 2023b; Lutte et al., 2023; Lutte & Morrison, 2022; Murillo, 2020), is characterized by challenges rooted in equity, packed with negative emotion(s) that go unvocalized, and cause some to suffer in silence. The suffering and frustration were conveyed eloquently through the numerous quotes embedded throughout the chapters, providing a first-person account of the experience in the women's own words. Thus, the interview method selected empowered interviewees to share detailed accounts of inequity and explain their feelings about the actions or inactions that resulted in challenges, barriers, and/or unfavorable outcomes (Johnson, 2023b; Tracy, 2019).

Approaching Minimums, Going Missed

As a Black Male in aviation and higher education, I hesitated to critique this excellent book because I did not want it to undermine or overshadow the profound testimonies within or labor contributed by the interviewees. This text highlights many issues within the DEI efforts made by the aviation industry, specifically by commercial airlines. The notions of racial and gender equity are contentious constructs for U.S. society when they should not be (Gooden, 2015; Johnson, 2023a), and for the aviation industry, they are "pressure points." The book does an excellent job defining, explaining, and situating these pressure points in the aviation context so even the lay reader can understand them. It provides an opportune platform to apply pressure on the industry, specifically industry leadership, to force them to reflect and make the changes necessary to redress the inequities, inhospitable work environments, and sexist policies/practices at the micro-, meso-, and macro-levels. However, the book falls short and misses a keen opportunity to apply pressure on individuals with the power to execute change because it "goes missed after reaching minimums" by not providing specific action items or solutions that industry leadership can reference, adopt, implement, and execute.

Morrison leveraged several prominent examples to detail the challenges, barriers, and inequities women of color within U.S. aviation experience on a day-to-day because of their race and gender. This facet of the text is a cornerstone in its relevance and intentionality to address performative DEI measures; it is a core strength of and reinforces the book's other strengths, accentuating the salience of the equity-centric messaging within. The messaging places the onus of DEI, particularly equity advancement back on organizations rather than the minoritized individuals. This makes sense because the organization is the entity that needs to change, and the type of change that must occur for equity to be sustained can only be facilitated from the top down despite the best efforts of employees working from the bottom up. That said, I have two critiques.

The first is that the text "approaches minimums, but goes missed." This means the text guides the audience down to minimums via an apt methodology that effectively utilizes the equity-centric messaging through the definitions, challenges, and controlling image narratives but falls short (i.e., goes missed) due to a lack of action items aviation entities and their leadership ought to implement to improve minoritized experiences. Although the book states early on that it will not provide specific solutions to the issues outlined within (e.g., the inadequate DEI efforts of organizations and institutions, which impacts the recruitment and retention ability of minoritized individuals), it does not necessarily detail any tangible analytical tools (e.g., racial equity analyses) that an aviation organization or institution could implement to begin redressing the many salient issues discussed. The second critique is that the conclusion was robust but could have been strengthened had a call-to-action been used to culminate the text. This call-to-action could have been brief, consisting of one to three recommendations for policy or practice individuals, institutions, and organizations could follow to guide them on their reflective DEI journey, which would have been a profound way to coalesce the high-level takeaways embedded within the conclusion and reinforce prominent points made in each chapter, thereby strengthening the conclusion holistically.

Conclusion

As a Black male aviation professional with theoretical knowledge and robust experience in various sectors of aviation as well as government, I find the book and its primary message resonate on many levels. Equity, especially racial and gender, are constructs that many organizations and their leadership claim to be committed to, value, and uphold, but policies, the composition of leadership, and budgets demonstrate otherwise. Part of the reason for this stems from the fact that equity (in all its contexts) is a nervous area for organizations, entities, and leadership. This is evident and especially prominent within government entities, as adduced by Gooden (2015) and Johnson (2023a; 2023b); the aviation industry is not exempt from this. Rather than engaging in reflecting right the wrongs resulting from systemic inequity, commercial airlines prefer to promulgate the "right image" via participation in heritage months and brandishing trending hashtags on their social media accounts (e.g., BLM; Morrison, 2023) so they can be on the "right side" of DEI to circumvent cancel culture.

There is an assertion in the book made by one of the interviewees that some industries in the U.S. do not want or wish to be diverse, and aviation fits that mold. This is why equity within aviation has been more of a touted self-proclamation rather than fact rooted in tangible, substantive action. Such a bold statement is supported by the testimonies of others and is accentuated by the staggering statistics that detail the historical and contemporary participation rates of minoritized groups in aviation (Ison, 2010; 2018; Ison et al., 2016), particularly for women of color in the industry (Lutte & Morrison, 2022). Performative diversity has enabled the aviation industry, its leadership, and, to an extent, the FAA to rest on their laurels when implementing changes that will remove inequities in the system to foster DEI and improve the retention and recruitment of minoritized groups. This is because performative diversity is convenient for organizations to use (Morrison, 2023), specifically those within commercial aviation. Rather than abandoning performative diversity tactics that display a façade of counterfeit diversity and reflect upon the institutional structures, there is a staunch effort to remain “on the right side of history.”

The subsequent actions and implications of performative diversity use in conjunction with controlling imagery are meant to placate the masses, which results in aviation organizations suffering financial hits and bad media press. Such an ideological approach to DEI has paid dividends for these entities as they remain in a positive light for the public and reap the benefits of appearing to care about DEI without ever truly implementing change within their organization. However, this approach bestows an additional burden upon minoritized individuals who carry too much already simply because of their racial and gender identities (Morrison, 2023). The extra labor being referenced here is emotional in nature; instances of emotional labor and fatigue are commonplace in the public sector (e.g., higher education) due to a lack of recognition, praise, and/or compensation for leading DEI initiatives in the workplace (Fulton et al., 2019). Women of color in aviation already experience an immense amount of emotional labor because the field is coded as both White and male (Morrison, 2023), which is compounded when they are passed over for promotions or upgrades they are qualified for, expected to lead specific initiatives without additional compensation (Thomas, 2019), or have their experiences and/or voices diminished or ignored, respectively, by leadership, yet are expected to just “go with the flow.”

Morrison’s scholastic experiences within education, public policy, and women’s, gender, and sexuality studies, coupled with her practical expertise leading program assessment for the Center for Aviation at The Ohio State University, provide a compelling backdrop about the state of equity within the aviation industry. Based on the types of aviation professionals interviewed and the issues explained stemming from their lived experiences, the target audience for this book is broad. However, the aviation industry, government, and congressional leaders could benefit most. This benefit stems from the multitude of perspectives brought forward by the candid testimonies of the women of color interviewed about how and why DEI initiatives do not and have not been reflective of their experiences. There is much to learn from these experiences, and if the goal is to create an equitable and just industry, then policy and practice improvements must be derived from these experiences. That said, the text also applies to collegiate aviation program leadership, who are charged with educating, training, and funneling graduates into the aviation industry. Many of the inequities detailed within the industry also exist in higher education, specifically within collegiate aviation programs. These inequities were adduced by some of the female students interviewed. Given the college-to-career pipeline between higher education and industry, this text may be helpful for educational leaders in reflecting upon and redressing equity issues within their programs to increase minoritized students' retention, recruitment, and matriculation.

The core theme of this book, gender equity, intersects strongly with racial, social, and educational equity because of the multifarious and unique identities individuals working in aviation and society possess. Such a profound intersection serves as a robust call-to-action for those involved (i.e., allies and non-allies) to begin questioning if they are part of the problem or part of the solution and if the latter, then action needs to start with individuals reflecting upon ways the system or environment they work in has been and continues to be a part of the problem. In my opinion, this book, at a minimum, should be a required read for leaders of any aviation entity because of its content, readability, relevance, impact, and transferability to other fields, both internal and external to aviation. Further, because of the excellent messaging within the text, it should be a mandatory read for commercial airlines and collegiate aviation programs seeking to make an intentional change that is equity-centric and will be sustained instead of engaging in performative ploys or counterfeit diversity. To be most effective within educational institutions, I recommend it be assigned to all aviation faculty, staff, and administrators as a summer reading assignment and have it be a focal point of discussion during the first department meeting before the commencement of the new academic year. This provides everyone with ample time to read the book, reflect upon it, and be prepared for the uncomfortable conversations that are necessary to foster the change(s) outlined in the book to not only enhance the experiences of minoritized groups but also move the equity needle in a meaningful way. In other words, higher education institutions striving to “equity walk” instead of solely relying on “equity talk” (Johnson, 2022) should strongly consider mandating the book be read as a part of personnel professional development and, if necessary, incentivize reading the book, because I belief the text is that instrumental in the quest for equity within aviation and education.

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Business Aviation Days: Mentorship and Partnership

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Business aviation is a vital component of the U.S. economy, growing at a double-digit rate year-over-year since the pandemic, and offers many outstanding career opportunities for collegiate aviation program graduates. Despite the opportunities available, many students may need to be made aware of the options available in business aviation due to a lack of exposure compared to other aviation industry sectors. This paper describes one university's efforts to advance understanding of business aviation through a new annual multi-day conference that has produced new partnership and mentorship opportunities that greatly benefit students and industry alike.

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Introduction

As defined by the National Business Aviation Association, business aviation uses small aircraft, including jets, propeller-driven planes, and helicopters, for business transportation (National Business Aviation Association [NBAA], 2021). Business aviation is a significant driver in the U.S. economy, contributing over $128.3 billion to the U.S. GDP in 2018, supporting over 1.1 million jobs, and contributing to economic development in every state (NBAA, 2021). With the ability to fly into over 5,000 noncommercial public-use airports in the U.S., not served by airlines, business aviation efficiently links communities and economies of all sizes, minimizing travel time and increasing productivity. According to Fortune Magazine's Top 50 "World's Most Admired Companies" list, 98 percent of the companies featured utilize business aviation; however, only three percent of U.S. business aircraft are flown by Fortune 500 companies; the other 97 percent are flown by non-Fortune 500 companies and non-profit organizations such as universities, hospitals, firefighters, law enforcement, and government agencies with the vast majority of flights seating no more than six people and flying less than 1,000 miles (NBAA, 2021). The pandemic caused an increase in new users in the business aviation market, as people avoided large crowds in airports and commercial flights by flying business aircraft, stimulating growth in business aviation (CAE, 2023). The U.S. business aviation sector has become the largest in the world and continues to expand. In the first half of 2022, there were 15.2% more business aviation departures in the U.S. than during the same period in 2019 (Smith, 2022).

Business Aviation Careers

Business aviation offers many job opportunities, including pilot, aircraft maintenance technician, scheduler, dispatcher, safety manager, operations manager, aircraft sales and marketing, aircraft and insurance brokerage, and Fixed Base Operator (FBO) managers. A director or chief pilot often manages business aviation organizations, supervising flight operations and ensuring regulatory compliance. Proponents of business aviation cite career benefits such as job variety, better company culture, personalized service, direct passenger interaction, less seniority-based career progression, and improved work-life balance compared to the airlines. Industry experts predict the business aviation industry will grow by 18% in the next ten years, requiring 66,000 new professionals to support the expanding fleet (CAE, 2023). Over the next decade, business aviation will provide numerous career opportunities, but hiring professionals need help as they compete with the airlines for talent.

Recruiting Challenges

Airlines use their scale to recruit pilots regularly on collegiate aviation campuses with much success. Before the pandemic, air carriers had over 175 career pathway agreements with over 70 higher education institutions in the U.S. (Lutte & Mills, 2019). The number of agreements has increased post-pandemic due to rapid airline hiring. Recruiting young talent for business aviation is challenging due to competition from airline career pathway programs with a more substantial presence on collegiate aviation campuses than business aviation since there is no equivalent business aviation presence scale. Furthermore, airlines have recently increased pay by as much as 50% to meet pilot hiring demand and raised benefits such as higher employer contributions to 401(k) retirement accounts (McMillin, 2022).

A study by NBAA found that pilots who left business aviation for airlines did so due to better pay, schedules, retirement benefits, and job stability (NBAA, n.d.). To address this issue, experts suggest improving communication and education on the value proposition of a business aviation career, emphasizing the perceived better quality of life for pilots compared to those in the airline industry. To improve communication and education, business aircraft operators may partner with aviation technical schools, colleges, and universities to establish mentorship and internship programs to encourage young people to join the industry. Experts also suggest that some hiring standards, particularly for Part 135 commercial operators, may need to be revised to consider the quality of training and experience, not just numerical flight hours. The shortage of aviation professionals goes beyond pilots and includes maintenance professionals as well (McMillin, 2022).

Business Aviation Days

Auburn Business Aviation Days (ABAD) was founded in 2019 by alums of the School of Aviation who are leaders in the business aviation industry and have been recognized as NBAA Business Aviation Top 40 Under 40 Award Recipients for their industry efforts. ABAD is a multi-day conference held on the main campus of Auburn University and at the Auburn University Regional Airport (KAUO), which is only three miles away from the campus. It showcases the career opportunities and benefits of business aviation for both professional flight and aviation management students. Attendees include Part 91 and 135 flight departments, national associations advocating for business aviation, and various industry participants such as pilots, aircraft manufacturers, aircraft sales brokers, and insurance brokers. Auburn Business Aviation Days aims to expand the pool of future professionals, elevate career opportunities, and increase industry awareness beyond classrooms through networking and partnerships.

Networking is crucial to building connections between students, faculty, and industry participants in business aviation. By connecting with others, young professionals gain valuable insights into various companies, their fleets, work cultures, and operating environments. This knowledge helps them make informed career choices and relationships with potential employers. Networking also provides opportunities to learn about career opportunities that may not be publicly advertised and develop highly valuable professional references in the business aviation industry. Auburn Business Aviation Days networking may lead to new mentorships, providing advice on career opportunities, progression, overcoming challenges, and internships to gain practical experience. Mentors encourage students to join professional organizations like NBAA and Women in Corporate Aviation (WCA) to further connect young professionals with the larger community of business aviation professionals.

Creating partnerships between business aviation organizations and higher education institutions is crucial for many reasons. These collaborations bridge the skills gap by tailoring the curriculum to real-world applications and aligning it with the needs of the industry. As a result, graduates are job-ready and possess the knowledge, skills, and attitude required for business aviation. Partnerships established through ABAD also provide opportunities for business aviation members to get involved with higher education through career fairs, industry advisory board service, and funding scholarships and innovative research that improves the quality of education for the future business aviation workforce. Faculty members who may have limited professional exposure to business aviation can now apply their subject matter expertise in the context of business aviation in class, such as fatigue risk management in global business aviation in a human factors course, teaching the human factors content to be learned, but also the reinforcing the career opportunities in business aviation.

ABAD has grown since its inception in 2019. The program was held virtually in 2020 due to the pandemic and saw a spike in attendance in 2021 following the resumption of in-person events. A summary of ABAD organizational participants is provided in Table 1.

Table 1

Summary of Participating Organizations, Auburn Business Aviation Days

Year	*Business Aviation Organization*		
2019	Alfa Insurance AT&T Avilution Blue Origin Chick-Fil-A Chicken Salad Chick Coca-Cola Cox Enterprises, Inc. Eagle Aviation, Inc.	Encompass Health FedEx Corporate Fidelity Financial Trust Flightworks, Inc Grande Aviation Gulfstream Aerospace JetAVIVA Medical Properties Trust NBAA	NetJets OGARAJETS Quest Diagnostics Richards Aviation Sonic Tools Textron Aviation The Home Depot Universal Avionics
2021	Aflac Inc. AirMed Axis Jet B&C Aviation Blue Origin Buford Construction Chick-Fil-A Columbus Regional Airport El Reno Airport Authority Embraer Encompass Health FedEx Corporate Georgia Crown Distributing Co. Global Air Charters Harbert Management Corporation	Hill Aircraft InFlight Law Jet It Jeteffect JetEx Medway MMA Aviation MRO Insider NBAA Northern Jet Management OGARAJETS Peco Foods, Inc. Pioneer Aviation Management PNC Bank	Premier Private Jets Regions Bank SMI Sonic Tools Southern Company Textron Aviation Tuscaloosa Regional Airport Unmanned Safety Institute West Star Aviation Women in Corporate Aviation XO Global XOJET Aviation Zimmer Biomet Solutions
2022	Clay Lacy Aviation Contour Flight Management Dillard's, Inc Duke Energy Eagle Aviation, Inc.	JetEdge International Jeteffect Kennedy Aviation MMA Aviation MRO Insider NBAA	Solairus Aviation Southern Company Southern Sky Aviation Textron Aviation The Home Depot The Procter & Gamble Co.

Encompass Health
Flexjet
FlightSafety International
FMS Aerospace
Global Air Charters
Aerospace
Hill Aircraft
JetAVIVA
NetJets
Nor-Wes, Inc.
OGARAJETS
Phoenix Air
Group/Unmanned
Piedmont Jets
PNC Bank
Progress Rail
Thoroughbred Aviation
Tuscaloosa Regional
Airport
Wheels Up
Women in Corporate
Aviation
XOJET Aviation
Yonderwest

The Alabama Business Aviation Association (ALBAA) starts the Business Aviation Days event with a charity golf tournament. This tournament serves as a fundraiser for ALBAA student scholarships and allows industry professionals and students to network in an informal environment. The event continues with the welcome reception hosted by the School of Aviation on the main university campus. Throughout the next several days, there are various events to promote diversity and explore trending career topics in the business aviation field. Women in Corporate Aviation hosts a breakfast for aviation program students, and afterward, students attend multiple speaker panels focused on trending business aviation topics. Faculty members welcome industry participants who serve as guest speakers in their classrooms, examining course topics through the lens of business aviation. Students get to meet business aviation executives at the Executive Experience reception on the second evening of ABAD. Students can explore the industry's offerings through a static display of corporate aircraft of all sizes that support a variety of business aviation missions. At the networking fair, students can connect with recruiters from participating organizations. A sample schedule of events for ABAD is provided in Table 2.

Table 2
Sample Schedule of Events, Auburn Business Aviation Days

Day 1	Day 2	Day 3
- Scholarship Fundraising and Networking Golf Tournament (Robert Trent Jones Golf Trail, Grand National) - Welcome Reception (Main Campus)	- Women in Business Aviation Breakfast (Main Campus) - Speaker Panels (Main Campus) - Executive Experience Reception (Auburn University Regional Airport)	- Classroom Guest Speakers (Main Campus) - Aircraft Static Displays and Networking Fair (Auburn University Regional Airport)

Figure 1

An industry representative speaks to aviation students.

Note. Photo courtesy of Art Morris III.

Figure 2

Students and industry representatives at a reception.

Note. Photo courtesy of Art Morris III.

Figure 3
Students tour a business aviation test aircraft during the static display.

Note. Photo courtesy of Art Morris III.

Figure 4
Static display aircraft at Auburn University Regional Airport.

Note. Photo courtesy of Art Morris III.

Positive energy and momentum sparked by ABAD can lead to new partnerships that expand the business aviation workforce. These partnerships have created new student internships and mentorships and a heightened understanding of the rewarding career prospects available in business aviation. Furthermore, several business aviation organizations are contemplating the creation of new pilot career pathway programs, with insurance underwriters participating in discussions that aim to reassess pilot hiring criteria, placing greater emphasis on the quality of training and experience rather than just numerical flight hours, similar to many airline career pathway programs.

Auburn Business Aviation Days is made possible through generous sponsorships at various levels. The revenue generated from corporate sponsorship fees covers the program's expenses. Preparation for the following Auburn Business Aviation Days starts soon after every conference, taking into account industry professionals, students, and faculty feedback. The event is held in autumn when the weather is more predictable than the unpredictable spring weather in southern regions. The scheduling committee must consider avoiding overlapping with other business aviation events like the National Business Aviation Association Business Aviation Convention & Exhibition (NBAA-BACE) and Citation Jet Pilots Owner Pilot Association conference and ensure not to plan the ABAD during the week of a home football game when hotels and conference services are limited.

Conclusion

Auburn Business Aviation Days has been an immense help to Auburn's aviation students by providing them with access to new partnerships and mentorship that foster career opportunities in the business aviation industry. These new relationships have resulted in students finding employment in world-class business aviation organizations, helping students and industry alike.

For information regarding Auburn Business Aviation Days 2023, please visit aub.ie/ABAD.

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Collegiate Aviation Review International

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The Use of Industry Advisory Boards in Aviation Degree Programs-An Exploratory Case Study

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This exploratory case study was presented at the UAA Conference in Fall 2023 to share initial findings. The researchers sought to determine the level of aviation degree programs utilizing Industry Advisory Boards (IAB), what their makeup looks like, and what the meeting schedule constitutes. Additionally, the researchers questioned the participants as to the challenges and opportunities they would like to see improved within their programs. The initial conclusion is that there is no significant consistency amongst different IABs, including the name of the group. However, some consistency existed in that many respondents indicated seeking more diversity and effective planning techniques.

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Introduction

Currently, accreditation organizations such as the Aviation Accreditation Board International (AABI) require industry feedback as a metric for accreditation completion. However, what this feedback looks like has not been researched, nor is any guidance readily available for aviation degree programs. In fact, there is very little research in relation to industry partnerships with aviation degree programs in any context. This research quickly found that the term used to describe this industry partnership was inconsistent and included labels such as industry advisory board (IAB), working groups, and industry advisory committees. This paper uses IAB as an all-encompassing term to represent these groups.

As there are no formalized best practices or guidance on how to utilize industry feedback, these researchers proposed the following research questions:

RQ1: How do aviation degree programs incorporate industry feedback?
RQ1a: What is the current makeup of the individuals and organizations in which aviation degree programs seek this feedback?

RQ2: How are IABs used in aviation degree programs?
RQ2a: What level of formality exists when organizing and working with the IAB?

Methodology

This exploratory study's purpose, then, was to determine how faculty and program directors perceive how their aviation program utilizes industry feedback and, if they have an advisory board, how it operates. A survey was determined to be the best way to collect this information. This survey was sent out to all current University Aviation Association (UAA) members in addition to being posted to both author's LinkedIn profiles.

Survey design and data collection

The survey was created using Survey Monkey, and survey questions were influenced, in part, by the published work of researchers Soderlund et al. (2017), who sought to learn more about advisory boards in communication programs.

Respondents were initially asked about their institution's usage of an IAB, with the intent to ask different questions based on this response. The questions then asked about their own IAB, if they had one, including the make-up, size, duration, frequency of meetings, benefits, and challenges they currently face. If no IAB existed, questions focused on the reasons why they did not in order to understand potential barriers to creating an IAB. The survey was distributed via email to UAA and AABI membership distribution lists and posted on both researchers' LinkedIn accounts.

Results & Discussion

The preliminary results included benefits such as industry connections, budget support, resource planning, and scholarships. Industry connections included curriculum development or management, networking opportunities for both students and faculty and internship and employment opportunities. Faculty who are aware of their IAB involvement seem to have an overall positive perspective of their involvement. However, there does seem to be some concern as it relates to communication and timelines.

Survey participants expressed concerns or suggestions regarding communicating the objectives of the board, the results of the board's feedback, and even keeping the meetings on track. Additionally, getting the IAB members on campus and ensuring a strong relationship is built with each member was mentioned frequently. Lastly, a big push was to ensure diversity of the board not only from a demographic perspective but also as far as industry representation, associations with the university, and types of positions within various organizations.

Conclusion, Discussion & Future Research

This initial exploration serves as a launching point for additional research to fill in the many gaps in information. The ultimate end goal is to publish a best practice guide for aviation degree programs that will help aviation programs implement and utilize IABs effectively; however, more information must be gathered first. This research team seeks collaborators from other institutions who would like to work with us on a multi-case study of specific IAB usage. During the conference presentation, one audience member asked if there were specific criteria to join, and outside of being associated with an aviation degree program, there is not. The research team wants to get a holistic view of current IAB usage in order to give the most comprehensive best practices that are backed by research.

Aviation programs reside in a wide range of colligate structures, and the more information we can gather from wide-ranging perspectives, the more value we can add to research findings. Being able to research IABs from different-sized programs, programs from different areas of the country, programs located in public and private universities, and programs offering two-year and four-year degrees would provide us with the optimal mix of diverse perspectives.

Following that phase of research, the team plans to focus on IAB members and their motivations for serving on an IAB. We also want to identify the barriers that prevent IAB members from serving in their full capacity. Questions will explore why board members serve. What do they appreciate from their institutions? What challenges do they face? What would make it easier for them to engage?

The final phase of research will result in the publication of a comprehensive guide for best practices for aviation advisory boards. Longer-term research might also include follow-up exploration that examines the effectiveness of the best practices guide and ongoing revisions, should those be warranted.

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Development of a Safety Performance Decision-Making Tool for Flight Training Organizations

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The purpose of the research was to transform a non-statistical risk score model composed of 12 Safety Performance Indicators (SPIs) into a predictive safety performance decision-making tool. The model uses what-if scenarios to evaluate how changing controllable input variables affect the level of operational risk within the system. These risk score outputs provide a keen insight into the overall level of risk within the organization.

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Introduction

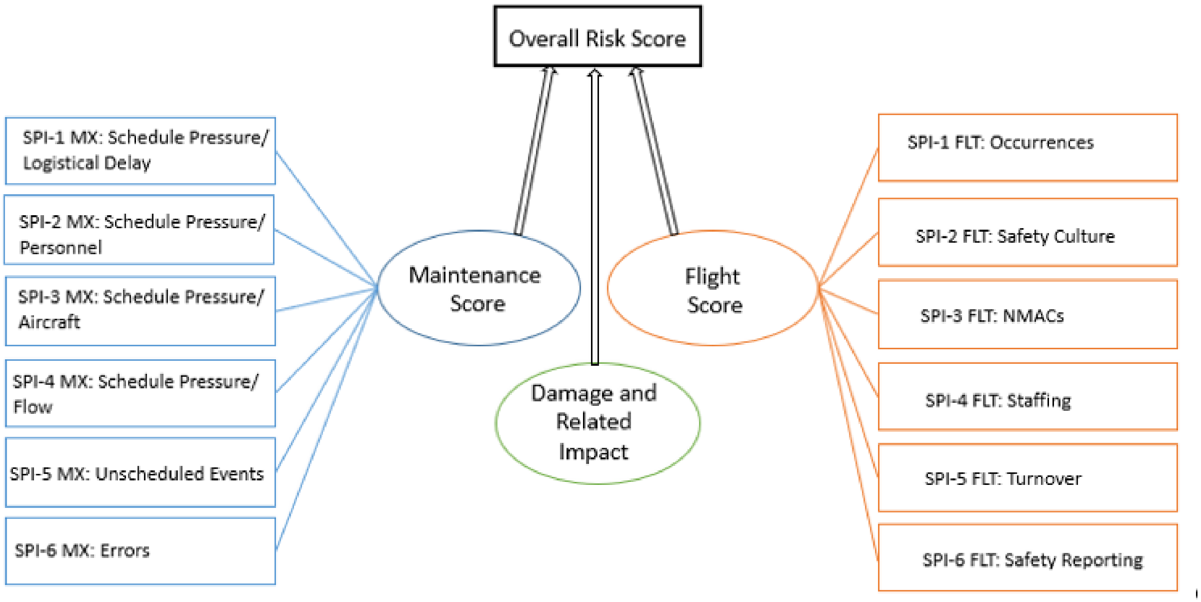
With the introduction and requirement of a Safety Management System (SMS) in aviation, the focus is shifting from traditional forms of reactive data collection and analysis toward approaches and techniques that bolster and improve the effectiveness of the organization's SMS. A vital portion of this process includes the development and implementation of safety performance indicators (SPIs). ICAO Doc 9859, Safety Management Manual, and ICAO Annex 19 define an SPI as a data-driven safety constraint used for observing and evaluating an organization's safety performance. SPIs are used to monitor and mitigate known safety risks to elicit corrective action before an adverse event occurs (Pierobon, 2016).

The purpose of the research was to create and validate a safety performance decision-making tool to transform a non-statistical model composed of 12 SPIs determined by Anderson, Aguiar, Truong, Friend, Williams, and Dickson (2020) to be most indicative of flight risk-specific to flight schools, into a predictive, safety performance decision-making tool. The model uses what-if scenarios to evaluate how changing controllable input variables affect the level of operational risk within the system, portrayed within the model as the risk score outputs. These risk score outputs provide a keen insight into the overall level of risk within the organization.

Theoretical Framework

The theoretical framework driving the research was founded upon a model developed by Anderson et al. (2020); a sequential, mixed-method design study was conducted, including a qualitative data collection and analysis phase, followed by a quantitative data collection and analysis phase. Subject Matter Experts (SMEs) in maintenance and flight operations selected the appropriate Safety Performance Indicators (SPIs). Once the appropriate SPIs had been selected, formulas were developed to quantify each selected SPI based on monthly operational data, see Anderson et al. (2020). Expert elicitation was used to establish inter-rater reliability for the assessment of SMEs' evaluations. Twelve SPIs were selected for use within the model. SPIs 1-6 MX encased the maintenance side of operations; SPIs 1-6 FLT includes indicators relevant to flight operations (see Figure 2).

Figure 2.
Diagram of the non-statistical model developed by Anderson et al. (2020) composed of SPIs and associated indicators.



Methodology

Monte Carlo simulation methodologies were used to build a safety decision-making tool based on SPIs determined by Anderson et al. (2020) to represent flight risk within flight training organizations to evaluate predictive, what-if scenarios to evaluate how the variations to controllable input variables affect the risk score outputs indicating the level of risk posed to safe operating conditions. The study used the quantitative method to convert a non-statistical model into a safety decision-making tool, utilizing Monte Carlo simulation; this simulation will allow to run what-if scenarios to assess how modifications to the controllable input variables impact the level of operational risk within an organization’s flight department. The use of Monte Carlo simulation is valuable in accommodating the uncertainty and variability of 22 uncontrollable input variables, as the only controllable input variables are the four listed below. The remaining variables were subject to uncertainty.

- The number of full-time instructor pilots,
- The number of aviation maintenance technicians available,
- The number of active flight students, and
- The total number of aircraft in the fleet.

Population and Sample

The target population to which the model generalizes is large, collegiate 14 CFR Part 141 flight training organizations within the United States operating under the specifications defined by the FAA within Title 14 of the Code of Federal Regulations Part 141 (FAA, 2017). The sampling data used to determine the probability distributions of the uncontrollable input variables within the model consisted of two years of operational data from both flight and maintenance operations dating from September 2017 to September 2019 for a flight training organization in the United States.

The study conducted simulation runs based on the true operational ranges specified below to simulate the range of operating conditions possible within a flight training organization with varying levels of resources with respect to personnel (Aviation Maintenance Technicians and Instructor Pilots), students, and aircraft:

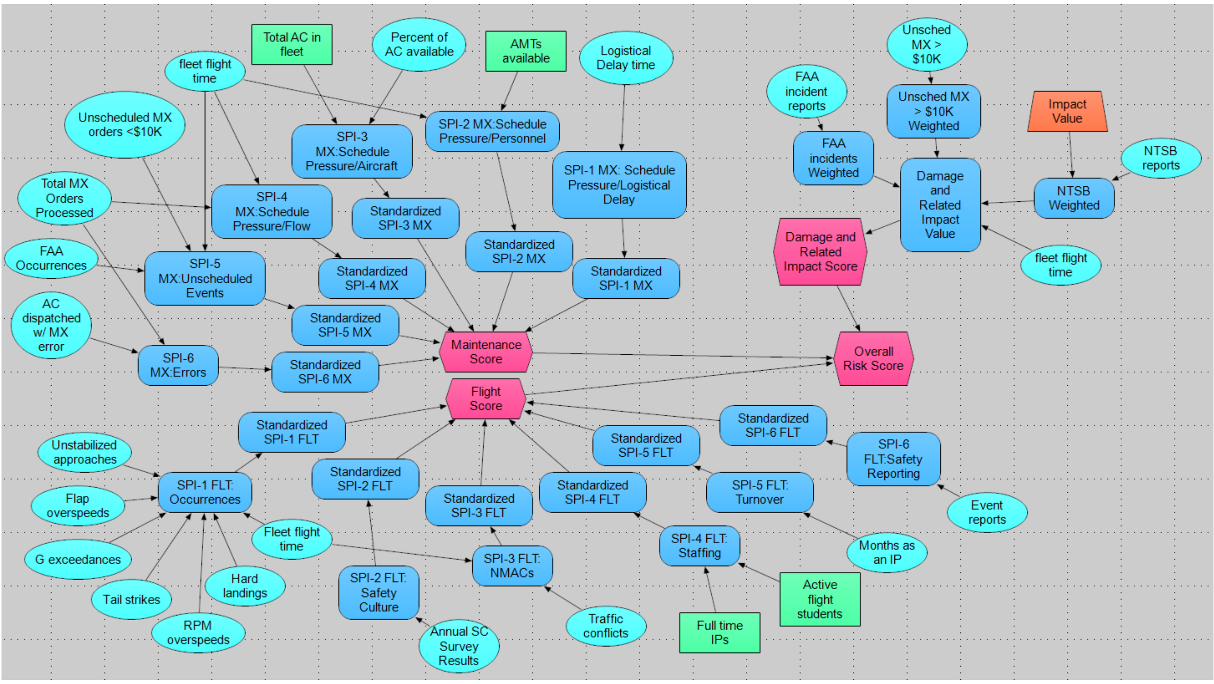
- Aviation Maintenance Technicians available: 14-35
- Aircraft available: 50-82
- Full-time Instructor Pilots: 100-200
- Active Flight Students: 335-1300

These ranges were selected because they reflect the higher and lower operational limits of the sample data drawn for the organization. The model could easily be adapted for use in any flight training organization with flight data acquisition abilities and an operational SMS.

Design of the Mathematical Model

Figure 2 depicts the structural definition of the model used for the Montecarlo simulation. The green-colored squares depict the four controllable input variables. The light blue-colored ovals represent the 22 uncontrollable input variables specified as probability distributions supplying an array of random values to the model based on probability distributions drawn from the raw data sample. The blue rounded rectangular boxes are SPIs and depict calculation nodes producing the results of the model. The orange trapezoid represents a value that is input as a constant. The impact value was input into the model as a constant value of 1, indicating no damage or injuries incurred was selected for the purpose of this study. The pink hexagons represent the risk score output variables.

Figure 2.
Structural definition of the model.



Data Analysis Approach

Various trials of the model were completed using different random number generator seed values to confirm the output of the simulation, which produced consistent results across trials. The distributions of the output variables were compared with descriptive statistics from simulation to simulation to demonstrate consistency. ANOVA testing was used to assess the model's reliability (Hoyt, 1941).

The study simulated 10,000 trials for a given scenario with manipulated controllable input values. The mean, standard deviation, maximum, and minimum values were used to determine the impact on either the flight or maintenance score and the overall risk score. ANOVA testing was also used to test for differences across sets of results (Hoyt, 1941). A Generalized Sensitivity Analysis (GSA) (Spear & Hornberger, 1980) was conducted to analyze the results of the What-if Scenarios.

Results

Validity Testing

Three verification scenarios of the model were conducted to test validity. The shape of the distributions of the uncontrollable input variables from all the verification trials is the same as the distributions drawn from the raw data sample (see Appendix A).

Monte Carlo Simulation Results

To demonstrate the utility of the safety performance decision-making tool for real-world use, the controllable input values used to generate the what-if scenarios within the Monte Carlo simulation model were determined based on permutational variations of ranges of normal operating conditions specific to flight training organizations. These permutations were conducted by varying the level of personnel, including available aviation maintenance technicians and instructor pilots, as low, moderate, or high. Similarly, permutations of resource expenditures, including aircraft available and active flight students, were also varied by degree of low, moderate, or high.

Each trial was computed using the specified controllable input variables, capturing the output in a separate results matrix for each trial. This allowed the model to compute the risk score outputs, depicted as probability results, for the controllable input values given for each simulation trial (see Table 1).

Table 1
Controllable Inputs for What-if Scenarios 1, 2, 3, and 4

What-if Scenario	Controllable Input	Value	Description
Scenario 1	AMTs	14	Low personnel, high expenditures
	Aircraft	82	
	IPs	100	
	Students	1300	
Scenario 2	AMTs	22	Moderate personnel, high expenditures
	Aircraft	82	
	IPs	138	
	Students	1300	
Scenario 3	AMTs	35	High personnel, low expenditures
	Aircraft	50	
	IPs	200	
	Students	335	
Scenario 4	AMTs	35	High personnel, moderate expenditures
	Aircraft	56	
	IPs	200	
	Students	681	

Note. AMTs = Aviation maintenance technicians; Aircraft = Aircraft available; IPs Full-time instructor pilots; Students = Active flight students.

What-if Scenario 1 was conducted with the intent of simulating a scenario where personnel, including AMTs and instructor pilots, are low, but the necessary expenditures, including aircraft and active flight students, are high. Based on the specific controllable input variables used, results indicated What-if Scenario 1 had the highest mean value for the Overall Risk Score and the Flight Score, indicating a higher level of operational risk associated with conditions where a flight instructor capacity of 100 full-time instructors is not adequate to meet the demands of 1300 flight students, increasing the level of operational risk, specifically in the flight department. (See Table 2).

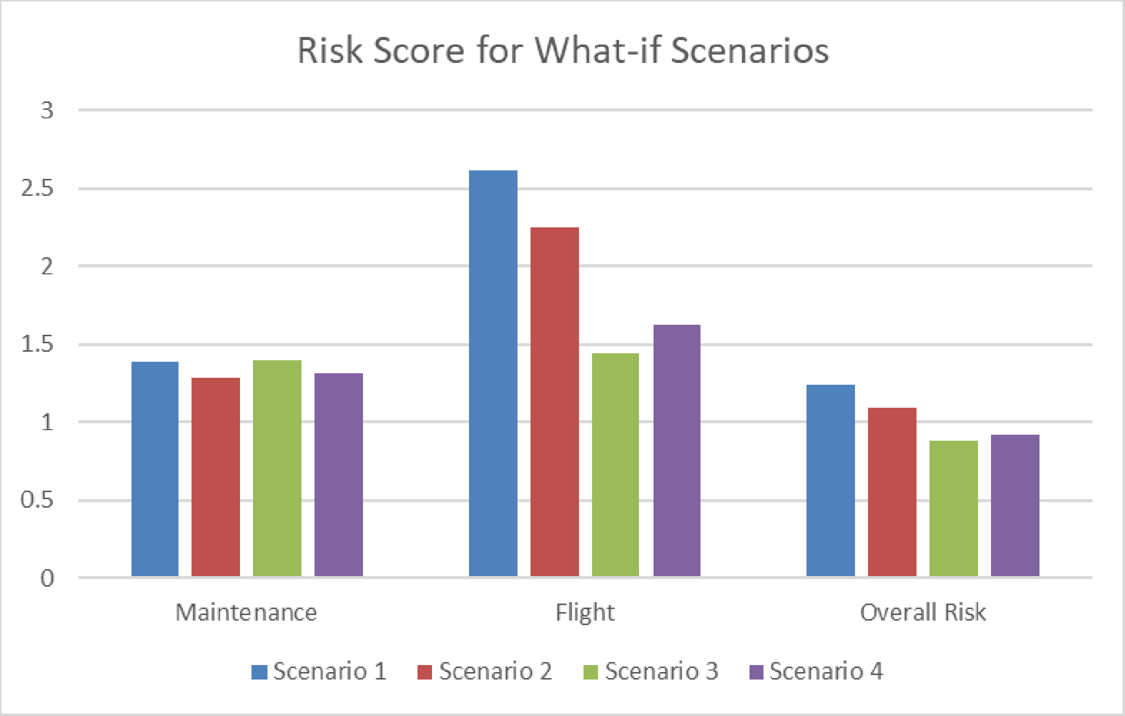
What-if Scenario 2 was conducted with the intent of simulating a scenario similar to What-if Scenario 1; however, in What-if Scenario 2, the number of personnel, including AMTs and instructor pilots, was increased from 14 AMTs to 22 and 100 instructor pilots to 138. The expenditures, consisting of aircraft and active flight students, remained high. Intuitively, both the Flight and Maintenance Scores improved from What-if Scenarios 1 to 2, indicating a reduction in the level of operational risk by closing the gap between the number of instructor pilots and active flight students, reducing the Overall Risk Score. The lowest Maintenance Score occurred in What-if Scenario 2, indicating the ratio of 22 technicians to 82 aircraft is optimal (See Table 2).

What-if Scenario 3 was conducted with the intent of simulating a scenario opposite of What-if Scenarios 1 and 2, where there is an excess of personnel and a low level of expenditures, including a low number of flight students and few aircraft available. The excess of personnel drove the Maintenance Score up from the previous trials, indicating an excess of available maintenance technicians increased the level of risk within the maintenance department, negatively impacting safety. The Flight Score was the lowest in What-if Scenario 3, indicating a 1:1 ratio of instructor pilots to flight students is optimal. Of all four What-if Scenarios, What-if Scenario 3 had the lowest Overall Risk Score (*M* = 0.8845, *SD* = 0.0955), indicating the safest level of operating conditions compared to the other three trials (See Table 2).

Finally, What-if Scenario 4 was conducted with the intent of simulating a scenario similar to What-if Scenario 3; however, the aircraft was increased from 50 to 56, and the number of flight students was increased from 335 to 681. The amount of available personnel remained high. Within What-if Scenario 4, the Flight Score increases from 1.441 to 1.621, indicating the level of risk increases as the gap between the number of personnel and expenditures closes (See Table 2).

Results indicate the lowest risk score for maintenance occurred in What-if Scenario 2, where the level of personnel was moderate, yet expenditures, including aircraft and students, were high. The lowest risk score for flight occurred in What-if Scenario 3, where the level of personnel was high, and expenditures were low. The Damage and Related Impact Score remained constant throughout; thus, no visual comparisons were made. What-if Scenario 3 also had the lowest Flight Score and Overall Risk Score, indicating operations are at the lowest level of risk when the level of personnel is high, yet the number of expenditures remains low. Although intuitive, this demonstrates the real-world utility of the model (see Figure 3).

Figure 3.
Maintenance, Flight, and Overall Risk Score What-if Scenario Comparison Chart



Discussion and Conclusions

Results of the four What-if Scenarios indicate the lowest risk score for maintenance occurred in What-if Scenario 2, where the level of personnel was moderate. Yet, the number of aircraft and students was high. The lowest risk score for flight and lowest overall risk occurred in What-if Scenario 3, where the level of personnel was high, and the number of aircraft and students was low.

Changes to the controllable input variables are reflected by variations to the risk score outputs, demonstrating the utility and predictive potential of the safety performance decision-making tool. The risk score outputs produced from the what-if scenarios could then be utilized by safety personnel and administration to make more informed safety-related decisions based on the mean level of operational risk predicted without expending unnecessary resources. The lowest Overall Risk Score occurs in What-if Scenario 3, indicating this flight training organization should strive to maintain an appropriate balance of high personnel to low expenditures to maintain the optimum level of operational safety.

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How to Embrace Artificial Intelligence in Aviation Education?

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Artificial intelligence (AI) has recently made significant advancements in the field of writing. It is now being used in academia to improve writing skills, generate research papers, and automate various skills such as critical thinking and problem-solving. This research allows aviation education professionals to understand the use of AI as a writing tool and the different options available in the market, how to incorporate and encourage AI content in the classroom and learn ways of staying ethical.

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The advent of technological advancements has instigated apprehension within various educational domains. Educators have adeptly devised strategies to integrate tools such as calculators, Wikipedia, Grammarly, and similar resources into andragogical practices, enhancing the overall educational experience. Rather than perceiving artificial intelligence (AI) as a problem to be solved, it is prudent to think of AI as the vanguard of learning, demanding high comprehension, incorporation into curricula, and active engagement within the classroom milieu. In this perspective, AI emerges as a novel educational asset that students should be encouraged to scrutinize critically and employ judiciously, ushering in a progressive paradigm for education.

Evolution of Aviation Education

The evolution of aviation education has undergone a significant transformation over the years, driven by advances in technology and a growing reliance on technological tools within the field. This evolution encompasses traditional teaching methods, the increasing dependency on technology, and the crucial balance between human expertise and technological integration. Brady et al. (2001) concluded that aviation students perceive aviation education as "a means of solving problems that occur in the course of life, and learn better in discussion groups than in lecture" (p. 8). Nevertheless, aviation education has traditionally relied heavily on classroom-based instruction and hands-on training. Traditionally, instructors deliver lectures and facilitate group discussions, and students learn through textbooks, flight simulators, and practical flight training. These methods provide a strong foundation in aviation fundamentals, safety protocols, and aeronautical knowledge. In addition, these methods allow students to achieve the required aviation skills required to succeed in flight training (Albelo et al., 2022).

In recent decades, there has been a substantial shift toward technology-driven education in aviation and flight training (Dincer, 2023). For example, the shift has been propelled mainly by incorporating virtual reality as a mode of flight instruction (Thomas et al., 2021; Thomas et al., 2022) and advanced computer systems in modern aircraft (Baral, 2013). Aviation students now need to master complex flight deck interfaces, navigation systems, and flight management computers. Consequently, aviation education has integrated technology-rich tools and platforms to train students effectively. Therefore, maintaining an optimal balance between human expertise and technology is paramount in aviation education. While technology enhances safety and efficiency, it does not replace the need for skilled pilots and aviation professionals. The instructor must emphasize the importance of fundamental airmanship, decision-making skills, and technological proficiency.

Current Challenges Related to AI

The incorporation of AI into aviation education is accompanied by intricate challenges encompassing several domains. These challenges can be categorized into three overarching areas: integration, pedagogical considerations, and expectations management.

Regarding integration, the adoption of AI in aviation education necessitates fostering critical thinking through the strategic use of technologies that combine innovative teaching methods. AI could be used to enhance flight simulators and scenario-based learning in the curriculum. These simulations can expose students to a wide range of challenging scenarios, encouraging them to think critically and problem-solve in real time. It is important to emphasize that AI is a tool to support decision-making, not a replacement for human expertise (Jarrahi, 2018). Encourage students to evaluate AI recommendations critically, understand their limitations, and exercise human judgment.

In terms of pedagogical considerations, redesigning curricula to incorporate AI elements is multifaceted. Educators face the intricate task of balancing integrating AI-driven content with conventional aviation training methodologies. To optimize learning outcomes, faculty members may necessitate supplementary training to effectively teach AI-related topics and proficiently employ AI tools in their teaching practices (Rivers & Holland, 2022). Moreover, the customization of educational content to suit the individualized needs of students presents an ongoing challenge. AI's potential for facilitating personalized learning experiences demands careful consideration and adaptation of andragogical approaches (Rivers & Holland, 2022).

When it comes to managing expectations, it is imperative to establish realistic outlooks regarding AI's capabilities within aviation education. Discerning the limits of AI while establishing attainable educational objectives is paramount (Zhang et al., 2023). Furthermore, ethical considerations become salient as AI plays an increasingly pivotal role in training, mainly when deployed for critical decision-making exercises and student performance assessments (Zhang et al., 2023). The alignment of the education provided with the evolving requirements of the aviation industry is another dimension of expectation management. Ensuring that graduates possess the requisite skills and knowledge employers demand is a pivotal objective.

Key Takeaways

First, the instructor is responsible for sending the context in which AI can and would be used in the classroom. One aspect of emphasizing the context in which AI could be used is to help the students understand its limitations. While AI is a powerful tool, it can still provide incorrect information and may not always be readily accessible. Conversely, setting the context of AI usage in aviation education emphasizes that students will likely encounter these tools (e.g., ChatGPT) in their professional careers and will be expected to harness them effectively. Therefore, students should learn how to leverage AI as one of their many academic tools, preparing them for future professions where AI technologies are increasingly prevalent. Lastly, the final aspect highlights the risks associated with using AI plagiarism checkers. It warns against the unfair accusation of plagiarism, mainly when content may have been generated by AI, and emphasizes the importance of maintaining a positive instructor-student rapport by not overemphasizing plagiarism detection.

Second, in the quest to promote academic integrity in aviation education, there is a pressing need to reconceive assignments with careful consideration for the integration of AI tools while maintaining academic rigor and ethical standards. For example, AI should be leveraged as a professional tool. Students should be encouraged to assess AI-generated responses for correctness critically. This approach reinforces the importance of independent thinking and empowers students to identify potential inaccuracies in AI-generated content. Instructors should primarily assign tasks requiring students to edit AI-generated responses for correctness. This activity will promote the constructive use of AI by refining the information provided, ensuring students engage actively with AI-generated content.

Moreover, assignments should be crafted beyond AI capabilities. Challenge students to submit assignments in formats that extend beyond the capabilities of text-based AI. For instance, request short video submissions where students visually demonstrate their problem-solving skills, fostering creativity and deep engagement with the subject matter. Alternatively, instructors could also assign tasks that involve the creation of infographics or visual projects. These assignments promote visual literacy and require students to synthesize information visually compellingly.

Lastly, instructors could practice localizing their assignments. Instructors could develop assignment prompts that incorporate local context or real-world applications, areas where AI often struggles due to its generalized knowledge. This practice makes assignments more relevant and encourages critical thinking as students must adapt AI-generated content to specific scenarios. Furthermore, instructors could adapt assignment prompts to align with topics covered in course discussions. This connection ensures that assignments are directly related to the course material and promotes a deeper understanding of the subject matter.

Conclusion

Overall, the paper underscores the pivotal role of AI in reshaping aviation education and highlights the imperative need for a balanced and strategic integration of AI tools into the curriculum. The evolution of aviation education, from traditional methods to technology-driven approaches, has accentuated the significance of maintaining a delicate equilibrium between human expertise and technological advancements. As the aviation industry continues to rely on cutting-edge technology, aviation education must adapt to provide students with the skills and knowledge required to excel in this dynamic field. This transition is accompanied by a set of challenges related to AI integration, pedagogy, and managing expectations. Educators must foster critical thinking, ensure the judicious use of AI as a supportive tool rather than a replacement for human judgment, and address the need for faculty training and personalized learning experiences.

Moreover, this paper emphasizes the responsibility of instructors to set the context for AI usage and educate students about its limitations. Encouraging students to harness AI effectively as a part of their academic toolkit prepares them for future professions where AI technologies are increasingly prevalent. In pursuing academic integrity, the authors suggest a thoughtful preconception of assignments, encouraging students to assess AI-generated content and engage actively with it critically. Assignments should extend beyond AI capabilities, challenging students to demonstrate problem-solving skills through various formats and fostering creativity and visual literacy. Localizing assignments and aligning them with course topics enhances their relevance and encourages critical thinking.

In the ever-evolving landscape of aviation education, embracing AI offers a promising path toward preparing students for the demands of the aviation industry while maintaining a focus on human expertise, creativity, and critical thinking. It is crucial for educators, institutions, and the aviation industry to collaborate and adapt to ensure that AI complements, rather than supplants, the core principles of aviation education. In doing so, one can usher in a progressive paradigm for aviation education that combines the best of human skill with the power of artificial intelligence.

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Engaging Aeronautical Science Students with Technology

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If the pandemic taught us something in academia, it was to be more flexible while leveraging creative methods in maintaining students' engagement with modern academic tools such as Nearpod. Additionally, allowing teacher autonomy supported a seamless transition to online platforms during the COVID-19 pandemic, which may translate well to a weather event without having to cancel class. Those who are researchers within the scholarship of teaching and learning community find this to be no surprise (Kahu, 2011; Ayuka & Jacobs, 2018; Keller et al., 2020). This research project examines the experience of one assistant professor of aeronautical science who implemented Nearpod into her classroom prior to COVID-19 mandates and how that was received by students before, during, and after the experience. By looking at the student evaluation data throughout this time period and one specific question asked on the end-of-course student reviews: 'What elements in this course MOST helped you learn the course content?' The research team will consider the number of responses and how many of them reference Nearpod as at least one of those elements. Additionally, the presenters will show different strategies used in aviation technical courses to integrate different tools and maintain student engagement as highlighted by students. Presenters are not associated with any of the companies that own the tools presented.

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Introduction

The authors found that aviation students, specifically those who are in class with the intention of becoming professional pilots, struggle to engage in technical content without being able to engage actively in the material. Nearpod is a web-based presentation platform that allows for multiple forms of engagement in a lecture-style classroom setting. This tool was used by one of the researchers who shared it with colleagues within her department and later by the university through collaboration with this research team. However, there are other similar tools, and this just happens to be the platform used by this set of researchers.

Through the COVID-19 pandemic and multiple hurricanes, this set of researchers began to truly understand the positive impact this was having in their respective courses, primarily instrument pilot operations and aerodynamics. Between their own personal experiences and frustration with lecture-based courses and feedback from students, in addition to the increased literature surrounding technology use in the classroom, this team set out to learn more in order to leverage these tools best.

Literature Review Summary

Through the literature review, it was discovered that most of the history of technology use in the classroom with published research mostly focused on “clickers” or other similar Audience Response Systems (ARS). Though this area was not heavily researched, when it was, it was commonly found within the medical professions' education system or more focused on K-12 students. There was one research project on Nearpod, specifically by McClean & Crower (2017), that utilized Nearpod in one specific module of a pharmacy and bioscience course, and it found that the significant majority of the students wanted to use Nearpod again.

Some benefits that were referenced in using ARS in any format included early alter to comprehension for the educator (Ismail et al., 2017), student buy-in to course content and engagement (McEnvoy, 2017), and improved test scores and student perception of success (Kaewunruen, 2019; Legar et al., 2020). However, no best practices or specific guidelines on how to integrate this type of technology into the classroom were discovered.

Research Questions & Methodology

The research team developed a goal to address the impact of interactive content with aeronautical science students in the classroom setting, with a specific focus on Nearpod. Ultimately, we seek to develop a best-practices guide for technical education in higher education using interactive technology in the classroom. This goal led to the following three research questions:

RQ1: What is the perception of aeronautical science students on the usage of interactive technology within a technical course?

RQ2: Does using interactive technology in a technical course show an improvement in end-of-course evaluations?

RQ3: Does using interactive technology in a technical course show an improvement in students' average grades?

At the time of the presentation, the research team had only been able to analyze the data on RQ1 and did so by analyzing student feedback on course evaluations and how many times Nearpod was used in open responses.

Course evaluations from the Spring of 2020 through the Spring of 2023 were pulled for the two faculty researchers. The researchers started in the Spring of 2020 because that was the first semester in which one of the researchers began using Nearpod consistently. Further data will be pulled in order to answer RQs 2 and 3. The team analyzed data on the total students in each class, total responses for each class, the mean score of the Likert scale question, “I am satisfied with the instruction in this course,” as well as a qualitative review of the open-ended questions relating to what helped the students the most, the least, and what they would change. Anytime a comment was made with regard to the presentation tool or any of the activities used within Nearpod, a node was made.

Results

A total of 901 students were in the courses analyzed, and 60% of those students completed the course evaluations. When prompted, “I am satisfied with the instruction of this course,” out of a possible 4.0, the mean score was 3.66, and the median was 3.68. Most (95%+) of the comments surrounding the usage of Nearpod were positive.

Students’ comments support some of the literature surrounding ARS that helps with early alert to comprehension included, “extra little quizzes in Nearpod and other sites that weren’t graded but helped enhance our understanding of the concepts” and “[nearpod’ allowed me to be engaged as well as make the class enjoyable to learning and review.” Other comments such as” definitely with other professors used this tool” and “using Nearpod really helped get the points across, instead of just sitting and looking at a PowerPoint and mothering else for 50 minutes” emphasized the benefit of the engagement feature from the student’s perspective.

Demonstration & Brief Discussion

During the presentation, the audience was invited to join the Nearpod, which was the presentation tool. At this point the presenters showed the “Draw It” feature using a slide from an aerodynamics course to allow participants to draw on the slide, type text, change colors, highlight, and more. Next, a pre-made Nearpod Matching activity was shared for the audience to use from the student's perspective. The presenters then shared what they saw from the teacher's view. Other features of the tool were also presented to the audience at this time that can be adjusted during a live presentation, such as open-ended questions in which students type in their answers, how students can have the presentations sent to themselves and take notes live within the tool so they do not have to have multiple windows open. Integration into Canvas was also shared in that it can be made as an assignment or embedded into a page for further reading outside of class.

Audience members ask questions about cost, which has multiple answers depending on what scale they are looking for. More information was provided after the presentation. The screen size is another concern for a few of the audience members, as well as the research team. However, none of the questions or concerns revolve around the functionality of the tool. Rather, they are about the specific features of this unique platform.

Moving Forward

The research team seeks to continue this research and answer RQs 2 and 3:

RQ2: Does using interactive technology in a technical course show an improvement in end-of-course evaluations?

RQ3: Does using interactive technology in a technical course show an improvement in students' average grades?

The goal will be to develop a best practice guide for aviation technical course educators to engage aviators in ground-based courses. The guide will aim to be comprehensive and include other interactive tools as well, though examples and data will be based on Nearpod.

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The Role of Fatigue Management in Achieving Resilience for Underrepresented Minorities

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Aviation education and professional flight training present unique stressors to college students, such as mental, physical, and time management demands and the extensive financial burden. These stressors, on top of an already challenging college environment, can create a source of fatigue for students if not managed appropriately. As aviation education institutions continue to make progress in recruiting and retaining students from underrepresented minority groups using various tools and resources, it is crucial to recognize that underrepresented students face additional sources of fatigue that contribute to their attrition. For example, racial identity, cultural fatigue, and imposter syndrome can manifest in the daily life of a student in the form of microaggressions or biases. It is critically important to recognize these as sources of fatigue and find ways to address them holistically.

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Fatigue management, particularly within the context of professional flight training and aviation education, plays a crucial role in supporting the well-being, performance, and overall success of students from underrepresented minority groups. For instance, fatigue management is essential for maintaining the physical and mental health of individuals. However, fatigue can also have a negative effect on students' performance, productivity, safety, and work-life balance. This paper explores the evolution of diversity, equity, and inclusion (DEI) in aviation education, the role of fatigue management within flight training, and how higher education institutions can achieve resilience for underrepresented minorities through the combination of these two concepts. The goal is to contribute strategies to the existing literature on how DEI practices and fatigue management can make an impact on the retention of underrepresented minorities.

DEI Implementations in Aviation Education

In recent years, achieving DEI goals for pilots and mechanics in the aviation industry has been an ongoing challenge. Conversely, research has also shown the benefits of DEI practices, such as higher retention and better performance (Albelo & O'Toole, 2021; Albelo et al., 2023b; Kim & Albelo, 2020). When it comes to aviation education, Albelo & O'Toole (2021) have shown that training programs that focus on diversity awareness and skills development tend to be more successful, while factors like the type of instructional mode and mandatory versus voluntary participation have limited influence on outcomes. Overall, aviation education has made progress in broadening access and participation by historically underrepresented groups. Efforts to recruit and retain individuals from diverse backgrounds, including women and minorities, have gained momentum (Albelo et al., 2023a; Albelo et al., 2023c; Fowler et al., 2023; Kim & Albelo 2021; Lutte, 2019). Scholarships, mentorship programs, and outreach initiatives have been established to encourage aspiring aviators and aviation professionals from diverse communities.

Curriculum enhancements represent another significant advance. Aviation education programs have started to incorporate DEI principles into their courses, ensuring that students gain not only technical skills but also an understanding of the cultural, social, and ethical aspects of aviation (Albelo & O'Toole, 2021; Albelo et al., 2022). These changes help graduates become well-rounded professionals who are not only technically proficient but also culturally competent and sensitive to diverse perspectives. Furthermore, aviation institutions have made strides in fostering inclusive learning environments. This includes creating spaces where students from different backgrounds feel welcomed, respected, and valued. Efforts to combat stereotypes, microaggressions, and bias within aviation education have helped create more inclusive classrooms and campus cultures (Albelo et al., 2023b; Albelo & McIntire, 2022).

Aviation organizations and institutions have also been proactive in diversifying their faculty and staff. Recognizing the importance of role models and mentors from underrepresented backgrounds, they have made efforts to hire and promote individuals who can serve as inspirations to students and contribute to a more diverse leadership pipeline within the aviation industry. In response to these advancements, research into DEI within aviation education has flourished. Scholars and institutions have conducted studies to assess the impact of DEI initiatives, providing valuable insights and best practices for ongoing improvements (Fowler et al., 2023; Kim & Albelo, 2021; Kim & Albelo, 2020; Sanders, 2022). This research-driven approach ensures that DEI efforts are evidence-based and continually evolving to meet the ever-changing needs of aviation education.

Role of Fatigue Management in Flight Training

Research has also shown that fatigue management plays a critical role in collegiate flight training, ensuring the safety, well-being, and performance of aspiring pilots (Mendonca et al., 2021). Flight training programs at colleges and universities face unique challenges related to fatigue, given the rigorous schedules and high-stress nature of aviation instruction (Keller et al., 2019; Mendonca et al., 2019; Romero et al., 2020). Effectively managing fatigue is essential for achieving successful flight training outcomes.

First and foremost, fatigue management in collegiate flight training is pivotal for safety. Flight instructors and student pilots must be alert, focused, and capable of making quick and precise decisions during flight. Fatigue can impair cognitive function, reaction times, and situational awareness, posing a significant risk to flight safety (Keller et al., 2019; Mendonca et al., 2023). Therefore, implementing strategies to mitigate fatigue-related risks, such as regulated duty hours and adequate rest periods, is imperative in collegiate flight training programs (Mendonca et al., 2021; Romero et al., 2020). Furthermore, fatigue management contributes to the overall quality of flight training. Students who are well-rested and alert are more likely to retain information, learn effectively, and perform better during flight lessons (Mendonca et al., 2023). Flight instructors also benefit from fatigue management, as they can provide high-quality instruction and maintain a positive and supportive teaching environment when they are not excessively fatigued.

In addition to safety and quality, fatigue management is essential for the well-being of both instructors and students. Flight training can be physically and mentally demanding, and chronic fatigue can lead to burnout and decreased job satisfaction among instructors (Mendonca et al., 2019). For students, managing fatigue helps prevent stress and burnout during training, contributing to a more positive and successful learning experience (Mendonca et al., 2021). Collegiate flight training programs are increasingly recognizing the importance of addressing fatigue proactively. This involves implementing policies and procedures that regulate duty hours, promote adequate sleep, and provide resources for managing stress and fatigue. Flight schools are also incorporating fatigue management principles into their curriculum, educating students about the risks of fatigue and strategies for mitigating its effects (Romero et al., 2020).

Achieving Resilience for Underrepresented Minorities

While collegiate flight training programs are critical pathways to careers in aviation, they can also pose unique challenges for underrepresented minorities. Achieving resilience for underrepresented minorities in collegiate flight training is a multifaceted endeavor that involves addressing various forms of fatigue, including racial identity fatigue, emotional fatigue, cultural fatigue, and impostor syndrome. These challenges are particularly relevant in aviation education, where students face demanding schedules, rigorous training, and high-stress environments. To foster resilience among underrepresented minority students in this context, it is essential to implement fatigue strategies that not only mitigate exhaustion but also create an inclusive and supportive learning environment.

Racial Identity Fatigue

Racial identity fatigue arises when individuals from underrepresented racial backgrounds experience the stress of navigating environments where they are a minority, often encountering stereotypes, biases, or microaggressions (Smith et al., 2006). To address this form of fatigue in collegiate flight training, institutions should prioritize diversity and inclusion efforts. Creating a culturally competent environment where students of all backgrounds feel valued and respected is crucial. Implementing bias awareness training for faculty, staff, and peers can help reduce racial identity fatigue. Additionally, mentorship programs that connect underrepresented minority students with supportive role models can provide guidance and encouragement, fostering resilience by promoting a sense of belonging.

Emotional Fatigue

The high-stress nature of flight training can lead to emotional fatigue for all students, but underrepresented minorities may face unique emotional challenges due to the additional pressures of representation (Michielsen et al., 2004). To address emotional fatigue, colleges and universities offering flight training programs should offer mental health resources and support services. Providing access to counseling and wellness programs can help students manage stress and build emotional resilience. Moreover, creating peer support networks or affinity groups for underrepresented minority students allows them to share experiences, discuss challenges, and offer each other emotional support, reinforcing their resilience.

Cultural Fatigue

Cultural fatigue can occur when individuals from underrepresented backgrounds feel compelled to constantly explain or defend their cultural identities, which can be draining and distracting (McLlvenny, 1999). Collegiate flight training programs should emphasize cultural competence among both faculty and students. This includes incorporating cultural awareness training into the curriculum and fostering an environment where questions are encouraged and stereotypes are challenged. By promoting cultural humility, institutions can help reduce cultural fatigue and bolster the resilience of underrepresented minority students.

Impostor Syndrome

Impostor syndrome is a common phenomenon where individuals doubt their abilities and feel like frauds despite evidence of their competence (Hawley, 2019). Underrepresented minority students may be more susceptible to impostor syndrome, particularly when they are in environments where they are underrepresented. Combatting impostor syndrome involves creating a growth mindset culture that emphasizes effort, persistence, and learning from failures. Flight training programs can provide mentorship and role models who share their own experiences of overcoming challenges, helping students realize that their feelings of inadequacy are not unique and can be overcome.

Holistic Fatigue Strategies

Achieving resilience for underrepresented minorities in collegiate flight training requires holistic fatigue strategies that encompass all these dimensions. These strategies should include regular check-ins with students to assess their well-being and provide opportunities for open discussions about their experiences. Additionally, offering workshops and training sessions on stress management, coping strategies, and self-care techniques can equip students with the tools they need to combat fatigue and build resilience. Moreover, flight training programs should continually evaluate their curriculum and policies to ensure they are inclusive and culturally responsive. Encouraging diverse perspectives in aviation education not only enriches the learning experience but also helps reduce the cognitive load associated with navigating unfamiliar or hostile environments, thereby mitigating emotional and cultural fatigue.

Conclusion

For underrepresented minorities who may face additional stressors due to discrimination or lack of representation, managing fatigue becomes even more critical. Resilience is closely tied to well-being, and addressing fatigue helps individuals maintain the energy and focus needed to navigate challenges effectively. Furthermore, fatigue can significantly impair cognitive function, decision-making, and overall academic performance. When underrepresented minorities face fatigue due to long working hours, excessive workload, cultural fatigue, emotional fatigue, and impostor syndrome, their ability to excel in their flight training may be compromised. Effective fatigue management ensures that individuals can perform at their best (Romero et al., 2020; Mendonca et al., 2021), contributing to their resilience by mitigating the negative impact of exhaustion.

Fatigue can hinder career progression, as it may lead to burnout. Resilience for underrepresented minorities often involves overcoming barriers to career advancement. Effective fatigue management can help individuals maintain a consistent and sustained effort toward their goals, enhancing their resilience by facilitating progress in their careers. An educational environment that prioritizes fatigue management demonstrates a commitment to diversity, equity, and inclusion. It recognizes that everyone, including underrepresented minorities, deserves fair treatment and support in maintaining their well-being. This supportive environment contributes to a sense of belonging, which is a key aspect of resilience.

For underrepresented minorities who may face unique challenges related to work-life balance, such as ethnic identity fatigue, imposter syndrome, or navigating additional responsibilities, fatigue management becomes crucial. Achieving resilience often involves balancing work, personal life, and self-care. Organizations and educational institutions that promote flexible schedules and policies that accommodate diverse needs contribute to this balance. All in all, fatigue management is vital to achieving resilience for underrepresented minorities. It impacts their mental health, performance, safety, and overall well-being. By addressing fatigue and promoting a supportive and inclusive environment, organizations and institutions can empower individuals from underrepresented minority groups to thrive, overcome challenges, and succeed in their resilience and ability to persevere in adversity.

Acknowledgments

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Clear of Clouds? An Assessment of Appealed 91.155 Enforcement Actions

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When flying under visual flight rules, pilots must remain clear of clouds. The exact distance varies by airspace class, and this is determined by specific regulatory requirements found within 14 C.F.R. Section 91.155. But there are important questions about the extent to which pilots comply with this regulation, as determining one's exact distance from clouds is challenging. In this conference paper, we assess the decisions of the National Transportation Safety Board (NTSB) in 20 Federal Aviation Administration (FAA) legal enforcement actions involving a violation of cloud clearance requirements. Among these cases, we examine how 91.155 violations were discovered, the form of sanction imposed by the FAA, the timelines associated with appeals for these cases, and the vote composition of the NTSB in these decisions.

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Introduction

When flying under visual flight rules (VFR), pilots must remain clear of clouds. Specifically, Title 14 of the Code of Federal Regulations (14 C.F.R.) section (§) 91.155, formally titled *Basic VFR weather minimums* (hereinafter "91.155"), sets forth exact flight visibility and minimum distance from clouds requirements for VFR flights in each class of U.S. airspace. Put a different way, when operating in certain airspace, pilots are restricted in how close they may fly to clouds, and they may only legally fly if the visibility conforms with the requirements of 91.155.

However, determining the distance from clouds is difficult. One article in the popular aviation press goes so far as to assert that 91.155 is "[o]ne of the most-often busted federal aviation regulations… because pilots often have a hard time judging how close they really are to clouds" (Pope, 2015, para. 1). And so, there are important questions about the extent to which pilots comply with the cloud clearance provisions of 91.155. Pope (2015) further concedes:

> [T]here's no way to tell exactly how far you are from clouds, and unless you're really close – or penetrate a cloud – you won't get a call from your friendly local FAA rep. But you shouldn't use the lame defense of 'I didn't know' to purposely fly too close to clouds (para. 5).

Indeed, while violating 91.155 may, of course, cause flight safety issues, it may also lead to a legal enforcement action brought by the Federal Aviation Administration (FAA) against the pilot. In this paper, we examine the latter issue by assessing a sampling of 20 legal enforcement action cases where 91.155 (and, in some cases, its predecessor, 91.105) was violated. Originating from a presentation delivered at the 2023 Collegiate Aviation Education Conference and Expo, this paper provides insight as to how the FAA discovers 91.155 violations, the penalties associated with such a violation, and the decisions of the National Transportation Safety Board (NTSB) in reviewing these cases on appeal.

Background & Literature Review

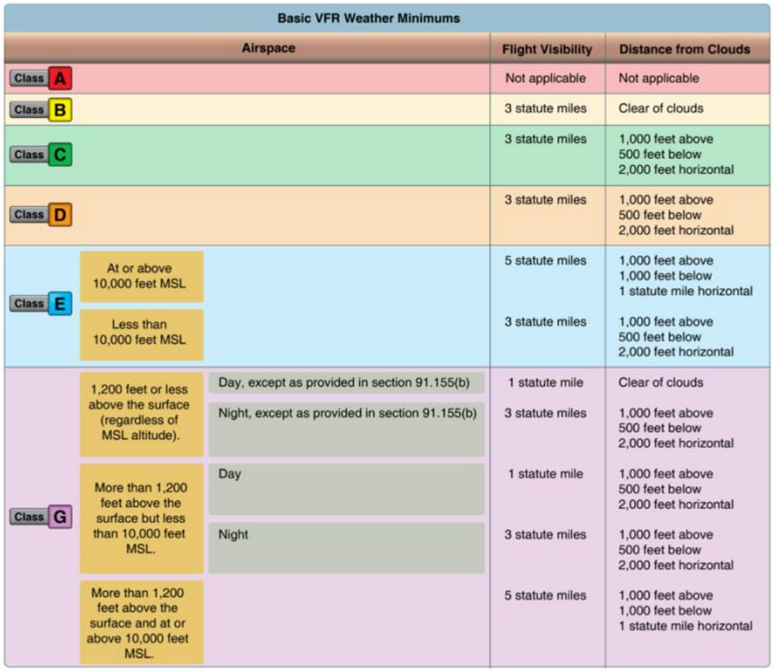
The FAA has organized the National Airspace System (NAS) into different classes of airspace—classes A, B, C, D, E, and G (see Figure 1) (FAA, 2016). Section 91.155 prescribes minimum weather standards for VFR operations within each of these classes. The weather standards stipulated in 91.155 are organized by two elements: flight visibility and distance from clouds (Anderson et al., 2015).

Figure 1
FAA Airspace Classification

Note: Federal Aviation Administration, 2016. In the public domain.

VFR weather minimums were first promulgated in 1937 and have since been amended to establish the current minimums provided in 91.155 (Anderson et al., 2015). As previously discussed, these minimums vary by airspace. For example, when operating in class B airspace, a pilot needs only three statute miles of visibility and must remain clear of clouds. If, however, the pilot is operating in class D airspace, they still only need 3 statue miles of flight visibility but must remain at least 1,000 feet above, 500 feet below, and 2,000 feet horizontal distance from clouds (FAA, 2016). Figure 2 shows all the weather minimums stipulated by 91.155. Note VFR weather minimums are not applicable in class A airspace because only IFR operations are permitted in class A airspace (FAA, 2016).

Figure 2
Basic VFR Weather Minimums as Stipulated by 91.155



Basic VFR Weather Minimums

Airspace			Flight Visibility	Distance from Clouds
Class A			Not applicable	Not applicable
Class B			3 statute miles	Clear of clouds
Class C			3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
Class D			3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
Class E	At or above 10,000 feet MSL		5 statute miles	1,000 feet above 1,000 feet below 1 statute mile horizontal
	Less than 10,000 feet MSL		3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
Class G	1,200 feet or less above the surface (regardless of MSL altitude).	Day, except as provided in section 91.155(b)	1 statute mile	Clear of clouds
		Night, except as provided in section 91.155(b)	3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
	More than 1,200 feet above the surface but less than 10,000 feet MSL.	Day	1 statute mile	1,000 feet above 500 feet below 2,000 feet horizontal
		Night	3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
	More than 1,200 feet above the surface and at or above 10,000 feet MSL.		5 statute miles	1,000 feet above 1,000 feet below 1 statute mile horizontal

Note: Federal Aviation Administration, 2016. In the public domain.

Seeing, Avoiding, and VFR Flight into IMC

All the requirements of 91.155, though, are admittedly complicated. One may reasonably wonder, then, what is the point of 91.155? In a word, safety. In other words, its purpose is two-fold. First, 91.155 helps ensure pilots can "see and avoid other aircraft" (especially IFR aircraft), which is essential when operating under VFR (Anderson et al., 2015, p. 133). Second, 91.155 helps prevent a pilot operating under VFR from flying into instrument meteorological conditions (IMC).

Existing literature considers both these issues and their safety implications. Previous studies have examined see and avoid in the context of midair collisions (e.g., Mooris, 2005) and the factors contributing to continued VFR flight into IMC—such as deficiencies in training, behavioral psychology, pilot decision-making skill, and ways to reduce the hazard (Major et al., 2017; Goh & Wiegmann, 2001; O'Hare & Smitheram, 1995; Wiggins & O'Hare, 1995; Goh & Wiegmann, 2002; Lozier, 2007; Wilson & Sloan, 2003).

There is, however, only limited research that examines the legal perspective of 91.155 violations and subsequent consequences for pilots. In a comprehensive legal analysis of 14 C.F.R. Part 91 see and avoid rules and associated NTSB decisions in pilot enforcement action cases, Anderson et al. (2015) found 91.155 "expects a prudent pilot to obtain accurate weather information, and comply with the minimums for visibility and cloud clearances" (p. 137). Further, Anderson et al. (2015) argue that "weather minimums serve as support for the pilot's duty of vigilance to see and avoid other aircraft" and that the "pilot's duty to comply with VFR weather minimums dovetails with the duty to be vigilant for other aircraft" (p. 141).

FAA Enforcement and Appeals

Section 91.155 carries the force of law. Thus, when pilots are operating under VFR, they must comply with the stipulations of 91.155. And if they fail to do so, the FAA has the authority to bring a legal enforcement action against them. Specifically:

> Under 49 U.S.C. Section 44709(b), the [FAA] Administrator is authorized to issue orders suspending or revoking certificates issued under 49 U.S.C. chapter 447 (*e.g.*, airman certificates issued under 49 U.S.C. Section 44703) if the Administrator decides that safety in air commerce or air transportation and the public interest require that action (Barry, 2014, p. 408).

Whether the FAA elects to exercise this enforcement authority depends on many factors, including the FAA's compliance program and the agency's internal enforcement guidelines (e.g., FAA, 2022). If the agency does indeed determine legal enforcement action is the appropriate response to an apparent regulatory violation, the certificate holder may still challenge the FAA's decision by appealing the enforcement order to the NTSB for review (Barry, 2014; Yodice, 2014; FAA, 2022). The NTSB may "amend, modify, or reverse the FAA order if it finds that safety in air commerce or air transportation and the public interest do not require affirmation of the order" (Barry, 2014, pp. 409–10). At the NTSB, the case is first heard by an Administrative Law Judge (ALJ). During this hearing, the ALJ will hear testimony as the FAA and pilot both make their arguments for why the order should be affirmed, modified, or reversed. Typically, at the end of the hearing, the ALJ will issue a decision in the case (Yodice, 2014).

The ALJ's decision may then be further appealed by either the FAA and/or the pilot to the full Board—referring to the five members of the NTSB, appointed by the President and confirmed with the advice and consent of the U.S. Senate (see 49 C.F.R. § 800.2)—for review. The Board only reviews certain legal questions on appeal but may affirm, modify, or reverse the ALJ's decision (Yodice, 2014). In this study, we assess decisions issued in the *second* step of this appeals process, that is, decisions made by the full Board, not ALJs.

It is important to note the above description is, of course, only a very *brief* overview of FAA enforcement and the appeals process. If interested in a far more detailed explanation of these procedures, including appropriate citations to legal authorities, see Barry (2014), Yodice (2014), and FAA (2022).

Methodology

In this study, we set out to answer the question: How has 14 C.F.R. § 91.155 been enforced by the FAA in the context of appealed enforcement cases? To answer this question, decisions issued by the Board in enforcement action cases on appeal were sourced from the NTSB's publicly available *Opinions and Orders Query* database. This database is home to full Board opinions from 1992 until the present day and allows one to filter a search by *FARs/Regulations (aviation/marine) Charged*. We searched the database for appealed cases involving violations of 91.155 and its predecessor, 91.105. The 91.155 search produced twelve results, and the 91.105 search produced seventeen results. Some of the documents produced in the search, however, were not directly germane to our purpose in this study. Thus, we eliminated irrelevant cases or documents, leaving only *Opinion and Order* documents.

This yielded a sample of 20 cases for us to assess. These decisions were then reviewed and coded into a database for analysis using Microsoft Excel. For each case, we recorded the (1) NTSB Order Number, (2) date of the event, (3) date of initial FAA enforcement order, (4) date of ALJ decision, (5) date of a full board decision, (6) the form of sanction at issue on appeal, (7) the decision of the ALJ and any modifications made to the sanction, (8) the decision of the full Board, (9) modifications and/or final outcome based on the full Board's decision, (10) the Board vote composition including (11) number of Board members in favor, (12) number of Board members opposed, and (13) the total number of Board members participating. We also recorded if there was a concurrence or dissent issued by any Board members, though there were none. For a complete list of the decisions analyzed here, see Appendix A.

Upon organization and classification of the data, a mixed methods approach to evaluating the cases was employed. A qualitative synthesis of specific cases was used when individual cases pointed to a specific understanding of the enforcement mechanism, descriptive statistics were employed to observe comparisons when generalizable conclusions could be drawn, and quantitative means testing was conducted where appropriate.

Results & Discussion

Twenty NTSB decisions (used interchangeably in this section with *cases*) were descriptively analyzed to identify how 91.155 violations were identified by the FAA, the forms of sanction, changes to the sanction as a result of adjudication, the timelines associated with appealing these cases, and the voting composition of the Board members. Among the 20 decisions analyzed here, seven were issued in 1992, five in 1993, two in 1994, and one each in 1998, 2001, 2002, 2007, 2008, and 2020.

Identifying 91.155 Violations

We begin with a practical issue: *how* the FAA determines cloud clearance rules have been violated. Unfortunately, not all cases analyzed provided a clear answer to this question. Three cases, however, did stand out. In the most recent case, *Administrator v. Fullerton* (2020), the cloud clearance violation was identified by an FAA inspector on the ground, as he “was conducting observations from Mackinac County Airport in St. Ignace, Michigan” (pp. 2–3). The inspector visually “observed an aircraft operating at a distance of less than 300 feet below the overcast cloud ceiling” and “later determined the aircraft he observed… was operated by respondent” (i.e., the pilot against whom the enforcement action was brought) (p. 3). Such identification is in line with an assertion made by Hamilton & Nilsson (2020) that “[t]he majority of FAR violations come to the attention of these FAA inspectors during the regular conduct of their duties” (p. 46).

Relatedly, in *Administrator v. Powell* (1994), the violation was discovered after the pilot departed VFR from an airport when the weather conditions were IFR. Prior to the flight, the pilot called a local automated flight service station (AFSS) for a weather report. The weather was reported to be IFR. So, the pilot filed an IFR flight plan. To the pilot, however, the weather “was improving” and “was VFR” (*Administrator v. Powell*, 1994, p. 4). After being advised by AFSS that there would be an IFR clearance delay due to inbound traffic, the pilot decided to depart VFR despite having filed an IFR flight plan. Another aircraft on the ground at the same airport was in a similar situation, but that pilot elected to wait for an IFR clearance and “advised ATC that respondent’s aircraft had just taken off” (p. 6). The reported weather before and after the pilot’s departure was IFR, including a special weather report indicating IFR conditions. Also notable in this case, an air traffic controller testified at the ALJ hearing as a witness for the FAA, testifying “it was unlikely that the weather could have changed from IFR to VFR and then back again to IFR in 37 minutes, as [the pilot] suggests” (p. 7). Although it was not expressly stated in all decisions, in many of the cases we analyzed, it appears the identification of 91.155 violations involved a report by Air Traffic Control (ATC) to the FAA.

Along this vein, the third case that stands out is *Administrator v. de Mooy* (1992). Here, ATC was communicating with an aircraft on an IFR flight plan at an IFR altitude. ATC observed VFR traffic in the vicinity of this IFR aircraft and alerted the flight crew to its position and altitude. The IFR aircraft responded to ATC “that they saw the [VFR] aircraft and it was ‘going in and out of the clouds’” (p. 3). Then:

> [The IFR aircraft] requested and received permission from ATC to descend in order to read the tail number of the VFR traffic. Although he was unable to ascertain the number, the captain identified the aircraft as a Twin Beech turbine. Soon afterward, the controller received a transmission from 'Twin Beech 3281 Tango' that stated its position as 30 miles east of Kalamazoo at 3000 feet. This location matched the site of the VFR traffic the controller had been tracking. Based on the aforementioned data, the controller concluded that the aircraft he was talking to was the VFR aircraft observed by the [IFR flight] crew (*Administrator v. de Mooy*, 1992, p. 3).

Simply put, in *de Mooy*, the discovery was made when an aircraft operating under IFR observed a VFR aircraft violating 91.155 and reported that violation to ATC. Notably, both the captain and first officer of the IFR flight testified at the ALJ hearing.

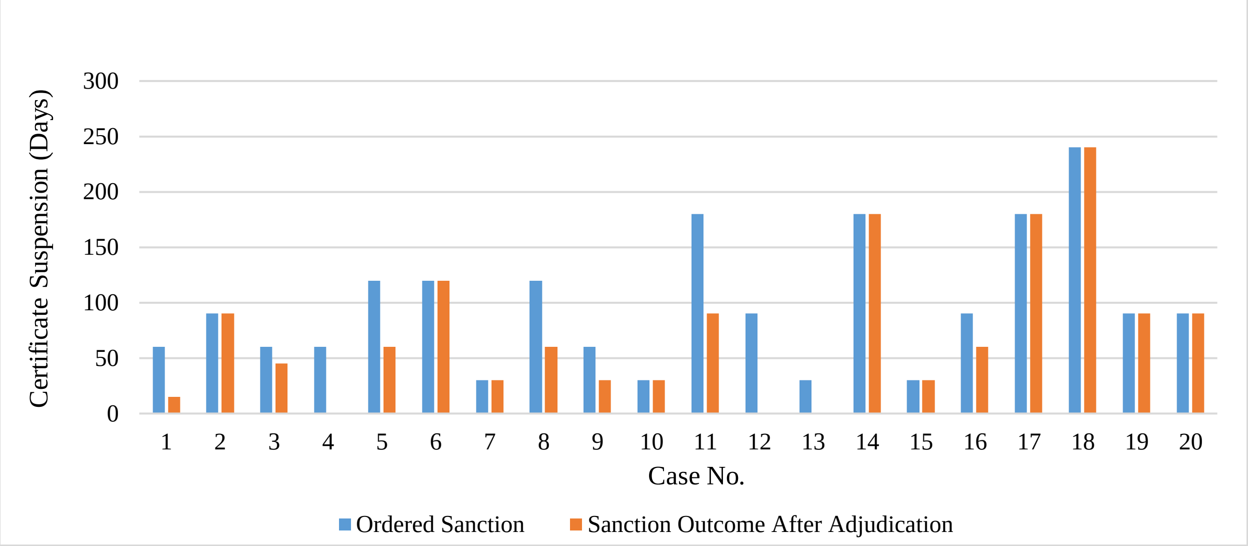
The common thread amongst these three cases is the *visual observation* of a 91.155 violation. This presents its own issues worthy of discussion, and we leave a deep dive into definitions, admissibility of evidence, and credibility findings to the law reviews (e.g., Anderson et al., 2015). However, it is still important for pilots to be aware of how violations of 91.155 were discovered and to consider this in their aeronautical decision-making when flying during murky, borderline VFR–IFR days and in cloud avoidance circumstances.

Form of Sanction

For all cases (*n* = 20), certificate suspension was the form of penalty selected by the FAA. We analyzed these suspensions in two contexts. First was the penalty *originally ordered* by the FAA and, second, the *final* or *actual* penalty after appellate adjudication. In other words, did the appeal to the ALJ, and then to the full Board, make a difference with respect to the length of the suspension period? And if so, by how much?

Time periods for FAA-ordered certificate suspensions ranged from 30 days (*n* = 4) to 240 days (*n* = 1). The mean FAA-ordered suspension period was 97.5 days (*SD* = 59.11). In half the cases (*n* = 10), the final suspension period was different from the FAA-ordered suspension period. Figure 3 illustrates this difference.

Figure 3
FAA Ordered Sanction versus Sanction Outcome After Adjudication



In examining Figure 3, cases 4, 12, and 13 stand out regarding the outcome of the final sanction. In each of these cases, the outcome after appealing to the Board, with respect to sanction, was not strictly a reduction in the suspension period. In case four, the Board's decision was to remand the case back to ALJ. In case 12, the Board dismissed the sanction entirely. In case 13, the Board affirmed the decision of the ALJ who had "waived the 30-day suspension sought by the Administrator… in light of [the pilot's] timely filing of a report under the Aviation Safety Reporting Program" (*Administrator v. Beckman*, 1994, p. 2). Excluding these three cases, the mean reduction of the suspension period was 47.14 days (*SD* = 25.14). A related samples *t*-test was performed—again, excluding these three cases—and found a statistically significant difference between the ordered sanction period and the final sanction period after appeal, *t*(16) = 2.814, *p* = .012. For this *t*-test, Cohen's *d* = .808, a large effect.

Case Timelines

We turn now to case timelines. Analysis in this area was limited because not each case included an exact indication of the day of the alleged violation or the exact day the FAA issued its initial certificate suspension order. We began by assessing the time between the issuance of the full Board's decision and the ALJ's initial decision. Among all 20 cases, the mean period between the issuance of these two decisions was 720 days (*SD* = 234.12). Among cases that also included in the opinion the date of the event (*n* = 15)—for clarification, *when* the alleged violation occurred—the mean period between the date of the full Board's decision and the date of the alleged violation was 1,356.6 days (*SD* = 398.22). See Figures 4 and 5, respectively.

Figure 4
Days Between Full Board Decision & ALJ Decision

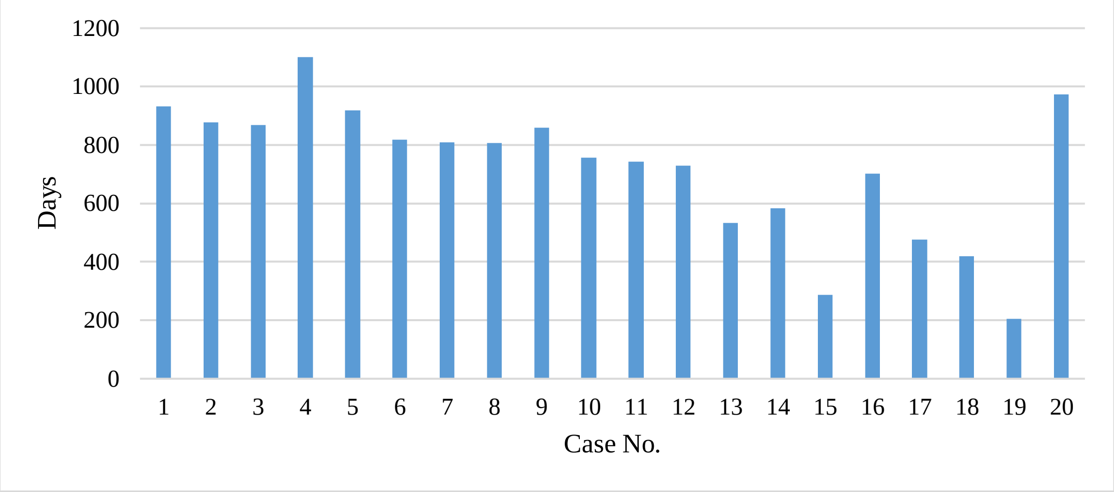
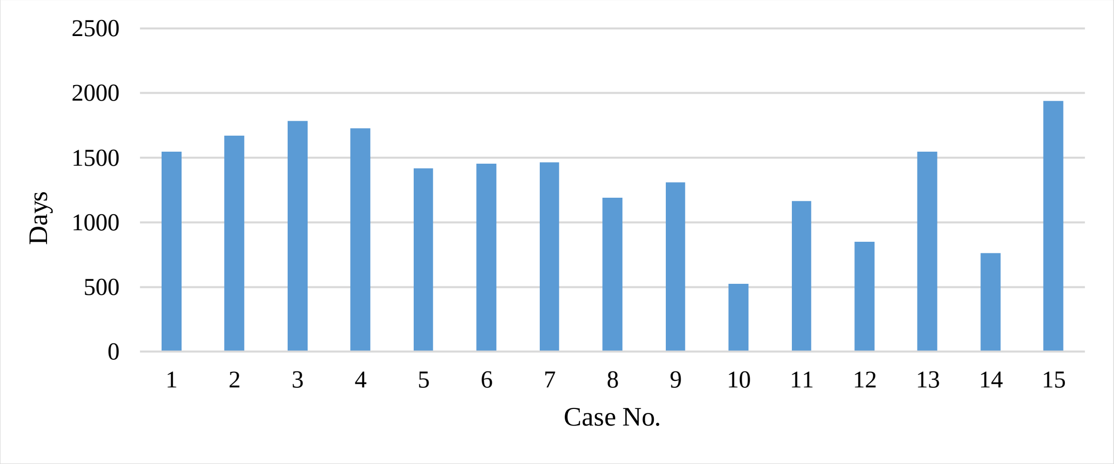


Figure 5
Days Between Full Board Decision & Date of Event (n = 15)



These lengthy timelines, particularly the time between the Board's decision and the ALJ's decision, are likely the result of these cases being non-emergency appeals. For emergency appeals, the NTSB *must* review the case and issue a decision within 60 days (Yodice, 2014). But on the contrary, for non-emergency appeals, as Yodice (2014) observes, "[t]here is no formal time limit on how long it may take the NTSB to docket a case and finally dispose of it" (p. 440).

Board Vote Composition

Finally, we reviewed the vote composition of the Board members in 19 of the 20 cases analyzed. Of the cases where we were able to assess Board vote composition (n = 19), 89.5% (n = 17) were unanimous 5–0 (n = 15) or 4–0 (n = 2) decisions. In each of the two cases that were not unanimous, the Board vote composition was four in favor and one opposed. In the first of these 4–1 decisions (case 1 in Figure 3), the Board affirmed, in part, the decision of the ALJ, which had reduced the FAA-ordered certificate suspension from 60 days to 15 days. Additionally, the Board reversed a portion of the ALJ's decision, finding the pilot had also violated 14 C.F.R. § 91.9, but that decision did not lead the Board to make a change in the final period deemed appropriate for certificate suspension. In the second 4–1 decision (case 15 in Figure 3), the Board affirmed the original FAA sanction and, in doing so, reversed the ALJ's initial decision—which had reduced the FAA's ordered sanction from 30 days to 20 days. No Board member authored either a concurrence or dissent in any of the cases analyzed. This all suggests that among cloud clearance violation cases appealed to the full Board, the Board members tend to vote generally in line with one another, with only rare disagreements about the outcome.

Conclusion

Cloud clearance compliance may be challenging for pilots, yet based on the 20 cases analyzed here, there is evidence to suggest the FAA does indeed enforce 91.155. All the cases involved certificate suspension as the choice of sanction. And it was not entirely uncommon, among these cases, for the NTSB to reduce the pilot's certificate suspension period. Avoiding this process entirely, however, should be the goal for pilots. Thus, when operating under VFR, it is vital for pilots to comply with the cloud clearance requirements of 91.155 for both safety and regulatory compliance purposes.

Limitations and Future Research

There are important limitations to consider in this study. Due to a lack of public data, we have analyzed only a modest sample of 20 cases. We were unable to assess enforcement actions and the associated penalties for cases that were never appealed to the NTSB and cases that were not appealed from the ALJ to the full Board. As the NTSB's *Opinions and Orders Query* database only includes decisions issued since mid-1992, we were only able to assess appealed cases dating back to 1992. We also did not examine whether, after the Board's decision, any of these 20 cases were further appealed to the appropriate Federal District Court or Federal Circuit Court of Appeals. Thus, we are far from able to assess the complete legal landscape of FAA enforcement actions with respect to 91.155 violations. We caution readers to consider this study's results only in the context of appealed cases to the full Board. It is also important to observe the FAA reclassified airspace in 1993; therefore, the exact regulation that was enforced pre-1993 was different from today's 91.155 (see Aircraft Owners and Pilots Association, 1993).

Future research may seek to generate a more detailed understanding of 91.155-related FAA enforcement actions. Data to complete such an analysis may potentially be sourced via a Freedom of Information Act request, as others have done in related contexts (e.g., Harper & Bliss, 2023).

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Appendix A List of Decisions Issued by NTSB Analyzed in This Study

NTSB Order Number	Year	Case
EA–3496	1992	Administrator v. Hamilton
EA–3502	1992	Administrator v. de Mooy
EA–3595	1992	Administrator v. Worth
EA–3618	1992	Administrator v. Kiscaden
EA–3639	1992	Administrator v. Smith
EA–3713	1992	Administrator v. Rudzek
EA–3716	1992	Administrator v. Symmes
EA–3760	1993	Administrator v. McLarty
EA–3765	1993	Administrator v. Wang
EA–3926	1993	Administrator v. Saliba
EA–3935	1993	Administrator v. Murphy
EA–3991	1993	Administrator v. Rolund
EA–4207	1994	Administrator v. Beckman
EA–4299	1994	Administrator v. Powell
EA–4701	1998	Administrator v. Ahl
EA–4920	2001	Administrator v. McGatha
EA–4957	2002	Administrator v. Laraux
EA–5275	2007	Administrator v. Simmons
EA–5407	2008	Administrator v. Lackey
EA–5866	2020	Administrator v. Fullerton

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The Global Impact of Improving Aviation Safety in Africa

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Aviation safety has been a pillar of the aviation industry since the early 20th century when the Wright brothers made their historic maiden flight. Air transport has increased exponentially since then, with tons of cargo and millions of passengers moving monthly around the world. This increase in flights has made it imperative to reduce the number of accidents and incidents and to achieve the same level of aviation safety worldwide, but that has not been the case in Africa. Organizations like the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) have fostered aviation safety since the 1940s. More recently, in 2001, ICAO published Annex 19 on Safety Management, which provides standards and recommended practices under the safety management system (SMS) and the state safety program (SSP). In January 2018, the African Union launched the Single African Air Transport Market (SAATM), which presents a great opportunity for the improvement of aviation safety in Africa. Based on data from various aviation organizations and on-the-ground experiences in the past decade spearheading many aviation projects in Africa, the author, a 30-year aviation veteran with expertise in aviation safety, provides a fresh analysis of the state of aviation safety on this vast and rich continent of 54 countries. Key issues and practical solutions to those issues are presented while highlighting the global interconnectivity of aviation safety with the goal of enhancing the efforts of the various stakeholders working to raise the level of aviation safety in Africa.

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Introduction

Aviation safety has been a pillar of the aviation industry since the early 20th century when the Wright brothers made their historic maiden flight. Air transport has increased exponentially since then, with tons of cargo and millions of passengers moving monthly around the world. This increase in flights has made it imperative to reduce the number of accidents and incidents and to achieve the same level of aviation safety worldwide. But the level of aviation safety seen in Europe or North America, for instance, is not observed in Africa despite a significant percentage of goods and persons being transported in and out of Africa worldwide.

Organizations like the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) have fostered aviation safety since the 1940s. In 2001, ICAO published Annex 19 on Safety Management, which provided standards and recommended practices under the Safety Management System (SMS) and the State Safety Program (SSP). The IATA Operational Safety Audit (lOSA) launched by IATA in 2001 was designed to assess the operational management and control systems of an airline with safety improvement as a backdrop.

Even the U.S. government back in 2009 launched some initiatives (U.S. Government Accountability Office (GAO), 2009): « Recognizing the importance of improving aviation safety in Africa, the United States and the international aviation community have worked to improve aviation safety in Africa. This congressionally requested report discusses (1) challenges in improving aviation safety in Africa, (2) key U.S. efforts to improve aviation safety in Africa and the extent to which they address the identified challenges, and (3) international efforts to improve aviation safety in Africa. To address these issues, GAO synthesized literature and aviation safety data, interviewed federal officials, and visited four African countries.»

Life-threatening events like air transport incidents and accidents that happen in one part of the world affect the entire world because passengers are of different backgrounds (business people, diplomats, tourists) and of different nationalities. Africa is comprised of 54 countries, and passengers fly from one African city to another and inside the same country as well as to and from African cities to destinations worldwide on board African airlines and international airlines. It is, therefore, evident that improving aviation safety in Africa is a global matter that needs continuous focus with frequent meetings similar to the one organized in 2007 by the Flight Safety Foundation (Flight Safety Foundation, January 30, 2007).

Figure 1
Some Aviation Safety Numbers (based on data from IATA)

Aviation Safety in Africa in Numbers (IATA 2022)

Airline companies in Africa:	Approx. 700 in 54 countries
Accident rate in Africa:	8.76 per million sectors
Accident rate worldwide:	1.21 per million sectors

The worldwide accident rate means that overall, there is one accident for every 826.088 flights; or that a person taking one flight every day would need to fly for 2,263 years before experiencing an accident. (IATA Annual Safety Report, 2022 - Executive Summary and Safety Overview Edition 59)

The following new analysis comes from a 30-year aviation veteran who has worked on various continents and has in-depth knowledge of African aviation. The analysis highlights the global interconnectivity of aviation safety, provides valuable information about the state of aviation safety in Africa and its impact on the aviation safety level worldwide, identifies some of the key issues, and provides practical solutions to those issues in order to raise the level of aviation safety in Africa.

Methodology

This analysis was enhanced by internet queries based on data obtained from the following organizations: International Civil Aviation Organization (ICAO), International Air Transport Association (IATA), Federal Aviation Administration (FAA), European Union Aviation Safety Agency (EASA), African Airlines Association (AFRAA), African Development Bank Group (AfDB), and Civil Aviation Authority Agencies of some African countries.

Limitations

There were limitations to this analysis, such as Difficulties in obtaining information from civil aviation authorities, consistency of data, accuracy and veracity of some data, taxonomy not agreed upon for some databases, and difficulties in navigating multiple databases.

Key aviation safety issues in Africa

There has been a new impetus in the past decades to improve aviation safety in Africa. As Shila and Anne (2015) said, «Aviation safety implementation in the African region is essential as air transport is expected to play a key part in the region's economic growth through a variety of means such as the transportation of passengers and cargo to and from the region.»

Issues arise at two levels: at the level of civil aviation authorities and at the level of the industry, namely airline operators and service providers.

A) Issues at the level of Civil Aviation Authorities:

They are of multiple origins.

Inconsistent implementation of the ICAO Standards and Recommended Practices (SARs): This inconsistency is reflected in the absence of clear aviation laws that organize civil aviation and define the powers of the civil aviation authority in terms of regulation, supervision, and enforcement. This legislative weakness leads to the absence of national aviation regulations that comply with the standards and recommended practices of ICAO, the governing body for both international and domestic flights.

Reduced regulatory oversight of civil aviation authorities: The decrease in oversight is primarily due to the lack of financial, logistical, and human resources to supervise aviation industry activities. Civil aviation inspectors are financially and logistically limited to conducting oversight activities, which are central to maintaining high safety levels in a state's aviation industry.

*Inconsistent continued education and training of Civil Aviation Inspector*s: Some civil aviation inspectors are not up-to-date with their training and are limited to conducting effective inspections of aircraft and assessment of pilot qualifications, for instance.

Lack of an accident investigation office for the continent and lack of modern equipment to conduct serious accident/incident investigations: Civil aviation authorities do not always have an investigation office with trained inspectors who can probe incidents and accidents and draw safety conclusions to be used to improve the safety level and decrease incidents and accidents. *Insufficient airport infrastructure and supervision of airport subcontractors and lack of primary and secondary radars for air traffic controllers*: The aerodromes and control towers are insufficiently equipped. Also, primary or secondary radar and security around the runways, such as adequate fencing, are lacking, which results in numerous runway incursions. These safety issues pose a risk to aircraft and passengers as well as to the local populations who often find themselves in traffic areas.

Inconsistent weather forecasting: There is an insufficiency of funding and qualified personnel for weather services and forecasting from civil aviation agencies. Weather reports are sometimes not from approved sites.

B) Issues at the level of the aviation industry

The main issues with industry entities like airline operators and service providers that hamper the improvement of aviation safety are the following:

Non-compliance with the complete airline certification process as per ICAO Annexes and Doc 8335: Airline operators don't always undergo the complete certification process, which leads to a frequent use of derogations. Some domestic airline companies do not have an Air Transport Certificate (ATC) and operate under derogation regimes that reduce safety margins.

Industry visits organized as part of ICAO's USOAP audits have demonstrated inconsistent compliance with regulatory requirements from several African airline companies.

Inconsistent follow-up in maintaining crew member competency: The lockdowns caused by the COVID-19 pandemic have negatively impacted the flight status of pilots with regard to their maintenance of competence and recent experience. The difficulties of travel to the simulators have resulted in exemption regimes, which are unfortunately becoming the rule. For instance, we still observe cases of pilots who have not carried out the regulatory exercises in the simulator since the end of the pandemic was declared.

Difficulties in maintaining aircraft: Some airlines cannot keep up with scheduled maintenance. Maintenance checks are sometimes delayed for financial reasons, and spare parts are difficult to source. The maintenance program recommended by the manufacturer and approved by civil aviation authorities is implemented to varied degrees. Airlines facing serious financial difficulties seek to survive by making savings in maintenance costs. For example, some equipment on the MEL (Minimum Equipment List) would remain out of order beyond the regulatory deadlines, and some aircraft are not equipped in accordance with their type of operation, such as the lack of ELT (Emergency Locator Transmitter) or GPWS (Ground Proximity Warning System).

The dearth of operational fundamentals in the organizational structure of airline operators: The accountable managers are often appointed and lack technical qualifications to occupy positions that involve aviation safety responsibilities. In addition, airlines have not implemented a positive safety culture inspired by the Safety Management System (SMS) and the aviation industry’s safety strategies and best practices.

Aging fleets: aircraft are usually twice as old on average compared to Europe or the USA. There is a lack of modern aircraft in the fleet of many African airline operators. Apart from the fleet of two or three African airline operators, aircraft usually are two or three times older on average than aircraft of airline operators in Europe or the United States. The aging fleets lead to very high maintenance costs, with airline operators in Africa incurring elevated costs to bring their fleets up to international standards to comply with noise abatement or CO2 pollution requirements.

Expensive security deposits are required for transactions with African airline operators, and insufficient cash flow is affecting the sustainability of operations, especially after the COVID-19 pandemic. Several African airline companies have very tight financial accounts. There is no maintenance reserve, and spare parts are purchased only after the aircraft breaks down. The steering wheel of spare maintenance parts such as wheels and consumables is minimal. Vendors or resellers of spare parts take advantage of this situation to overvalue the parts when aircraft are in « Aircraft On Ground » (AOG) status. Even burst tires during a domestic flight can interrupt operations for several days.

Portfolio diversification: Airlines doing cargo and passenger operations fared better during economic downturns. The business model of many airline operators is similar to that of non-aviation businesses, which is an unsustainable practice due to the fact that reserves are not built up while funds are used for current expenses such as spare parts, fuels, rent, and salaries.

Proposed solutions for the improvement of aviation safety in Africa

Tangible improvement in aviation safety in Africa can be achieved if simultaneous and synergistic progress occurs simultaneously at the level of the civil aviation authorities of African countries and at the level of the industry’s airline operators and service providers, with the establishment of clear performance indicators and solution-driven safety culture at the core of all actions.

Given that air transport involves cross-continental flights in addition to domestic flights, improvement of aviation safety in Africa must also include continental initiatives as well as regional and national initiatives. Drawing from the author’s intercontinental aviation experience and expertise in aviation safety through projects led in Africa, the following proposals can help raise aviation safety level in Africa:

Establishment of an African continental safety body: This body will a) issue harmonized aviation standards for African countries almost similar to the European Union Aviation Safety Agency (EASA), b) enhance the efficiency of the work of existing regional African safety bodies, which are under-staffed and lacking funds and c) with support from aviation entities like the Federal Aviation Administration (FAA), EASA, and the Flight Safety Foundation in terms of training, logistics and On-the-Job Training (OJT) make a huge difference.

The newly established continental safety body will draft a common regulation that will make possible regional supervision and facilitate the implementation of the single market of air transport in Africa. It will harmonize the work of the existing regional African safety bodies. Some initiatives are currently underway, such as Cooperative Development of Operational Safety and Continuing Airworthiness Programme (COSCAP), Agency for Aerial Navigation Safety in Africa (ASECNA) and Autorités Africaines et Malgache de l’Aviation Civile (AAMAC – Civil Aviation Authorities from Africa and Madagascar), but the recurring problem is the financial viability of these structures that remain fragile because they depend on the contributions of Member States.

As with the EASA, the continental safety body would not replace the States’ civil aviation authorities but have a precise mandate in certain domains, such as safety supervision, by mutualizing the existing resources. The regional offices of ICAO, African Civil Aviation Commission (AFCAC), and IATA, through their Global Aviation Safety Plan (GASP) or IOSA, for instance, could provide technical support to this newly-formed African aviation safety body that will not take away the States' sovereign authority.

Continuous capacity building for Civil Aviation Inspectors: The proposed Continental Safety Body would be responsible for training inspectors who will work at the continental and state level. Training records will be kept at the continental level, and each inspector will be evaluated annually. Wages and working conditions will be harmonized as a great incentive for inspectors.

*Development of airport infrastructure and acquisition of ground equipment***:** African countries should increase the budget allocated for the development of airport infrastructures and ground support equipment (control towers, primary and secondary radars, firefighting, search and rescue equipment, emergency response plan kits). The African Development Bank Group (AfDB), which finances numerous airport infrastructure projects in Africa, should involve local communities in the environmental sustainability and long-term viability of these infrastructures. Networking partnerships and twinning arrangements between African airports and USA airports are recommended as they will ease the implementation of high-level security procedures in African airports. Some twinning agreements are in progress and should be expanded to allow more airports in Africa to undergo the FAA's Category 1 Assessment.

Organizational restructuring of African airlines: Focus must be placed on the restoration of the operational foundations. It requires a) effective implementation of Safety Management Systems (SMS) while relying on a new solution-driven safety culture based on self-reporting as well as proactive and predictive approaches to address operational risks, b) integration of the IATA Operational Safety Audit (IOSA) Program as a baseline for the safety level for airline operators and c) promotion of networking and code-shares agreements between airlines in the USA and Africa and sharing of safety best practices. In abiding by aviation regulations as a baseline for safety, airlines will be able to add safety performance indicators to their compliance checklist. Safety performance can be achieved through the implementation of Flight Data Analysis (FDA), Flight Operational Quality Assurance (FOQA), Runway Excursion Risk Reduction (RERR) tool kit, and Control Flight into Terrain (CFIT) prevention measures, for instance.

Modernization of airline fleets: This can be achieved by changing the practice of aircraft lessors using prohibitive leasing conditions and criteria based on "country risk level." Currently, the waiting time for new aircraft delivery is four to five (4-5) years for many African airlines. Reducing costs of new aircraft and spare parts and excessive acquisition delays would be very helpful. The African Development Bank is setting up a purchasing platform for aircraft and spare parts, and manufacturers and spare parts brokers should support this initiative. New communication, navigation, and search and rescue requirements (per ICAO Annexes) call for new equipment, and for older fleets, it is very costly to bring up to Airworthiness Directives (AD) standards.

Adoption of efficient financial model for airline companies: Implement secure, effective, and cost-efficient financial services and adoption of modern retailing standards (usage of Artificial Intelligence (AI)). Implement airline financial management training for airline staff. Allow flexible repayment terms and set up maintenance reserves.

Implementation of a continental aviation single market: There are existing initiatives for integrating regional aviation markets in Africa that can mutualize resources, which will foster the improvement of aviation safety. There must be an enhancement of air connectivity and boosting of economic growth across the African continent. An increase in competition that leads to lower airfares, improved services, and greater choices for travelers in Africa is beneficial. There should be facilitation of travel for tourists, domestic and international, as well as a maximization of the efficiency of SAATM (Single African Air Transport Market), a project of the African Union Agenda 2063, by involving African aviation safety experts. More positive actions include reduction of transportation costs, enhancement of supply chain efficiency, promotion of intra-African trade, regional infrastructure development, integration and unity, and promotion of environmental sustainability to achieve the “Net Zero by 2050” emission targets agreed to by industry and the UN’s International Civil Aviation Organization (ICAO) member states.

Conclusion

The world has become a “small village” thanks to the easy movement of persons and goods. Improving aviation safety in Africa is feasible and involves global actions, reflected by the African proverb that “a bundle cannot be fastened with one hand.” Air transport incidents and accidents that happen in one part of the world affect the entire world, given the various nationalities of passengers.

As Cox (2018) said in USA TODAY, «African aviation has some challenges. Some operators use older airplanes, and the maintenance is not up to global standards. The environment can be problematic, and some airports on the continent lack good infrastructure. These elements, in combination, result in a higher accident rate than in other parts of the world. Despite these challenges, aviation safety in Africa has improved over the years. There are some very dedicated safety professionals at work continuing the improvements. Overall, I would say that aviation in Africa is improving, but significant challenges remain. High-quality operators and regulators working together can make a big difference.» Certainly, the improvement of aviation safety in Africa is a matter of personal, national, continental, and diaspora pride for African stakeholders while also being a global endeavor of interest to the entire world.

The Single African Air Transport Market (SAATM) is a key step towards unlocking Africa’s economic potential and improving safe connectivity both within the continent and with the rest of the world. As reported in Aviation Pros (2020), “The International Air Transport Association (IATA) and African Airlines Association (AFRAA) have joined forces with the African Civil Aviation Commission (AFCAC) on a three-year safety project. The objective is to provide technical support to the African air operators of states party to the Single Africa Air Transport Market (SAATM) to ensure that they achieve and maintain global aviation safety standards. The initiative is backed by African Development Bank grant funding provided to AFCAC and is specifically for carriers in countries that have signed up to the African Union’s (AU) flagship Single African Air Transport Market (SAATM) program. The project will identify eligible airlines, conduct gap analyses, and recommend corrective actions for each participating carrier to prepare them for IATA Operational Safety Audits (IOSA) or IATA Standard Safety Assessment (ISSA) evaluation.” Such initiatives would benefit from enlisting aviation safety experts from Africa, Europe, and the USA gathered in a task force aimed at maintaining the momentum for maximum impact.

Cox (2018) rightfully recognized two high-performing African airline operators when he said, “There are many good airlines operating in Africa, to name two: South African Airways and Ethiopian Airlines. I know pilots from both of these airlines, and both are committed to safety. Statistically, both of these airlines are on par with other global operators and are highly respected." Consequently, improving aviation safety in Africa means having more African airline operators with the same level of safety as South Africa Airways and Ethiopian Airlines. Also, having more aviation safety experts from Africa, like the author, involved in global and continental initiatives is vital.

Aviation safety in Africa is a hot topic, as the address from IATA's Regional Vice President for Africa & Middle East, Mr Kamil Alwadhi, at the Aviation Africa 2022 Summit in Kigali, Rwanda shows (Business and Financial Times Online, September 27, 2022). The author has been passionate about aviation safety in Africa for more than a decade, has worked on many improvement projects on the continent, and believes that it is possible to improve aviation safety in Africa by following the steps in the aforementioned analysis. The author hereby offers time and expertise for projects aiming at raising the level of aviation safety in Africa because the global interconnectivity of the issue means the entire world benefits when the level of aviation safety in Africa improves.

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UNIVERSITY AVIATION ASSOCIATION

Collegiate Aviation Review International

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Aviator Healthcare Hesitance: An Examination of Healthcare Avoidance, Pilot Mistrust, Presenteeism, & Risk

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Safe aviation operations require pilots to maintain constant physical and psychological well-being. While the FAA and pilot advocacy organizations encourage aviators to discuss health concerns with their medical providers, studies demonstrate continued healthcare hesitance behaviors. This article explores possible factors impacting aviator healthcare hesitancy, including pilot personalities, financial considerations, and pilot mistrust. After providing a background of these areas, the article turns to research into the impact of presenteeism within the community, along with its associated personal and operational safety risks. Ultimately, this article seeks to prompt and aid future research by providing an overview of the current literature on the prevalence and implications of healthcare hesitance in the aviation community.

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Civilian and military aviation operations require physical and emotional well-being for safe operations. As a result, pilots are periodically evaluated by specially trained physicians to determine their aviation fitness (Medical Certificates, 2022). These exams are designed to ensure pilots are free from physical or psychological symptoms that would compromise the safety of aviation operations. While regulators, unions, and advocacy groups have pushed for improved acceptance of previously disqualifying conditions and a reduction in mental health stigma (i.e., Geil, 2023; Federal Aviation Administration [FAA], 2023c), recent research continues to demonstrate a troubling trend of healthcare hesitance among the aviation community (Hoffman et al., 2019, 2021, 2022, 2023; Nowadly et al., 2019; Patel et al., 2023). These hesitancies may come from many sources, including pilot personality, financial considerations, and mistrust of regulatory agencies. As a result, aviators demonstrate a high propensity for presenteeism – the act of piloting aircraft with prohibited health symptoms – inducing unnecessary personal and operational risk in aviation operations (Hoffman et al., 2019, 2021, 2022, 2023; Johansson & Melin, 2018; Patel et al., 2023). This paper seeks to prompt and aid future research by providing an overview of the current literature on the prevalence and implications of healthcare hesitance in the aviation community.

Why the Hesitance?

“Roger” seemed to have it all. A graduate of the U.S. Military Academy at West Point, Roger led and commanded U.S. Army UH-60 ‘Blackhawk’ aviators in Iraq and Afghanistan. After nearly ten years of service, he decided to transition into the National Guard, fly as an Air Ambulance pilot for a local Emergency Services company, and start a family. He spent his free time at local beaches with his wife and their two young children while helping local veterans overcome their mental health symptoms by hosting sporting events and therapeutic writing seminars. He seemed to be the military aviation poster child – strong, outgoing, dedicated to service, and above all, resilient. However, without notice, Roger became another mental health statistic. But why? With so many avenues to get professional help from his employer, the Veterans Administration, his medical co-workers, and even peer support from the veterans he was helping, why was Roger unable to seek the help he needed? This is an example of the danger of healthcare hesitance.

For this article, healthcare hesitance is defined as a delay or refusal to seek needed healthcare services. Among the aviation community, research indicates this hesitance may stem from a fear of losing one’s medical certification to fly – a condition known as “grounding” (Hoffman et al., 2019, 2021, 2022, 2023; Johansson & Melin, 2018; Patel et al., 2023; Wu et al., 2016). Exploring the cause of this fear, three possible areas emerge - pilot personality, financial considerations, and a lack of trust.

Pilot Personality

Successful pilots often possess characteristics that can make help-seeking difficult. Additionally, aviation can become part of an aviator's psyche, making it hard to separate their hobby or profession from themself. These can negatively affect health-seeking tendencies.

Pilot Mindset

Personality characteristics that make individuals successful pilots can also make them hesitant to seek external care (Britt et al., 2016; Wu et al., 2016). Movies like Top Gun and The Right Stuff showcase these self-reliant, resilient, determined, and ego-filled attitudes. While these are characterizations of stereotypical aviators, there is truth in their projections. When in the air, pilots must have the confidence to rely on themselves and, perhaps, the one other pilot next to them. When mechanical or other issues arise in flight, they must have the determination to solve the problem on their own, along with the resilience to overcome adversities, as there is often no one else to turn to. Combined, these aspects can create the strong ego many associate with aviators (Albright, 2017; Wu et al., 2016). While these mindsets are helpful when overcoming adversities in flight, they can prevent pilots from seeking the mental and physical assistance they may need (Britt et al., 2016; Wu et al., 2016).

Pilot Identity

For many pilots, flying is more than a job. It is a passion (Fraher & Gabriel, 2014; Kurukulaadithya et al., 2023). Many have dreamed of being a pilot since childhood, looking skyward whenever they hear an airplane, even as adults. Adding to that, researchers have found commercial and recreational pilots that compare the sensation of flying to a euphoric drug-induced high, with some arguing it can be just as addictive (Kurukulaadithya et al., 2023). Having experienced these sensations while using the self-reliance and determination described previously to achieve this dream, being a pilot can become not just a career but part of their identity (Fraher & Gabriel, 2014). As such, the possibility of losing this aspect of themselves due to a medical issue can become unimaginable, causing some aviators to not even consider the possibility of seeking assistance, even for minor issues.

Financial Considerations

Financial considerations can also hinder healthcare seeking. Whether looking at the expense of medical treatments or the loss of income due to a medical suspension, pilots may feel forced to weigh both possibilities before reaching out for assistance.

Medical Expense

For aviation personnel, the costs associated with seeking medical care go beyond health treatment expenses. When an aviator is diagnosed with a disqualifying condition or seeks counseling for mental illness symptoms, regulatory agencies often require not only additional testing to verify their medical eligibility but also years of recurrent examinations to maintain their certification (Federal Aviation Administration, 2023b, Snyder, 2021; Weis, 2023). Costs for these additional evaluations can exceed $9,000 U.S. Dollars each and are often not covered by insurance (Pacific Neurobehavioral Clinic, 2023; Snyder, 2021; Weis, 2023).

These expenses can be especially true regarding required mental health evaluations and testing. As an example, a recent report details the journey of a former U.S. Army 'Chinook' Crew Chief who was previously diagnosed with PTSD but, with years of treatment, had been stable, symptom-free, and off all medication for many years. After spending six years and more than $30,000 of his own money on testing by FAA-approved experts, he is still without a medical clearance for recreational flying (Weis, 2023). As one can imagine, the threat of these costs deters aviators and prospective pilots from seeking assistance.

Lost Income

Another consideration affecting healthcare avoidance is the possibility of income loss. Pilots cannot exercise their profession without the required medical certification (Medical Certificates, 2022). While pilots for most major airlines can expect some income when grounded due to long-term disability insurance, commercial aviators without this coverage risk the loss of all wages until they gain recertification. Even those with disability insurance typically receive only one-half to two-thirds of their regular pay, and generally for one year or less (American Airlines, 2023; Southwest Airlines Pilots Association, 2016). One can imagine how these considerations could affect aviator healthcare-seeking tendencies.

Pilot Mistrust

Research indicates aviators' mistrust of both regulatory organizations and medical providers (Britt et al., 2018; Hoffman et al., 2019, 2021, 2022, 2023; Frantell, 2021; Nowadly, 2019; Wu et al., 2016). While the FAA has recently increased its mental health-related outreach to pilots and refresher training for aviation medical examiners, it is still to be determined if this is enough to overcome mistrust among aviation community members.

Organizational Mistrust

Most pilot-organizational trust issues appear to come from a negative presumption of any mental health counseling. When completing the FAA's MedXPress form, pilots are required to include all medical visits within the last three years (FAA, 2023a). While there are a few caveats for items that do not need reporting, including counseling not related to substance abuse or medical or mental health treatment, examinations, or evaluations, this item is often cited privately by aviators as a primary obstacle to seeking mental health support. Additionally, neither the MedXPress form for aviators nor the Guide for Aviation Medical Examiners provide guidance on what constitutes a treatment, examination, or evaluation (FAA, 2023a,b). This leaves initial interpretation up to the examiners and applicants, providing a gray zone many aviators appear unwilling to tread. Instead, recent research indicates a propensity towards seeking informal care to avoid disclosure (Hoffman, 2021, 2022, 2023; Daku, 2021; Nowadly, 2019).

Well-publicized FAA actions in 2002 and 2023 provide substance to pilots' organizational mistrust (Airplane Owners and Pilots Association [AOPA], 2007; National Business Aircraft Association [NBAA], 2023). Operation Safe Pilot in 2022 cross-checked social security disability information against aviation medical disclosures (AOPA, 2007). This resulted in 3,220 pilots receiving notices of investigation for making false statements with possible punishments, including criminal prosecution, loss of their medical certification, and possible nullification of earned aviation qualifications. Only 40, or 1.24%, were ultimately prosecuted, but this appeared to reinforce aviators' fear of the FAA medical system (AOPA, 2007). This year, nearly 5,000 current and former military members found themselves in a similar situation when the FAA cross-checked medical applications to VA disability records (NBAA, 2023). Nearly 75% have already been cleared, with only 1.25% told to stop flying until further evaluations can be conducted. The discrepancy between the number initially notified versus the number instructed to stop flying (4,800 versus 60) appears to have re-emphasized caution in the aviation community about the risk of seeking assistance that could require reporting (NBAA, 2023).

Provider Mistrust

Since most aviators do not deal directly with federal regulators, much of the mistrust is exposed at the provider level. A recent study among U.S. Air Force pilots found that only 57% were comfortable reporting minor issues with their flight surgeons, and only 44% were comfortable discussing major, grounding-level issues (Nowadly et al., 2019). Interestingly, when asked about 'Other Pilots' in their unit, 87% believed they would withhold minor issues, while 74% stated they would withhold grounding qualifying conditions. When exploring the pilot-provider relationship, 48% stated that regulations negatively affected the connection with their flight surgeon, with greater transparency of certification and waiver processes as a possible remedy.

Healthcare Avoidance Prevalence

Research into healthcare avoidance by Hoffman et al. (2019, 2021, 2022, 2023) highlighted the prevalence of healthcare avoidance among recreational, commercial, and military pilots alike. The four-question survey asked participants if fear of losing their medical certification had caused them to seek informal care, fly with new symptoms that should have been evaluated, fly when on medication that required approval, or withhold or misrepresent their medical status. The results demonstrate the depth of aviator avoidance, with nearly 76% of military pilots and 70% of unionized commercial pilots reporting 'yes' to at least one question. Almost 44% of unpaid recreational pilots reported the same. Additionally, 15% of respondents chose not to answer at least one of the questions. Seeking informal care was the top response, with 46% of all pilots and 56% of military pilots self-reporting this tendency, followed by withholding or misrepresenting medical information by 27% and 43%, respectively.

Presenteeism and Risks

Healthcare hesitance, regardless of the reason, can result in presenteeism, the act of presenting at work when one should call out sick (Johansson & Melin, 2018). As one can imagine, flying under these conditions increases both personal and operational risks. A study of European airline pilots found that 63% reported conducting such activities within the previous 12 months. Of those reporting presenteeism, 69% also reported making errors associated with their degraded physical or mental state while in flight. Additionally, while 65% reported taking sick leave in the past year, only 25% had done so for non-physical ailments.

Exploring the psychological effects of healthcare hesitance, a 2016 study of airline pilots found that 36% reported experiencing up to seven poor mental health days per month (Wu et al., 2016). The rate for those aged 41-50, that of a typical airline Captain, was 44.5%. The research additionally found that nearly 14% of Airline Transport Pilot participants screened positively for clinical depression, with 4% reporting suicidal thoughts within the previous 14 days. These findings suggest the need for research into overcoming barriers to seeking both physical and mental healthcare.

The Good News?

Reading these negative impacts of healthcare avoidance can be disappointing, but there is some good news – pilots want to seek help. One study on healthcare avoidance found that nearly 75% of pilots who reported at least one avoidant behavior also stated they would use alternatively sanctioned interventions if they were available (Hoffman, 2021). Additionally, 63% of non-avoiders stated they would also welcome alternative options. In a separate study of collegiate aviators, up to 69% said they were willing to use an anonymous hotline to get mental health assistance if one was provided (Daku, 2021). Almost half of the participants stated they would still use the service, even if they could be identified if they were deemed a risk to themselves or others. Ultimately, this indicates a willingness to seek help if it is provided in a format that provides pilots with psychological safety.

Future Research Needs

While this paper explored the current state of healthcare hesitance research, more focused studies are needed. Little is known regarding the extent to which organizational and social stigma, pilot attitudes, and institutional or instrumental barriers play a role in healthcare hesitance. How might age, gender, and participation in different career fields influence these barriers? Additionally, what types of alternative interventions do aviators consider acceptable? Mindfulness training, Transcendental Meditation, and internet-based cognitive behavioral therapy have demonstrated effectiveness in reducing mental health symptoms without direct engagement with medical professionals (Bostock et al., 2019; Hadjistavropoulos et al., 2021; Nestor et al., 2023). Could these options provide the alternative interventions aviators are seeking? While there is at least one study exploring barriers to mental healthcare and the perception of alternative treatments among U.S. Army Aviation personnel, similar research on other aviation populations is needed.

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Applying UAS Technologies at Night during a Wildlife Hazard Assessment

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Airports operating under the Code of Federal Regulations Part 139 should conduct a wildlife hazard assessment (WHA) when some wildlife-strike events have occurred at or near the airport. The WHA must be conducted by a Qualified Airport Wildlife Biologist (QAWB). The required elements in a WHA include the identification of the wildlife species observed and their numbers and the location of features on and near the airport that could attract wildlife. The collection of data pertaining to mammal populations during a WHA is generally time-consuming, labor-intensive, and costly. Protocols to collect this data include trapping and marking animals and systematic surveys using a spotlight and/or night vision equipment. The purpose of this study was to investigate how UAS technologies could be effectively applied to streamline the QAWB efforts during a WHA at night. Researchers, including students, used a DJI Mavic 2 Enterprise Dual with visual and thermal cameras and a spotlight, as well as a Matrice 210 with a Zenmuse XT2 thermal camera to collect data. Data were collected in a farmland area located two nautical miles south of Daytona Beach International Airport. We applied multiple strategies to mitigate the risks associated with drone operations in an airport environment. The safe application of UAS to streamline the WHA process is anticipated to provide several benefits to the airport operator, including task completion in reduced time, enhanced level of accuracy during the data collection process, reduced risks for the QAWB, and cost efficiencies. Most importantly, researchers expect to develop benchmark safety protocols that can facilitate the effective integration of UAS into the airport environment.

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Background and Problem Statement

The Federal Aviation Administration (FAA) Wildlife Strike Database released a composite ranking of the fifty most hazardous wildlife species to aviation operations (FAA, 2018). Counterintuitively, the highest-ranked wildlife species on the list is not a bird but a terrestrial mammal: the White-tailed deer. Although terrestrial mammals only account for 2% of total reported strikes, their potential to cause irreparable damage to aircraft, injury, and/or cause casualties is substantial. For example, collisions with White-tailed deer destroyed 24 aircraft, caused 28 injuries with one fatality, and cost $56,078,745 in economic losses from 1990 to 2021. Previous studies have also identified a positive relationship between the body mass of an animal and the likelihood of a damaging strike (Dolbeer et al., 2023; Pfeiffer et al., 2018). Similarly, there is evidence that supports a higher risk of strikes with terrestrial mammals at night (Dolbeer et al., 2023). It stands to reason that most terrestrial animals listed in the FAA's wildlife composite ranking tend to be crepuscular (most active before sunrise and after sunset) or solely nocturnal. Herein lies an opportunity to enhance current Wildlife Hazard Assessments (WHA) during periods of darkness.

Under the Code of Federal Regulations (CFR) Part 139, whenever a wildlife strike occurs on or near an airport, the owning airport operators are required to conduct a WHA to develop an effective Wildlife Hazard Management Plan (FAA, 2018). The WHA is a formal assessment conducted by a qualified airport wildlife biologist (QAWB) to observe and identify wildlife species, quantify their numbers, track their movements, and identify locations around the airport that could be potential attractants to wildlife (FAA, 2020). This approach, however, has several limitations that could be mitigated with the innovative technology that unmanned aircraft systems (UAS) provide (Hamilton et al., 2020a, 2020b, 2020c). For instance, traditional ground-based exploration (often with the assistance of binoculars) does not offer a bird's-eye view of wildlife, nor are the locations necessarily conducive to reach by vehicle or on foot (e.g., wetlands, marshes) (Cabrera et al., 2021). Furthermore, these assessments fail to capture the nocturnal nature or congregations of large-massed animals that have emerged as more dangerous to aircraft operations.

Information obtained from the scientific analyses of wildlife strikes to aircraft has indicated that different safety strategies to mitigate such risks are vital (Misra et al., 2022; Tella & Mendonca, 2023). According to Mendonca et al. (2020), these strategies should include research and innovative use of current technologies. The purpose of this study was to explore the use of UAS technologies at night by developing and refining a concept of operations to support data collection and analysis during a nighttime WHA. The researchers hypothesized that the use of UAS technologies could streamline the WHA processes during periods of darkness and provide "sight" to benchmark safety protocols to facilitate the effective integration of UAS into the airport environment.

Methodology

Drawing from a previous UAS exploration study (Cabrera et al., 2021), the researchers implemented the Concept of Operations (CONOPs) by shifting the wildlife observation window to the hours of twilight leading into nightfall. The elements of the UAS CONOPs include methods of operation (e.g., flight plan) and Safety Risk Management (SRM) protocols (Hamilton et al., 2020a). Through the development of CONOPs for a WHA at night, the researcher conducted all applicable pre-mission checklists, which included hazard identification and risk mitigation. For example, prior to the night operations, a pre-mission brief was held to organize the team into their respective roles for the evening, and safety precautions were taken. Lastly, an after-action review (AAR) was held to refine the CONOPs for potential improvements to the processes and procedures.

Coupled with the technical assistance of a QAWB (via Zoom meetings), a small team of undergraduate students assisted with data capture, visual observing, flight operations, and data analyses. This study employed a DJI Matrice 210 with an XT-2 thermal camera to achieve the thermal imaging requirement. The team used a dedicated trailer to house the necessary equipment to ensure optimal research procedures, such as an Automatic Dependent Surveillance–Broadcast (ADS-B) flight box, in concert with ForeFlight to monitor neighboring manned air traffic; and two television monitors, one to display ForeFlight information, and the other, connected to the drone's controller via a high-definition multimedia interface (HDMI) cable to mirror the drone's screen. It is noteworthy to mention that at least one member of our team stayed inside the trailer during the entire data collection process monitoring the live traffic feed and communicating (i.e., walkie-talkies) with the drone's pilot and the visual observer (VO) (Cabrera et al., 2021).

Our team adopted SRM procedures to help mitigate the possibility of conflicts between manned aircraft operations and UAS during the data collection process by including Geofencing, a visual observer (Hamilton, 2020a, 2020b, 2020c), and by conducting UAS flights below 300 feet above ground level (AGL). Moreover, the person inside the trailer monitored one TV set and wrote down any necessary observations (e.g., wildlife activities) on a Wildlife Survey – Airport Observation Sheet (WSAOS) in coordination with the drone's pilot and VO (see Cabrera et al., 2021).

The site for the study is located 1.67 nautical miles south of the southernmost boundary of the Daytona Beach International Airport (KDAB). This location is in accordance with the recommended five statute mile radius of an airport's air operations area (AOA) (FAA, 2018). This farmland is surrounded by large trees, fields, and other farmlands that are prone to various kinds of wildlife species, including "large birds" (e.g., Sandhill Cranes) and especially cattle and boars roaming the field. Worth noting is that aircraft operations close to that location are intense (at ≥ 1,000 feet AGL), especially flight training (FAA, 2023). This factor added significantly to the complexity of this project as proof of concept to integrate UAS operations in the area successfully without incident.

To obtain the best possible outcomes, the test flights first used both automated and manual flight modes. The first mode was projected to provide a baseline of the area and thermal signatures of resting objects (e.g., presence and location of mammals) by scanning in a grid-like pattern via the "DJI GS Pro" software. This software allows the user to create flight plans track, and store telemetry data in real-time. The second mode of flight then shifted to manual operations whereby the pilot-in-command (PIC) would observe and loiter over areas of interest. A mixed method approach was utilized during the analyses of the collected data to identify what, if any, added benefits there were to the methodology of the research project. Qualitative analyses helped identify the following:

1. The workflows and best practices for applying UAS technologies during a WHA at night;
2. Whether UAS thermal imaging was effective in the detection of wildlife during periods of darkness and
3. Whether UAS thermal imaging was effective in identifying the land uses and habitats at the data collection area that are potentially attracting hazardous wildlife to the airport environment.

Significance of the Study

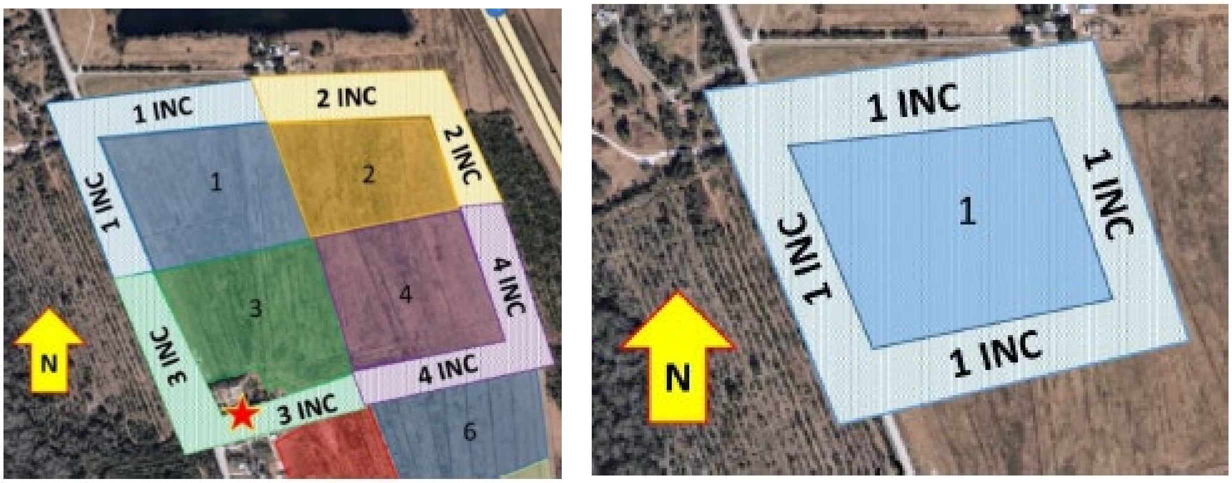
The most exciting aspect of this proof of concept is that it merged UAS technologies with WHA at night. To the knowledge of the researchers, this had never been done before. Thus, this project offered a unique opportunity to test the efficacy of thermal imaging to study the behaviors of terrestrial wildlife as well as possible environmental attractants for wildlife that are uncommonly observed during periods of low illumination. Historically, wildlife surveys conducted at night use trapping and animal marking techniques, which are highly invasive (FAA, 2018). Other methods call for night vision equipment that does not adequately penetrate the landscape or vehicle-mounted spotlights that potentially pose a hazard to low-altitude aircraft, other vehicles, or airport towers if pointed inappropriately (FAA, 2018). Hence, the use of UAS technology is a less intrusive means to assist with wildlife surveys and from an aerial perspective that extends beyond conventional practices. For our team, which included students, other benefits included collaboration in a research project addressing major safety issues afflicting the U.S. aviation industry, which is in alignment with the FAA (2022) mission (1), values (2), and vision (3):

1. Provide the safest, most efficient aerospace systems in the world;
2. Foster creativity and vision to provide solutions beyond today's boundaries and
3. Demonstrate global leadership in how the FAA safely integrates new users and technologies into the National Airspace System (NAS).

Key Findings

The findings from this study confirmed several key assumptions. One component of the CONOPS was to test flying at altitudes of 300, 200, 100, and 50 feet AGL in each quadrant of the research area, namely quadrants 1-4 (see Figure 1), to test the efficacy of thermal detection of animals. In Figures 2a and 2b, the presence of large-massed animals is clearly visible from as high as 300 feet AGL. The thermal signatures increased in visual clarity as the drone pilot descended to lower altitudes of observation (shown in Figures 2c and 2d).

Figure 1
Data Collection Area - Operational Quadrants



Note. The abbreviation "INC" is an adopted QAWB term for incidental or outside of the main area of observation.
Note 2. The color-coded areas were notional boundaries to help organize the observer's notations for the WSAOS and were not exact dimensions.

Figure 2
Images of Cows Obtained with a Thermal Camera

Note. Images obtained at ~300 feet AGL (2a and 2b) and at ~50 feet AGL (2c and 2d)

As expected, the drone was not only able to detect the presence of animals at multiple vantage points, but it was also able to overcome obstacles such as dense vegetation by climbing above the terrain. Throughout the duration of this project, the operational area went through various phases of grass and weed heights. A QAWB could have to traverse through potential physical obstacles to obtain the images and other data that are necessary for a WHA. Dense vegetation, for example, could pose additional hazards for QAWBs by subjecting them to terrestrial dangers such as sinkholes/depressions or snakes that are hidden from view.

Traditional ground-based methods of WHA data collection are limited in their ability to capture crepuscular animals during periods of darkness. As referenced earlier, the use of mounted spotlights to capture retinal eye glint trapping and tagging animals are some of the current practices for nighttime WHAs (FAA, 2018). Though some of these means may still be viable, the evidence strongly suggests that the use of UAS technologies is very capable of bestowing "sight" for large-massed animals at night. To demonstrate the disparity of the naked eye and thermal imaging, a side-by-side comparison is presented in Figure 3.

Figure 3
Comparison between Naked eye (3a) and Thermal Imaging (3b)

Another item to note is that from the ground-based horizon, a QAWB may not detect the presence of animals with the naked eye or even with binoculars due to high vegetation and or man-made structures. Even with a high-powered flashlight, the detection of animals was not feasible. It was only upon overhead thermal detection that the presence of nearby animals was discoverable (see Figure 3b). In addition to the advantage of viewing animals without the use of spotlights and invasive trapping techniques (FAA, 2018), the UAS vantage points, coupled with a camera/video feature on the drone, demonstrate the benefit of recording the observed number of animals. Instead of relying on estimations of moving targets as suggested by the FAA (2018), the QAWB can revisit the images and provide a more detailed account of the numbers and species of animals detected (see Figures 2 and 3b). Moreover, without the advantage of drone technologies and thermal imaging, a QAWB could lose valuable data that might go unaccounted for.

Lastly, our findings suggested that the SRM protocols helped our team mitigate the risks associated with UAS technologies during a WHA at night. Nonetheless, we acknowledge that there are risks associated with UAS operations at and around an airport environment. Thus, the ConOps should be periodically revised to incorporate procedures that improve aviation safety and efficiency.

Limitations

Though this research project was viewed as a proof of concept, the ability to fully test the effectiveness of incorporating UAS technologies during a WHA at night could not be fully ascertained. The QAWB that was consulted for this project could not physically attend. Hence, this study attempted to simulate what a conventional WHA would entail. However, without the on-site expertise of a QAWB to confirm the observations, the WSAOS stood to lose some of its potency based on the inexperience of the researchers. Likewise, the research location, though ideal from the perspective of distance from the neighboring airport and the intent to safely operate near low-flying aircraft, had a limited diversity of animal species. This could be in part due to the heavily trafficked two-lane highway that lined the outer limits of the operational area. Relatedly, the relative size of the animal is also a factor. There were instances where a thermal signature was detected; however, due to its size and the inability of the XT-2 thermal camera to zoom in from its lowest prescribed altitude, the object could not be discerned. The only means to get closer to obtain a better view is to lower the drone, which can have an adverse effect.

Moving the drone closer to the animals posed another concern for detection and/or potential disturbance to the wildlife. The cows did not appear to show any agitation or signs of unease, regardless of the drone's proximity to them. That said, there was an occasion where two coyotes were observed. As the drone operator moved in closer to get a clearer thermal resolution, the coyotes would periodically stop, curious about the signature sound of the drone's humming propellers (some have equated to the sound of a beehive), and would attempt to flee. Thus, the presence of drones may not always prove to be discreet enough for all animal observations.

Though drones have much potential to be an asset to WHAs, they have limitations. Weather is a contributing factor to the success of a drone operation. There were several lightning storms and late afternoon to evening showers this past summer. The inclement weather meant that the drone could not operate under these conditions, but the ability to set up the operations trailer and equipment was compromised due to the muddy terrain of the study area. Furthermore, drones are not the only consideration but the people who must operate them. There were numerous high heat advisories that threatened to cause heat-related causalities to the research team if the warnings were not observed.

Conclusion

The purpose of this study was to explore the use of UAS technologies at night by developing and refining a concept of operations to support data collection and analysis during a nighttime WHA. Through the capabilities of UAS technologies, the team was able to obtain wildlife data and information in locations that were potentially difficult to access by ground-based means. Moreover, the drone's technologies were able to observe and identify animals that would be very challenging for historical QAWB methodologies due to natural structures (e.g., tall trees, dense vegetation). By way of aerial advantage and onboard camera/video, UAS can provide vital information capture that QAWBs could use for later analyses and accounting. Lastly, UAS technologies will not likely remove the QAWB from the WHA equation; rather, it would serve as another tool to facilitate more timely assessments, remove unnecessary risks to the QAWB over terrestrial limitations, and enhance the clarity to observe large-massed crepuscular animals at night.

Future Studies

The opportunity to use UAS technologies with the real-time supervision of a QAWB during an actual WHA during nightfall would greatly appreciate the validity of this technology. At present, this study was simulated based on the suggestions and guidance of a remotely located QAWB via Zoom. Only through the practical application of an actual WHA can UAS technologies be fully vetted by a QAWB to verify the efficacy of their potential benefit. Every effort should be made to assemble a team to assist a QAWB during a WHA or to host a QAWB to test the merits of UAS technologies for nighttime WHA. Lastly, future studies should collect data in a year timeframe to investigate the impact of the seasons of the year on the presence and behavior of terrestrial mammals in the data collection area.

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