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The Impact Of Safety On Fleet Acquisition And Management In U.S Commercial Airlines

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THE IMPACT OF SAFETY ON FLEET ACQUISITION AND MANAGEMENT IN U.S COMMERCIAL AIRLINES

by

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ABSTRACT

The topic of aircraft safety is pervasive in many domains of the airline industry and it influences all types of air transportation operations. Aircraft acquisition and fleet planning are key functions in a commercial airline to ensure the achievement of the airline's operational goals such as matching capacity with demand. With fluctuations in passenger demand, it is vital to strategically plan an airline's fleet to best accommodate these changes and to safely do so. Existent literature suggests that aircraft safety is factored into passenger decision to choose an airline which then impacts the economics of an airline. The purpose of this study is to explore the impact of safety on fleet acquisition and management processes in commercial airlines in the U.S. The findings suggest that safety plays a major role in the aircraft acquisition and fleet management activities in commercial airlines and generates contributory variables that influence and are influenced by safety events in relation to an aircraft type. The results from this study serves as a conceptual framework for commercial airlines to better gauge the crucial elements that drive fleet planning decisions and to effectively execute strategic fleet management decisions.

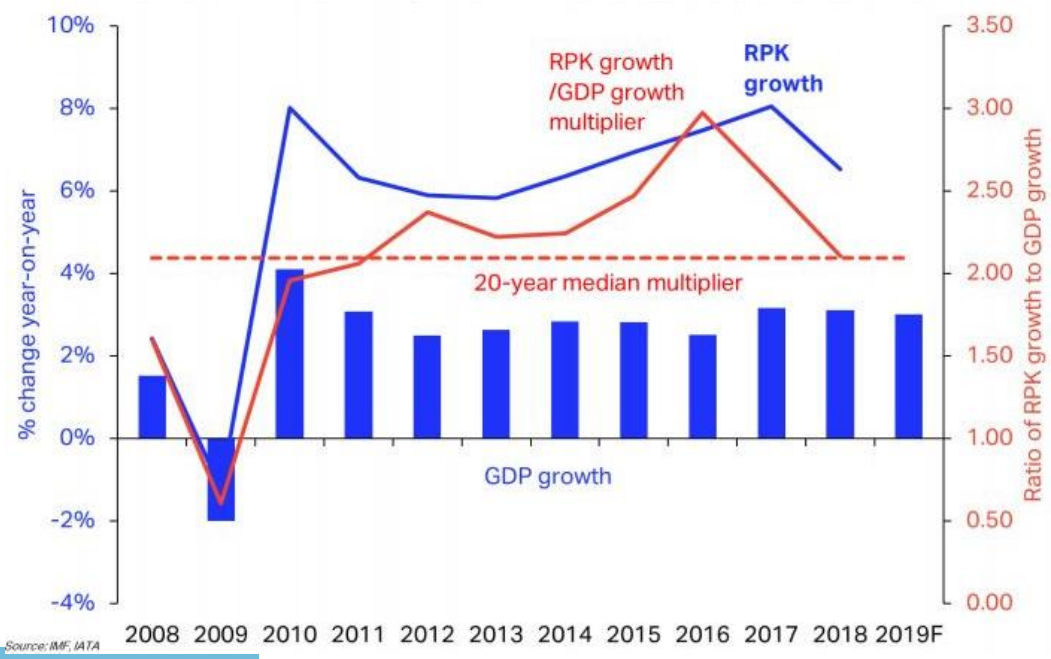
CHAPTER I

Introduction

Air transport industry players such as commercial airlines continue to play a vital role in the global socio-economic development. Clark (2007) describes the commercial airline industry as "complex organizations engaged in the daily miracle of safely moving millions of people and goods by air from one place to another. They walk a never-ending tightrope separating financial success and ruin" (p. 1). The International Air Transport Association (IATA) suggests a rise in passenger throughputs and demands for air travel over the past years from 2013-2018 in an economic review on the global air travel and GDP multiplier (IATA, 2019). Figure 1 below demonstrates the percentage of change in air travel recorded over a 11-year time period.

Figure 1

Global Passenger Traffic (RPK) & Global GDP (IATA, 2019)



The analysis utilizes revenue passenger kilometers (RPK) as a unit of measurement. RPK is defined by the distance travelled by revenue passengers (ICAO, n.d). Typically, the RPK for an air carrier is calculated by the "sum of products obtained from multiplying the number of revenue passengers carried on each flight stage by the corresponding stage distance" (ICAO, n.d). The economic analysis in figure 1 also indicates the fluctuations in the world gross domestic product (GDP) growth in relation to air traffic over the given time period. Even with the decline in GDP following the Great Recession and a spike in 2010 due to government stimulus packages, world GDP has remained in a fairly growth phase. The growth in passenger throughput has remained above the long-term average of 5.5% signaling an above-trend in passenger traffic in the future.

Globally, commercial airlines carried 4.1 billion passengers on scheduled services with an increase of 7.3% over the year of 2016 (IATA, 2017). The Global Industry Report published by IATA captures the immense economic benefits of the commercial airline industry to global GDP and this quote highlights the point "If aviation were a country, it's gross domestic product (GDP) would be similar to that of Switzerland's at around USD 660 billion" (IATA, 2017, p.7). Furthermore, Federal Aviation Administration (FAA), the regulatory agency of commercial aviation industry in the United States (U.S), states that commercial aviation accounts for more than 5% of the U.S GDP and contributes about USD 1.6 trillion in total economic activities (FAA, 2016, p. 3).

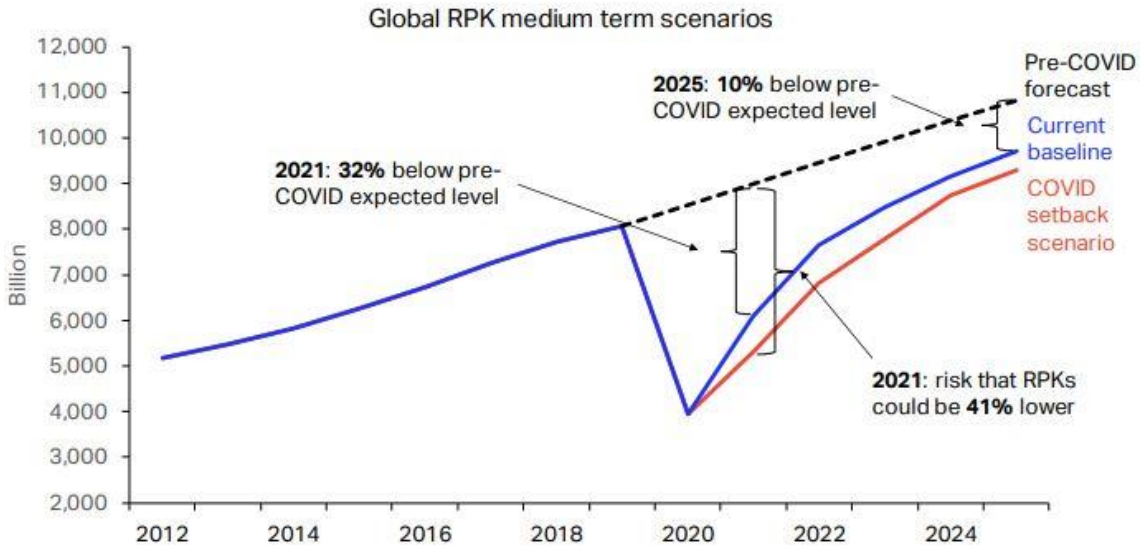
As part of the air transport industry forecast for the next 20 years, IATA anticipates an increase in passenger throughput of 8.2 billion movements in the year 2037

which has potential economic and social benefits to global GDP (IATA, 2018). Another key metric used in the calculation of passenger traffic in air transportation is revenue passenger miles (RPM) which defines the "number of miles traveled by paying passengers" (Kenton, 2020). RPM is calculated by multiplying the number of paying passengers by the distance traveled (Kenton, 2020). Utilizing this metric, the FAA predicts an increase in RPM of total mainline and regional air carriers up to USD 1.61 trillion by year 2039 (FAA, 2019).

However, these projections have been significantly altered since the onset of this study due to the impact of COVID-19 global pandemic. COVID-19 is a respiratory disease produced from the SARS -Cov-2 virus and can be easily transmitted through human contact (CDC, 2020). Due to its widespread nature and high infection rate, COVID-19 has impacted many industries including the air transportation sector (Nizetic, 2020, p. 3). Figure 2 below illustrates the return to growth forecast of RPK in the upcoming years following the pandemic.

Figure 2

Return to Growth Post- COVID-19 (IATA, 2020)



The projected RPK at year 2020 was forecasted to be around 8,500 billion and 10,200 billion RPK by 2024 (IATA, 2020). However, the current baseline of RPK in 2020 sharply drops to an estimated 4,000 billion displaying the immense influence of the pandemic on the air travel industry. Furthermore, the forecasted RPK post-COVID-19 shows a 10% reduction by year 2024 at an estimated 9,000 billion RPK. Using figure 2, IATA predicts a slow and gradual return of growth in the commercial air travel industry which highlights the fluctuating nature of traffic forecasts and unsuspecting elements that can influence passenger demand.

The importance of understanding passenger demand lies in its relationship to airline fleet plans and aircraft availability. In a study conducted by Zou, Yu, and Dresner (2015) on fleet standardization, the authors state that fleet planning decisions such as aircraft acquisition and fleet selection are important drivers in adapting to the passenger demand variations and competition in the industry (p. 150). Furthermore, Narcizo,

Oliveira, and Dresner (2020) emphasizes that a primary function in an airline is its ability to plan and manage its fleet to the dynamics of demand, costs and competitor actions (p. 149). With fluctuations in air traffic forecasted in the next 20 years, it is vital to implement strategic airline fleet planning decisions to successfully accommodate this change in demand.

The International Civil Aviation Organization (ICAO) considers aircraft fleet planning to be an integral component for the development of successful operations in any commercial airline (ICAO, 2010). The aircraft fleet planning process may depend on the various operational objectives of an airline such as marketing, development, alliance, and economic or financial objectives (Clark, 2007, p. 26). Based on the financial position of the airline, the decision to invest in an aircraft may depend on the acquiring method such as leasing or buying, air traffic demand, operating costs, productivity, and revenue generation (ICAO, 2017). Operational constraints in airlines may also play a role in fleet selection such as flight frequencies, market demographics, airport regulations, and route characteristics (Brueckner & Pai, 2007; Giovani & Reitveld, 2009).

Another key driver in the aircraft selection process is the flight safety or perceived safety of the aircraft type. According to Molin, Blange, MSc, Cats, and Chorus (2017), customer perception on the safety record of an aircraft type plays a vital role in the flight choice (p. 165). This assertion is evident in an incident involving the unearthing of cracks on the wings of a Qantas owned A380-800 aircraft found during a maintenance inspection (Falzon, 2012). This disclosure led to an outcry from media outlets describing the aircraft as unsafe (Clark, 2012). It was further elaborated that since the flying public

does not receive the technical information of such events, discomfort in passengers is a common reaction to these events.

According to subject matter experts in the industry, priorities of aircraft selection process in commercial airlines have changed over the years from profitability being the most vital to the safety of the aircraft being paramount (B. Waltz, personal communication, June 23, 2020). The reasoning for this transformation lies with the public image and customer perception of the airline.

Figure 3

The Evaluating Hierarchy System for Airline Image (Liou & Chuang, 2009)

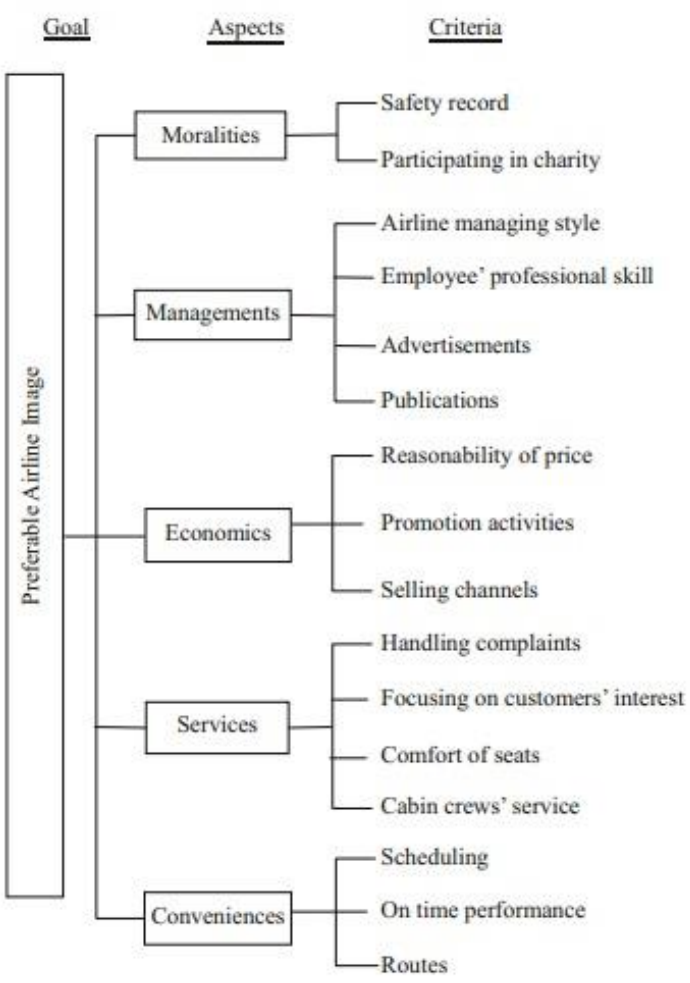


Figure 3 demonstrates a study done by Liou and Chuang (2009) on the factors that influence the corporate image in the airline industry. The evaluation hierarchy indicates that the safety record of the airline almost dominates the airline image and reputation in the industry (p. 1090). The study displays the weight of this element in preserving a desirable airline image in the air transportation industry. The authors suggest that building confidence in the flying public on safety and perceived safety of an airline is vital for its succession.

Figure 4

Statistical Analysis of Importance of Airline Choice Factors by Passengers (Chen & Chao, 2015)

Choice factors	Mean	Standard deviation
V5. Safety and reliability of the airline	6.85	0.428
V4. Punctuality of flights	6.52	0.639
V11. Efficiency in problem solving of passengers	6.43	0.722
V10. Service attitude of flight attendants	6.40	0.738
V13. Reliability and safety in baggage handling	6.30	0.799
V12. Speed of baggage transport	6.20	0.772
V3. Direct or connecting flight	6.18	0.837
V19. Efficiency of ground services staff	6.17	0.819
V21. Speed in providing flight information	6.00	0.885
V9. Cabin cleanliness and sanitation	5.91	0.828
V14. Convenience in making reservations	5.82	0.925
V1. Price	5.78	1.157
V 8. Seating comfort	5.71	0.955
V17. Convenience of online search system	5.65	0.998
V16. Completeness and user-friendliness of website functions	5.56	0.977
V2. Flight scheduling	5.48	1.149
V20. Promotional strategies	5.45	1.171
V18. Image and reputation of airline	5.25	1.212
V6. In-flight meals	4.99	1.247
V22. Other travel-related services	4.77	1.404
V15. Frequent flyer programs	4.74	1.308
V7. In-flight entertainment	4.01	1.468

Figure 4 above illustrates the mean choice of importance factors that influence a passenger's decision when choosing an airline for travel needs in a study conducted by Chen and Chao (2015). The results reveal that passenger choice is primarily influenced by the safety and reliability of the airline (Chen & Chao, 2015, p. 57). The ranking of statistical means and standard deviations suggest a measure of importance of variables

with highest concern to passengers when choosing an airline. The safety and the reliability of the air carrier variable surpasses all other variables at a mean of 6.85. Therefore, to effectively meet the forecasted rise in air traffic demand and to safely accommodate this change, commercial airlines must strategically plan and manage its aircraft fleets to best deliver its services.

Statement of the Problem

Extant literature suggests a relationship between the safety of an aircraft type, oversight from a regulatory entity, and impact on aviation industry (Molin et al., 2017). An example of such relationship was the post-event effects of the American Airlines Flight 191 accident involving a MC Donnell-Douglas DC-10-30 aircraft (NTSB, 1979). The National Transportation Safety Board (NTSB) concluded the probable cause of the accident to be asymmetrical stall and subsequent roll associated with the uncommanded retraction of the left wing and the loss of stall warning and slat disagreement indication systems. The flawed maintenance procedures of the AA base maintenance on DC-10-30 were at variance with that of the manufacturer and that led to the FAA "grounding" action (FAA, 1979). At the time of that particular accident and subsequent FAA action, the Air Transportation Association of America (ATA) estimated the DC-10s made up to 12% of the available seats on domestic carriers resulting in a loss of revenue at an average of USD 6 million a day in U.S carriers (Feaver, 1979).

The Douglas Aircraft Company encountered a similar occurrence following the crash of ValueJet Flight 592 on May 11, 1996 (FAA, 2008, p. 27). The aircraft model involved in the accident was a Douglas DC-9-32. The accident report published by the

NTSB identified the probable cause of the accident as a fire in the cargo area triggered by the actuation of unexpended chemical oxygen generators (NTSB, 1996, p. 137). In the aftermath of the fatal crash, a comprehensive 90-day regulatory inspection and review of airline operations and aircraft maintenance procedures were mandated by the FAA (FAA, 2008, p. 28).

The Franco-Italian aircraft manufacturers Aerie da Transporto Regionale (ATR) have also faced significant safety concerns with its ATR-42 and ATR-72 aircraft models. The initial aircraft accident involving the ATR-72-212 aircraft type was the crash of American Eagle Flight 4184 in Roselawn, Indiana in U.S due to loss of control caused by sudden and unexpected aileron hinge movement reversal (NTSB, 1994, p. a-2). A contributing factor to the accident was found to be inadequate oversight from the French authority Civil Aviation to ensure continued airworthiness of the ATR-42 and ATR-72 aircraft in icing conditions. Both variants of the ATR aircraft, similar in stabilizer design, had numerous accidents and incidents associated with roll control in icing conditions (NTSB, 1994, p. 75). This resulted in the FAA issuing a grounding order to cease operations of ATR-42 and ATR-72 aircraft from flying in certain icing conditions in autopilot configuration (Bryant, 1994).

The safety record of the ATR fleet has not been limited to the United States. Following a fatal crash in Taipei, the Civil Aerospace Authority (CAA) grounded all Taiwanese registered ATR-72-500s and ATR-72-600s for concerns regarding the aircraft's ability to meet the agency's safety standards (McKirdy, 2015). CAA ordered the turboprops to cease operations under its jurisdiction pending investigation of vital aircraft systems such as engine, fuel controls, and propeller systems (Polek, 2015). The

Iranian Civil Aviation Organization grounded its ATR-72-212 aircrafts on account of thorough safety checks following an accident in which the aircraft crashed on to the side of Mount Dena (Polek, 2018). Throughout history, the ATR-42 and ATR-72 aircraft series has been involved in 11 fatal accidents (McKirdy, 2015).

The Boeing 787 Dreamliner, produced by Boeing Aircraft Company, had endured concerns over its safety following an incident involving a lithium-ion battery catching fire in a parked All Nippon Airways (ANA) aircraft in January 2013 (FAA, 2013). Due to raised concerns over the safety of the lithium batteries on board the aircraft, the FAA issued an emergency airworthiness directive (AD) on January 16th 2013 to cease all operations of the Boeing 787-8, 787-9, 787-10 Dreamliner aircrafts within the U.S. until the manufacturers demonstrated that the batteries are safe for operation (FAA, 2013).

Pending investigation, civil aviation authorities around the world grounded the aircraft model under their jurisdiction including the Japanese Civil Aviation Authority (Ostrower et al., 2013). ANA Holdings and Japan Airlines which operate the largest fleet of Dreamliners suffered a combined loss of USD 110 million (Reuters, 2013). Furthermore, the Dreamliner underwent a recent grounding for eight of its aircrafts upon discovering a design flaw in its fuselage that may compromise its structural integrity (Johnsson & Kotoky, 2020).

Airbus, Boeing Company's biggest competitor, delivered its first A320neo aircraft to Lufthansa on 20th January 2016. The fleet was marketed by the manufacturer for its unbeatable fuel efficiency, reduced emissions, and enhanced engines (Airbus, 2016). Two years later, due to the occurrence of multiple in-flight engine shutdowns and aborted takeoffs, the European Aviation Safety Agency (EASA) issued an Emergency

AD to restrict operation of the A320 and A321 series (EASA, 2018, p. 1). The issues associated with the Pratt and Whitney engines powering the A320neos led have led to halted production of the aircraft type and operational delays in airlines such as IndiGo (Kotoky et al., 2018).

Boeing Company first unveiled the B737 MAX series (B737 MAX 7, B737 MAX 8) on August 30th 2011, touting the aircraft's operational efficiency, low fuel burn, and quieter engines (Boeing, 2011). The aircraft series was popular for its high production rate of 52 planes a months, setting a Guinness World Record for the "highest production large commercial jet" with 10,000 aircrafts assembled at Renton, Washington State in the U.S (Boeing, 2018).

The touted success of the aircraft series was cut short following two high profile accidents involving the aircraft type (Komite Nasional Keselamatan Transportasi, 2019; The Federal Democratic Republic of Ethiopia Ministry of Transport, 2020). The findings from the investigations revealed a design flaw in the flight control operating systems of the B737 MAX called the Maneuvering Characteristics Augmentation System (MCAS) (Komite Nasional Keselamatan Transportasi, 2019; The Federal Democratic Republic of Ethiopia Ministry of Transport, 2020). This led to a global grounding of this fast-selling aircraft pending repairs to the flaw and re-certification for return to service by various regulatory bodies around the world.

The grounding of the B737 MAX has led to substantial economic impact which affected the manufacturers in the supply chain, airline operators with large fleet types, and even regulatory oversight (Cameron & Sider, 2019; Nakahara, 2020). The costly grounding of the B737 MAX series was estimated at a loss of $4.1 billion with a

significant reduction in operational performance in various airlines including Southwest Airlines, the carrier with the largest fleet of the aircraft type (Reed, 2019). Furthermore, Federal Reserve economist Julian di Giovanni forecasted a 0.4% decline in GDP growth in the U.S by the first quarter of 2020 (Giovanni, 2020).

Ultimately, the catastrophic nature of the accidents created a negative perception of the B737 MAX aircraft and an 'unwillingness to fly' among the public (Rice, 2020). Since the grounding, the manufacturer has implemented changes to the B737 MAX aircraft series in terms of enhancing pilot training, software updates to the MCAS, and test flights pending recertification of the aircraft from the FAA (Boeing, 2019; FAA, 2020). On November 18th, FAA announced that the agency would rescind the grounding order of the B737 MAX with additional publication of Airworthiness Directives (AD)s to ensure compliance with design changes to the fleet type (FAA, 2020).

With air transportation playing a major role in the socio-economic development of the world, safety issues associated with aircraft fleets such as those mentioned have an impact on the air travel industry and affects the passenger confidence in air travel. Existing literature on aircraft fleet planning and management focuses primarily on concepts such as fleet standardization, influence of emission thresholds, and models based on route structure (Narcizo et al., 2020; Muller et al., 2018; Dozic & Kalic, 2015).

In a research study conducted by Molin, Blangé, Cats, and Chorus (2017), the authors explore the influence of passenger perceived safety on the choice of airline based on factors such as perception of airline and route attributes (p. 165). Moreover, the authors carry out a flight safety perception experiment consisting of 6 attributes to encompass airline characteristics which includes number of aircraft accidents occurred in

relation to the airline. The study, however, does not directly address the association of aircraft accidents to the aircraft type but refers to a previous study that highlights this association.

The authors refer to a research study conducted by Koo, Caponecchia, and Williamson (2015) that investigated the role of safety information on passenger flight choices (p. 1). The factors used in the study comprised of price, schedule, safety, travel time, and inflight service quality. To assess safety, the authors used number of flight accidents of a given aircraft type to convey safety information to the participants. The study concluded that safety and price factors dominate the influence of airline choice among passengers. A limitation of the study was that it only represented a small portion of the flying public as the study was administered to a college student population. The limitations led to an extension of this study organized by the same authors to observe the importance of safety in flight choice and included a broader population from a variety of age groups (Koo et al., 2018).

The findings from both studies emphasize the usefulness of understanding and interpreting consumer behavior, particularly the implications of passenger perception of safety on commercial practices in the aviation industry (Koo et al., 2015; Koo et al., 2018). The authors suggest the understanding of factors that influence passenger choice is crucial for various domains within the aviation industry, especially for airlines. The authors also noted that the findings can be utilized to construct marketing techniques to build a strong safety record to gain measurable market share (Koo et al., 2015, p. 7). Another practical use of the findings suggested by the authors was “transport planning” in aviation which suggests the aircraft acquisition and fleet management practices in

airlines (Koo et al., 2018, p. 160). The current study uses this extant literature as a foundation to further explore the impact of safety and its influence on the fleet planning procedures in commercial airlines in the U.S.

Purpose of the Study

The purpose of this study is to investigate the impact of safety on aircraft acquisition and fleet management in U.S commercial airlines. A qualitative content analysis of archival documents and case studies will be performed in relation to the influence of safety on fleet acquisition procedures within the global airline industry to lay out a theoretical framework for subsequent semi-structured interview with subject matter experts.

Creswell (2014) defines qualitative analysis as the method of scholarly inquiry using text and image data and consists of unique steps in data analysis (p. 183). The rationale for conducting a qualitative content analysis is to derive underlying themes and to establish a relationship between adverse safety events and aircraft acquisition. Subsequently, a semi-structured interview involving Subject Matter Experts (SMEs) will be conducted to gather insight and their perception on the effects of adverse safety events on fleet acquisition decisions.

Creswell (2014) notes semi-structured interviews as a method to collect qualitative data (p. 189). This method allows for an open-ended inquiry to gather perspectives of industry professionals. It is envisaged that the outcomes of the qualitative content analysis and semi-structured interview will provide deeper insights on the subject matter while providing clarifications on misconceptions related to the role of safety in

fleet acquisition decisions among U.S. commercial airline operators. Consequently, these results have the potential to add to existing literature, serving as a foundation for further research on the influence of safety on fleet acquisition in U.S commercial airlines and the probability to influence policies and practices in the airline industry.

Research Questions

It is envisioned that this study involving a qualitative content analysis of notable aircraft accidents and incidents, along with a semi-structured interview of subject matter experts in the airline industry will adequately address the following research questions:

1. What are the operational, economical and safety variables involved in airline fleet planning and management?
2. What is the role of a fleet's operational safety according to SMEs? How does the historical safety or perceived safety of a fleet type affect the choices for acquisition at the management level?
3. What are the processes and procedures in place to acquire or re-fleet aircraft following an adverse safety event?
4. How does an airline re-strategize following a major operations change such as the grounding of a fleet due to safety concerns?
5. What remarketing and rebranding techniques are utilized by airlines to resume operations of a fleet that has been grounded?
6. How can airlines restore faith and consumer confidence in air travelers when returning an aircraft to operations after adverse safety events related to the aircraft model?

7. What are the effects of regulatory decisions such as fleet groundings on airlines and what are the specific consequences in each department?

CHAPTER II

Literature Review

The following section provides a theoretical framework that justifies the investigation of the impact of safety on aircraft acquisition and fleet planning procedures in U.S commercial airlines. It also provides extant literature on the subject matter and identifies gaps in knowledge which will be addressed by the current research.

Airline Planning

Paul Clark (2007) defines fleet planning as the process by which an airline acquires and manages appropriate aircraft capacity in order to serve anticipated markets over a variety of defined periods of time with a view to maximizing corporate wealth (p. 1) . Clark (2007) also emphasizes the distinction between the 'acquisition' and management' activities regarding this process. Prior to deregulation, major air carriers would house a sizable fleet planning department within the organization. Today, airlines would outsource most of the tasks of this department while keeping the essential core activity within the company. The new fleet planners take on the role of a project manager, hence the distinction between the fleet acquisition and management responsibilities (Clark, 2007, p. 3). Following deregulation, the number of airlines, types of business models, and competition between airlines have risen (Kiraci & Akan, 2020, p. 1).

Strategic airline planning is the planning of routes and services, fare structures, and fleet development (ICAO, 2010, p. 1). This technique plays a major role in other interdisciplinary fields such as aircraft manufacturers, airport facilities, and regulatory

agencies. Commercial airlines establish routes and services based on the forecasted passenger demand at a destination airport which can be driven by factors such air fares, regional resources, population, seasonal cycles, and economic development (Feng J, Yongwu L, Shaolong S, Hongtao L., 2020). Another key variable in the route planning process is the competition and alliance opportunities with air carriers at particular destinations (ICAO, 2010, p. 1). Such opportunities can be driven by service fares, frequencies, aircraft types, number of stops, and customer perception of air carriers. Furthermore, the airline's route system is also dependent on the traffic rights granted by governments based on established bilateral agreements.

A variety of fares and rates are introduced by airlines to create or meet market competition (ICAO, 2010, p. 4). The fare structure of an air carrier plays a vital role in passenger demand of a particular route which eventually dictates the amount of revenue generated by the carrier. The rates are also based on the seat assignment process and dictates the capacity of services offered by the carrier. For example, in a study conducted by Klophaus and Grosche (2020) on the evaluation of consumer surplus in selecting long-haul routes connecting Germany with California and China, the authors refer to the analysis of air fares and its influence on revenue generation (Klophaus & Grosche, 2020, p. 4). One parameter used in the study to evaluate air fares was the class of service such as business and economy class. These classes of service were then determined based on the seat assignment and capacity of the aircraft. The authors analyze passenger choice in purchasing tickets based on the type of travel and available capacity of business class and economy class seat assignments. Thus, the services and associated air fares offered by

airlines is often dependent on aircraft capacity, composition, and the fleet mix of the carrier.

Fleet planning decisions are regarded as the leading determinations of the overall network plan of an airline. It holds a high level of priority in the strategic planning process and is a primary element for route planning and schedule development in commercial airlines (Belobaba, 2006). Below, figure 5 demonstrates the flow of decision making and the levels of planning in commercial airlines. Fleet planning is at the top of the strategic and long-term planning indicating its significance in the overall planning process.

Figure 5

Hierarchy of Airline Planning Process (Belobaba, 2006)

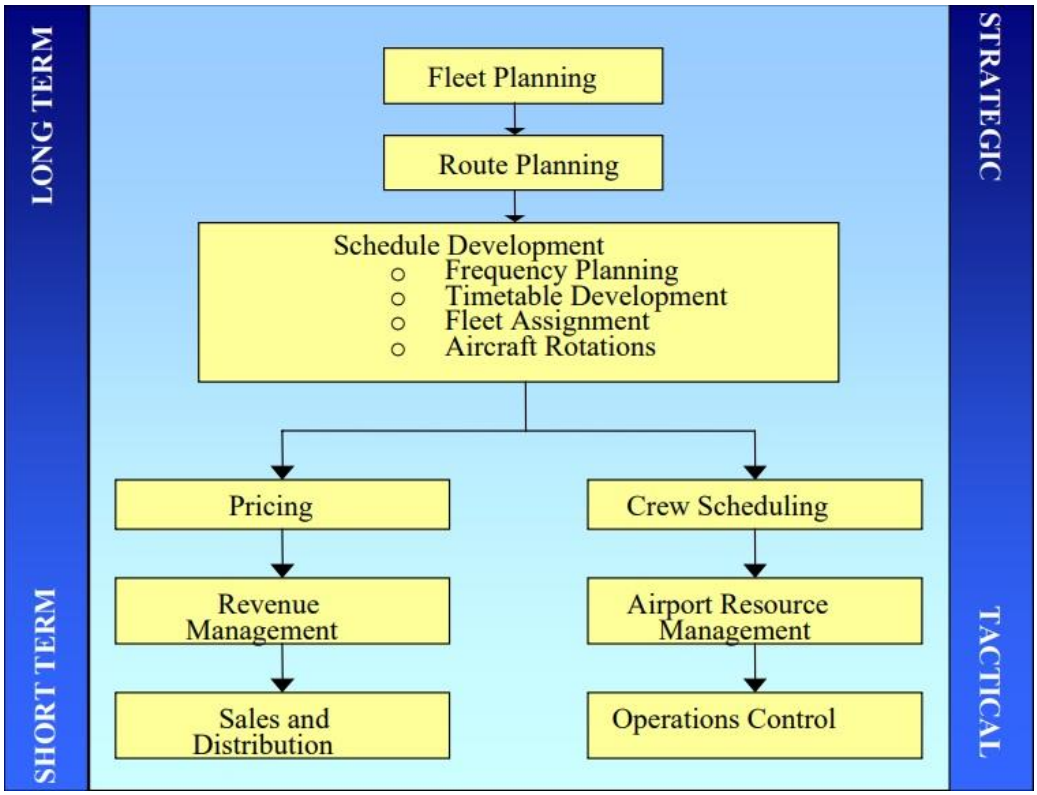


Figure 5 also highlights the commanding position of fleet planning which determines the air carrier's tactical decision-making elements such as air fares, revenue management, sales, crew scheduling, airport resource management, and operations control. Additionally, fleet planning is a costly venture in which airlines would invest large amounts of capital for a time period and has the potential to make a significant impact on the airline's financial position (ICAO, 2008, p. 2). Therefore, the task of developing a fleet plan is regarded as one of the most important decisions for an airline.

Fleet Selection

The general economics that factor into the fleet acquisition decision depends on the operating costs of the aircraft type, ownership cost of a new aircraft, trip costs, and its ability to generate revenue (Belobaba, 2009, p. 8). Prior to selecting a fleet, it is imperative to investigate the objectives of the airline to understand how and where resources are allocated. Clark (2007) categorizes airline objectives into marketing, development, alliance, and financial objectives (p. 26).

Marketing objective focuses on the type of services offered and variety of markets serviced by the air carrier (Clark, 2007, p. 26). For example, if the objective of the air carrier is to serve multiple markets through a hub, a fleet plan should be selected that provides the optimal fleet commonality. The geographical location of the airline network also plays a role in determining the type of aircraft selected. Secondly, the development objective focuses on the size of operations an airline desires to achieve. This is due to the critical mass of operations being a key factor to be recognized in competitive markets (Clark, 2007, p. 27).

Furthermore, the fleet selection process is regard to be critical to the success of operations as it allows airlines to gain competitive advantage in the industry and provides a high growth rate (Kiraci & Akan, 2020, p. 1). A fleet plan can be developed based on the anticipated size of operations an airline expects to achieve. An alliance strategy is the merging of airlines to create partnerships such as technical co-operation, codesharing, and virtual mergers (Clark, 2007, p. 28).

Alliances are primarily driven by the need to improve market reach, generate higher revenue, and to minimize operating costs (Clark, 2007, p. 28). Such alliances and partnerships thrive on fleet commonality and standards. Therefore, an airline with an alliance objective would most likely maintain a fleet homogeneous to that of their partners. Lastly, the magnitude of investment in a fleet, either owned or leased, will have an impact on the financial and economical objectives of the airline. The return-on-investments in a fleet acquisition project would dictate the achievement of the air carrier's financial objectives (Clark, 2007, p. 28).

To commence the fleet planning process, planners evaluate several factors that influence the air carrier's operations. These factors include traffic and yield forecasts, Average Load Factor (ALF), and Available Seat Miles (ASM) (Belobaba, 2006). ASM is quantified when one aircraft seat flies one mile, and ALF is calculated by dividing the total RPM by ASM (Kenton, 2020).

Figure 6

Airline Fleet Planning Evaluation Process (Belobaba, 2006)

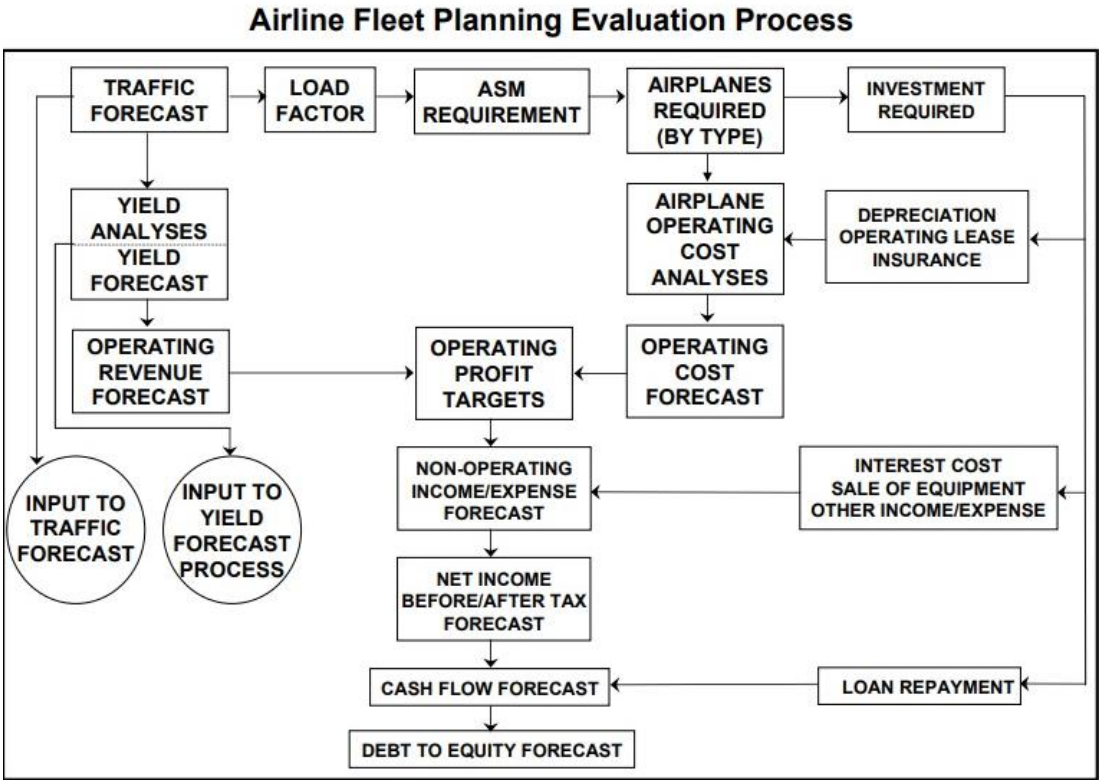


Figure 6 illustrates the airline fleet planning evaluation process in which the input variables such as traffic forecast, ALF, and ASM generate the types of aircrafts required for operation. This process also provides the airline with key financial information such as investments required and operating costs of the fleet. According to accounting standards, an asset requires to be depreciated on as systematic basis over its useful life to its residual value (IATA. 2016, p. 11).

Typically, aircraft assets are depreciated over 15 to 25 years with residual values ranging from 0 to 20% (IATA, 2016, p. 12). Depreciation values, along with operating lease insurance will be factored into the operating costs forecast. Using the operating revenue forecast which is derived from yield forecast and the operating costs forecasts, an

airline can calculate its operating target profits. Furthermore, using these values, the carrier can derive a net income/expense, cashflow, and debt to equity forecast.

Dozic, Lutovac, and Kalic (2018) conducted an empirical study on the aircraft selection evaluation criteria using a Multi-Criteria Decision Model (MCDM) (p.165). The authors began by emphasizing the importance of aircraft selection for airlines to accurately match supply with demand, and in turn increase the airline's profitability and minimize its costs (Dozic et al., 2018, p. 173). The authors proposed a new method to evaluate aircraft types based on the model's capability to meet the market conditions and route network. The method yielded crucial components needed to be considered such as seat capacity, range, maintenance costs, aircraft delivery time, acquisition method, fleet commonality, and passenger comfort. Dozic et al (2018) claimed that the model is practical in assessing aircraft selection under conditions of uncertainty (p. 165).

Furthermore, a study was conducted by Kiraci and Akan (2020) following the findings of Dozic et al (2018) using a MCDM for aircraft selection based on factors such as economic performance, technical performance, and environment impact of aircrafts models (Kiraci & Akan, 2020, p. 13; Dozic et al., 2018). Additionally, the model used sub criteria in its evaluation method including fuel consumption, service life, take-off weight, seat capacity, operating costs, and price.

Fleet Planning Models

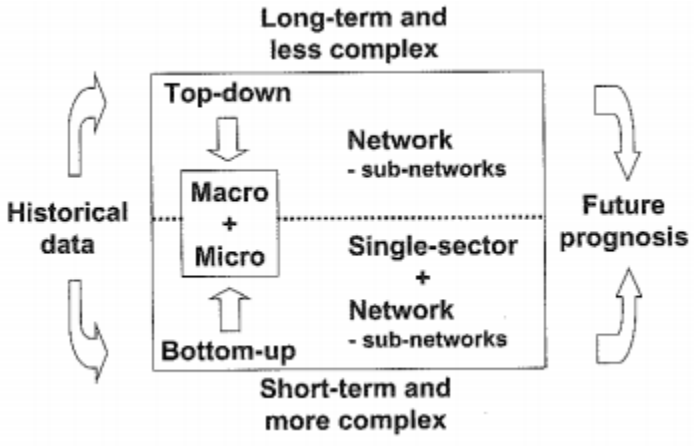
Airlines can utilize various methods for fleet planning. Due to the scale of operations, fleet planning is primarily conducted using computerized systems. There are several methods used by fleet planners and asset managers to plan and manage the organization's fleet composition. A few methods generated in existent literature include

fleet planning models that assess the flight frequencies of the airline and aircraft size based on market demographics, airports, and route characteristics (Pai, 2007; Dozic & Klaic, 2015).

Another model evaluated an aircraft fleet based on its environmental impacts based on the air carrier's short or long-haul routes (Giovani & Reitveld, 2009; Dozic & Klaic, 2015). Additionally, a study using Analytic Network Process (ANP) method explored factors such as costs (spares, maintenance, purchasing), security, reliability, and sustainability (Ozdemir et al., 2011; Dozic & Klaic, 2015).

Figure 7

Macro and Micro Fleet Planning Models (Clark, 2007, p. 50)



Macro and Micro approaches are the methods primarily used by commercial airlines to plan its fleet. As shown on figure 7, both approaches utilize historical data to produce an output (Clark, 2007, p. 50). 'Top Down' or Macro approach is a multi-year system analysis in which the number of aircraft required is calculated based on the macro traffic forecast (ICAO, 2010, p. 3). This approach utilizes the forecast aggregate

passenger demand from previous time periods and creates an expected growth rate. From this projected growth rate, future RPM values are generated.

Next, the expected load factor is determined using historical data which is necessary to achieve the expected RPM. The current ASM is derived from the number of aircraft in the fleet mix, their capacities, hours of utilization, and speed. An expected aircraft utilization will be determined by observing the frequencies in the network. Finally, the number of aircraft required will be computed by gauging the additional requirements based on the expected aircraft utilization (Clark, 2007, p. 50-55).

Figure 8

Capacity Gap Analysis (Belobaba, 2006)

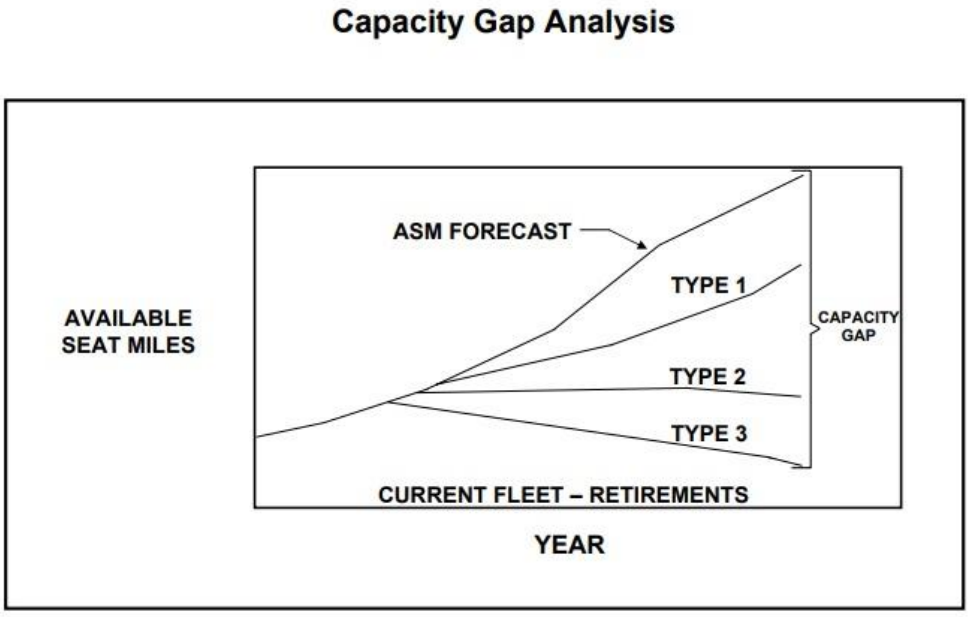


Figure 8 above depicts the capacity gap analysis in which there are multiple ASM forecasts calculated (Belobaba, 2006). The upper and lower boundaries indicate the 95% probability range. Within this range, the capacity gap can be calculated by the difference

between the ASM forecast, current ASM minus the planned retirements. The macro approach is a quick method and provides the airline with a broad estimate of the status of the fleet. Since the approach relies on historical assumptions, unexpected changes to the growth rates or achieved load factors can significantly disrupt the system (Clark, 2007, p. 55).

'Bottom up' or Micro approach examines individual routes in detail and provides the aircrafts that best fit the route's requirements (Clark, 2007, p. 55). This approach uses demand behavior in a small number of criteria to choose the individual flights for the routes. However, since micro approach bases its decisions on observed trends and data, there is a likelihood for complexities to arise when market conditions change due to route additions/deletions, new aircraft types, and competition (Clark, 2007, p.56).

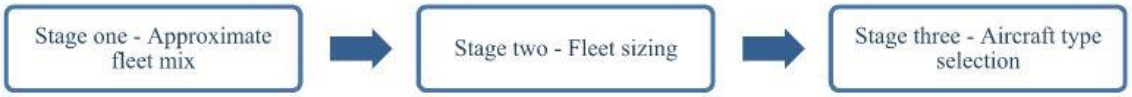
Another issue associated with this approach is the amount of data and resources required to execute this approach. All commercial airlines do not organize data on a true origin and destination basis. Therefore, utilizing this approach will be time consuming to track data sets in complex network systems. Occasionally, airlines will utilize another approach to fleet planning called schedule evaluation method (ICAO, 2010, p. 3). Schedule evaluation method is based on the quality of the previous schedule in which if the load factor appears excessively high or low, the analyst performs multiple modifications to the plan using measures such as frequency and previously assigned airplane itinerary structure (ICAO, 2010, p. 3).

Additionally, a three-stage fleet planning model was devised by Dozic and Klaic (2015) that addressed both fleet size and composition in airlines operating short to

medium haul routes (p. 30). Figure 9 below illustrates the general scheme of the three-stage fleet planning model obtained from the study.

Figure 9

Three-Stage Fleet Planning Model (Dozic & Klaic, 2015, p. 31)



The three-stage fleet planning model is used to determine the approximate aircraft fleet mix in terms of aircraft size based on a given route network. To determine an approximate fleet mix in stage one, authors categorize aircraft into two categories based on demand and distance between origin and destination retrieved from past fleet assignment data. Consequently, the strength of preference of aircraft from airlines is determined using approximate rule base. This stage would then generate two outcomes; same aircraft will be assigned to all routes, and small aircraft will be assigned to some routes and medium size aircrafts for the rest (Dozic & Kalic, 2015, p. 31).

Following this stage, a special heuristic algorithm is utilized to establish the minimum number of aircraft needed to operate a specific flight schedule in terms of aircraft size. The heuristic algorithm considers factors such as daily rotation of aircraft and required number of aircraft to be available at each airport to calculate the fleet size. Lastly, stage three uses even swaps method, an approach utilized to make trade-offs among a set of objectives across a range of alternatives, to determine at least two types of aircraft that match the defined markets (Dozic & Kalic, 2015, p. 33). Factoring 5 sets of decision criteria such as aircraft seat capacity, maximum take-off weight, luggage per

passenger, price of aircraft, and operating costs, a selection of aircraft can be determined (Dozic & Kalic, 2015, p. 33).

Moreover, fleet planners may find long haul routes to be challenging when developing a fleet plan. Carreira, Lulli, and Antunes (2017) approached this fleet planning problem by using long-haul routes serviced by TAP, a legacy carrier in Portugal (p. 639). The forecasted routes examined in the case study originate from Lisbon and end in 9 destinations in Brazil. The authors used an optimization model to generate recommendations on how TAP could alter its fleet plan to best serve these routes. The approach used fleet composition models along with fleet replacement models from existent literature to create an optimization model that determines the least number of aircrafts that can be used to service destinations in Brazil. The results from the study stated that acquisition methods such as leasing aircraft may allow for the carrier to better accommodate uncertainty without incurring high expenditures from purchasing aircraft (Carreira et al., 2017, p. 651).

Airline fleet plans may become complex due to a variety of factors within the aviation arena such as fluctuations in passenger travel, service frequency, changes to route structure, and introduction of new aircrafts or configurations (ICAO, 2010, p. 3). Occasionally, unanticipated events such as pandemics, natural disasters, and political instability can contribute to the complexity and create uncertainty (Khoo & Teoh, 2014).

Currently, the ongoing global pandemic associated with COVID-19, has introduced an economic slowdown in the air transportation industry and has displayed a decreasing trend in passenger demand (Nizetic, 2020, p. 3). Center for Disease Control and Prevention (CDC) describes COVID-19 as a respiratory disease originating from a

coronavirus called SARS-CoV-2 and is primarily transmitted through human contact (CDC, 2020). Due to its highly contagious nature, COVID-19 has caused a global pandemic resulting in significant economic turmoil. The pandemic has significantly affected the transportation industry, especially the air travel segment. On June 9th, 2020, IATA forecasted a reduction in revenue of USD 84.3 billion with a net profit margin of -20.1% (IATA, 2020).

Figure 10

Top 5 Industries Impacted By COVID-19 In March 2020 (Kumar & Haydon, 2020)

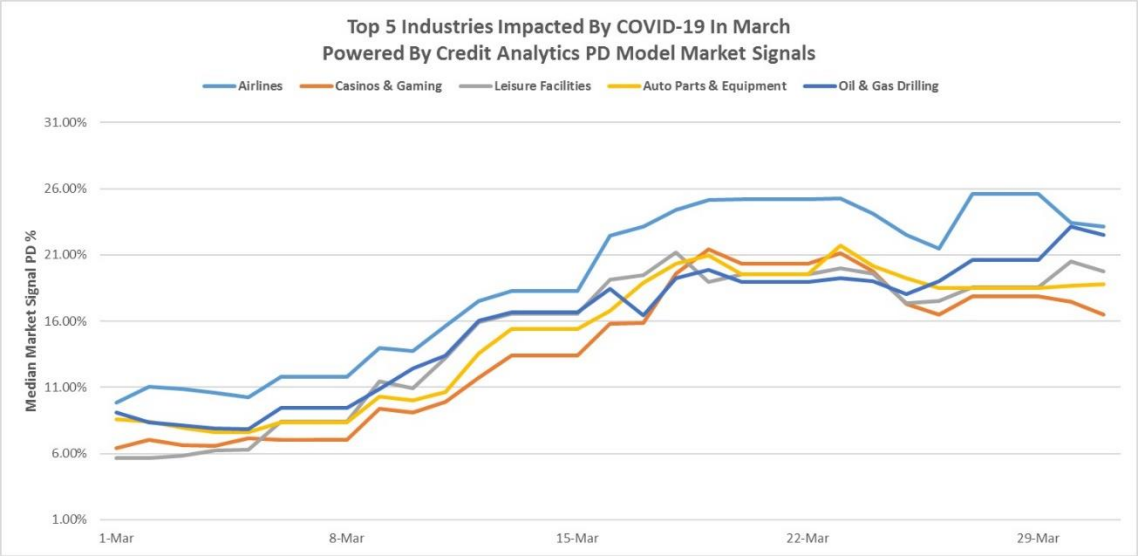


Figure 10 depicts the industries that have been impacted the most by COVID-19 in the month of March 2020 (Kumar & Haydon, 2020). The Credit Analytics Probability of Default Model Market Signals utilizes the stock price movements and asset volatility to calculate one-year probability of default (PD). The model indicates the airline industry as the industry that has been the most impacted by COVID-19 with an increase of mean market signal PD up to 25.2%. The authors suggest the immediate dip in PD to 21.5% on March 26 is the result of the U.S government stimulus checks and the bailouts for the

airlines. However, the PD returns to 25.6% the next day due to closed borders, aircraft fleet groundings, and reduction in air traffic.

Initially, COVID-19 forced many airlines to operate empty airplanes or aircrafts with low load factors to maintain the flight slots (Suau-Sanchez, Voltes-Dorta, Cuguero-Escofet, 2020, p. 1). With the reduction in normal operating schedules, airlines witnessed a significant reduction in Available Seat Kilometers (ASK) which measures the passenger carrying capacity. Below, figure 11 obtained from an analysis conducted by Official Airline Guide (OAG) illustrates that the international markets have been significantly impacted by the pandemic compared to domestic markets within the listed regions in figure 12.

Figure 11

Change in ASK in International Markets Within One Year (Suau-Sanchez et al., 2020, p. 3)

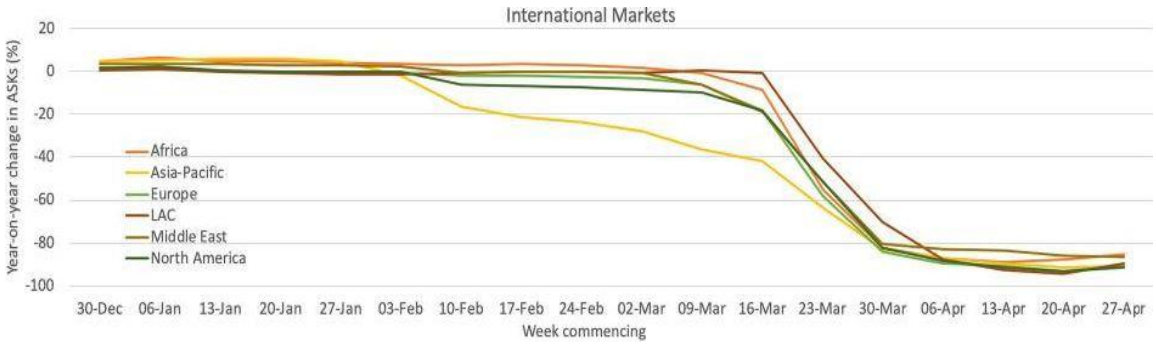
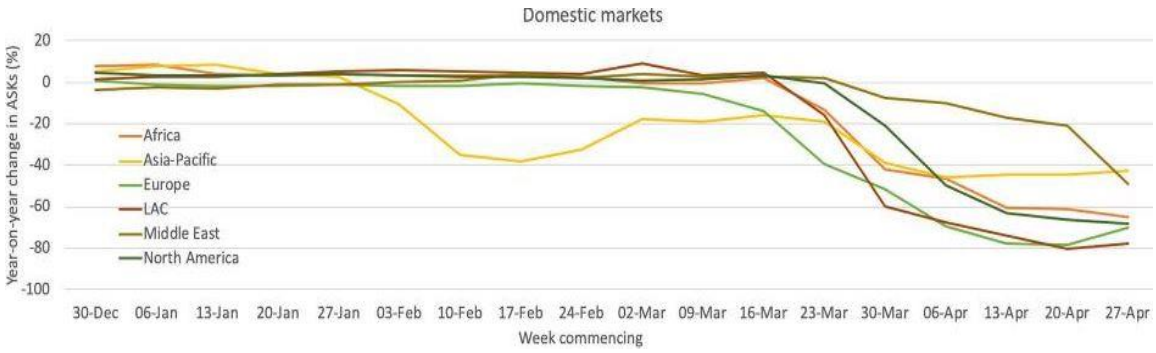


Figure 12

Change in ASK in Domestic Markets Within One Year (Suau-Sanchez et al., 2020, p. 3)



Due to the escalation of the pandemic and its rapid contagion, the airline industry underwent a wide-spread aircraft grounding following implementation of travel bans and border closures (Suau-Sanchez et al., 2020, p. 2). Figure 11 above indicates the drop in ASK following the worldwide grounding of fleet around 16th of March 2020. Furthermore, figure 12 depicts the surge in COVID-19 cases in Asia-Pacific regions and temporary lockdown which resulted in the significant drop in ASK between 27th January and 10th February 2020 (Suau-Sanchez et al., 2020, p. 3).

Following an interview with senior industry executives, it was suggested that Full-Service Network Carriers (FSNC), such as those operating within international markets, may need to substantially downgauge their fleets due to capacity issues (Suau-Sanchez et al., 2020, p. 4). These actions may entail replacing wide-body aircrafts with narrow-body aircraft to operate long-haul routes and working with regional airlines to feed its shorter routes.

Since the beginning of the pandemic, over 17,000 aircrafts, which comprises about 64% of the global fleet worldwide, has been reported to be inactive and placed in

temporary storage (Doyle, 2020). Early in the year, mass groundings of nearly 5000 passenger aircrafts took place within the Eurocontrol area (Adrienne et al., 2020). With such drastic alterations to air traffic and operational aircraft, the fleet planning process has become increasing complicated.

Existent literature presented covered a selection of crucial factors that play a role in the overall function of fleet planning and aircraft management decisions in commercial airlines. Aircraft safety and the perception of aircraft safety is known to influence consumer behavior which in turn impacts the economics of an airline (Koo et al., 2018). In the research study conducted by Koo et al (2018), the authors concluded that customer perception of aircraft safety can be utilized to structure various domains within an airline such as "transport planning" referring to the process of fleet planning (p. 160).

Additionally, the relationship between customer perception and aircraft operational safety has an impact on the reputation of the aircraft manufacturer and its host nation. An example of this relationship can be deduced from periodic poor safety issues associated with some Antonov models such as An-26 and An-24 that has implied impact on the reputation of the manufacturer; Antonov (Lacagnina, 2006). From a historical perspective, Antonov produced about 436 aircraft until 2006 that failed to meet the airworthiness certification requirements in 16 countries. Furthermore, following two fatal accidents in Moscow involving the Antonov An-148 aircraft, accident investigators questioned the safety of the aircraft model (Los Angeles Times, 2018).

Another example of this association can be inferred from the tainted reputation of the state-owned Commercial Aircraft Corporation of China; COMAC (Harrison, 2019). COMAC has gained an unfavorable reputation in the aviation industry in relation to the

operational performance of its aircrafts. With a majority of its customers being Chinese buyers, COMAC has struggled to earn a position in the Western market due to delays in aircraft deliveries and poor engineering efforts leading to technical glitches with its C919 aircraft (Meszaros, 2020).

A search for extant literature by author suggests lack of studies linking the role of safety in fleet selection and aircraft management practices in U.S commercial airline operations. The remainder of this section consists of qualitative analysis of multiple notable aircraft accidents that have established an association with aircraft safety and concerns from regulatory and governing bodies in the field of aviation. The analysis will generate themes which will provide a foundation to formulate a semi-structured interview with subject matter experts (SMEs) for the consequent phase of this study.

McDonnell Douglas DC-10 Case Study

Initially, the Douglas Company produced the DC-10 for a potential contract CX-HLS involving the transportation of equipment and troops for the Unites States Air Force (Airways, 2014). Having lost the contract with the Air Force, the aircraft model underwent multiple transformations to be utilized for the transportation of revenue passengers and cargo. Following the merger with McDonnell Aircraft in 1967, the manufacturer began production of the DC-10 in 1970 and first rolled out the aircraft model on July 23rd 1970. Upon receiving regulatory clearance and approval from the FAA, the first air carriers to acquire the aircraft type were American and United Airlines in 1971 (Airways, 2014).

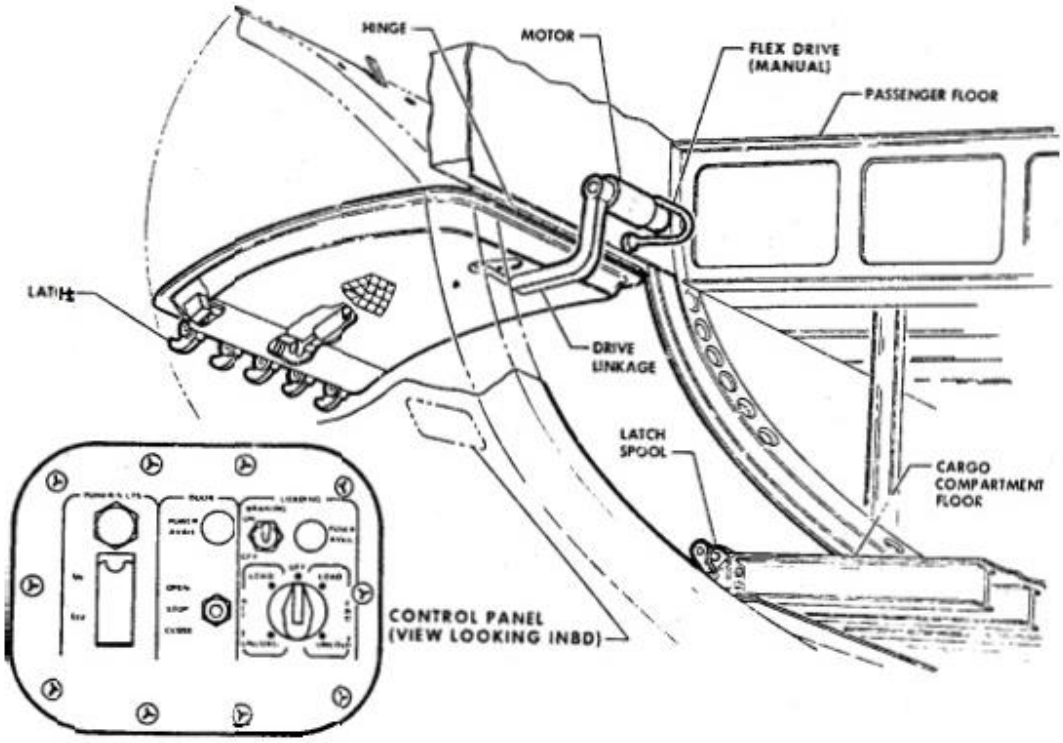
After the DC-10 gained operational certification approval from the FAA for entry into revenue services with airlines, the aircraft was beset with its first technical and safety

snag after reports of unsecured rear cargo door in an American Airlines aircraft almost led to a catastrophic accident in Detroit (NTSB, 1972). American Airlines Flight 96 departed Detroit, Michigan on June 12th 1972 towards its destination of LaGuardia Airport with a scheduled stop in Buffalo, New York. During cruise flight at approximately 11,750ft, the flight crew experienced a loud noise and flying debris, with a sudden movement of rudder pedals to the full-left position. Upon positioning all three thrust levers to idle, the aircraft yawed to the right. Following the rapid decompression, a portion of the fuselage floor collapsed into the cargo compartment. With sluggish elevators and no operational rudder controls, the flight crew managed to return to Detroit for an emergency landing to Runway 03 Left of Detroit Metropolitan Wayne County Airport (NTSB, 1972, p. 2).

The probable cause of the accident was determined to be the improper engagement of the latching mechanism of the aft cargo compartment door during preparation of the flight (NTSB, 1972, p. 12). It was concluded that the design characteristics of the door latch appeared to display that it was secured when in fact the latch lock pins were not in place. Figure 13 below displays the aft cargo compartment door mechanism as noted by the NTSB. The NTSB provided recommendations to the FAA to require modifications to the cargo door latching systems to DC-10 aircrafts (NTSB, 1972, p. 38).

Figure 13

DC-10 Aft Cargo Compartment Door Latch Mechanism (NTSB, 1972)



On March 3rd 1974, Turkish Airlines Flight 981 underwent a violent decompression at Flight Level 90 caused by the opening of the left cargo door on its DC-10 aircraft following its departure from Paris Orly Airport in France (BEA, 1974). The fuselage burst activating the pressurization aural warning and the No. 2 engine dropped sharply to the left and into a nose-down attitude (BEA, 1974, p. 6). The aircraft impact the Ermenonville forest and all 346 souls on board perished in the accident. The Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) concluded the probable cause of the accident to be in-flight ejection of the left aft cargo door that was not securely fastned, resulting in a sudden depressurization. The NTSB issued safety

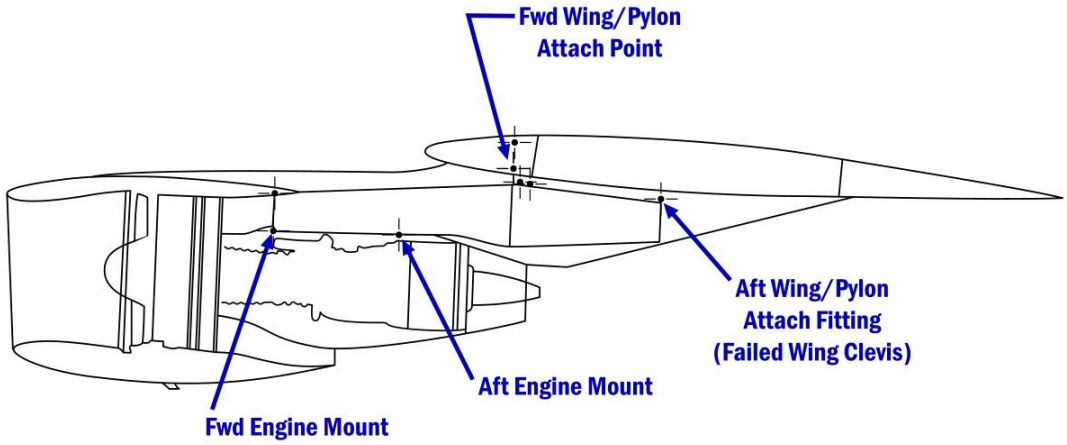
recommendations to modify the aft cargo compartment door locking system (BEA, 1974, p. 49). The FAA issued an Airworthiness Directive (AD) to modify vent doors, replace locking mechanism viewing window, revise lower cargo door markings, and revise electrical wiring for all cargo latch actuators (FAA, 1974).

Apart from the problems associated with the aft cargo door locking mechanism, the DC-10 aircraft has suffered other structural concerns. On May 25th 1979, American Airlines Flight 191, a registered DC-10-10, crashed near a trailer park in Chicago, Illinois (NTSB, 1979, p.1). The NTSB concluded the probable cause of the accident to be the asymmetrical stall and ensuing roll of the aircraft caused by the uncommanded retraction of the left wing outboard leading edge slats and the loss of stall warning and slat disagreement indication systems.

As part of the causal findings of this accident, the NTSB noted the vulnerability of the pylon attach points and the leading edge slat systems that caused the detachment of the engine and pylon after liftoff. With the detachment of the pylon, the electrical system generating power to the stall warning system and the slat disagreement warning system was disabled. Following the separation of the pylon, the hydraulic lines driving the actuator of the left wing's outboard leading edge slats were severed leading to retraction of the slats. This caused an asymmetric stall and loss of control of the aircraft (NTSB, 1979, p. 67). The investigation revealed improper maintenance procedures conducted on the American Airlines owned DC-10 aircrafts that damaged the pylon and lack of communication among the operators and manufacturers. Figure 14 below illustrates the engine and pylon attach points on the DC-10 aircraft.

Figure 14

DC-10 Engine and Pylon assembly (FAA, n.d)



Following the crash of American Airlines Flight 191, the NTSB recommended the FAA to issue an emergency AD to inspect all pylon attach points on DC-10 aircrafts by approved maintenance methods (NTSB, 1979, p. 70). The FAA issued a fleet grounding order to temporarily cease operations of DC-10 aircrafts until the aircrafts underwent required inspection and modification to the bolts attaching the aft engine mount to the pylon bulkheads of No. 1, 2, 3 engines (FAA, 1979). The grounding lasted 37 days in which the manufacturer was required to ensure integrity of wing slat position alerts and incorporate a redundant stall warning system which drew information from two Angle of Attack (AoA) sensors (Ostrower, 2019).

The wide body aircraft was a popular model utilized by domestic and foreign carriers alike. The temporary cease in operations brought on a variety of disruptions to these carriers. During this time, U.S airlines operated 138 DC-10s and foreign airlines flew 137 (Feaver, 1979). Furthermore, the Air Transportation Association of America

(ATA) estimated that 12% of the seats on domestic carriers were represented by the aircraft type leading to a loss in revenue of up to USD 6 million a day in the U.S. Moreover, following the grounding, the McDonnell Douglas stock prices dropped 2 1/2 points to a 20 7/8 on the New York Stock Exchange (NYSE) (Feaver, 1979).

Furthermore, the aircraft gained an unfavorable reputation by the flying public following the occurrence of high-profile accidents and among airlines for its uneconomical fuel efficiencies (Bradsher, 1989). The manufacturer eventually replaced the DC-10 with the MD-11, an aircraft with a re-engineered cockpit and introduction of newer technology (International Aviation HQ, 2020). The DC-10 aircraft was responsible for a total of 32 hull-loss accidents (Aviation Safety Network, n.d). Below, table 1 displays the themes derived from the case study upon analyzing common codes emergent in the consequences of the events related to the aircraft type.

Table 1

Themes from McDonnell Douglas DC-10 Case Study

Aircraft accident case	Theme 1	Theme 2	Theme 3	Theme 4
DC-10	Operational factors	Financial aspects	Public perception elements	Regulatory concerns

Aerei da Transporto Regionale ATR- 42/72 Case Study

ATR-42 and ATR-72 are twin-turboprop aircraft designed by Franco Italian manufacturers Aerei da Transporto Regionale in 1981 (Airliners, n.d). ATR-42-300 is a Pratt and Whitney (PW) 120 powered turboprop aircraft with a standard configuration of 48 seats, ideal for short haul and regional carriers (ATR, n.d). The ATR-42-320, similar

in capacity houses a more powerful engine of PW121 (ATR, n.d). The aircraft series received its certification for commercial operations from the European Aviation Safety Agency (EASA) in 1985 and 1988 (EASA, 2012, p. 4). The ATR-72 is a derivative of the ATR-42 series with an extended fuselage accommodating 66 seats and powered by a PW124B engine (ATR, n.d). ATR-72 family consists of a series of ATR-72-210 and ATR-72-500, both with increased capacity and powerful engines. The ATR-72 series received its certification for commercial use from EASA in 1989 and 1992 (EASA, 2012, p. 19).

One of the first fatal accidents involving an ATR-42 aircraft occurred on October 15th 1987 in Conca di Crezzo in Italy on October 15th 1987 (ASN, n.d). According to the Aircraft Safety Network (ASN), a third-party repository curated by the Flight Safety Foundation, icing conditions prevailed during the time of the accident (ASN, 2016; ASN, n.d). It was reported that the aircraft departed from Milan in icing conditions and the crew consecutively lost control of the aircraft and crashed into Mount Crezzo killing all 37 members on board (ASN, n.d).

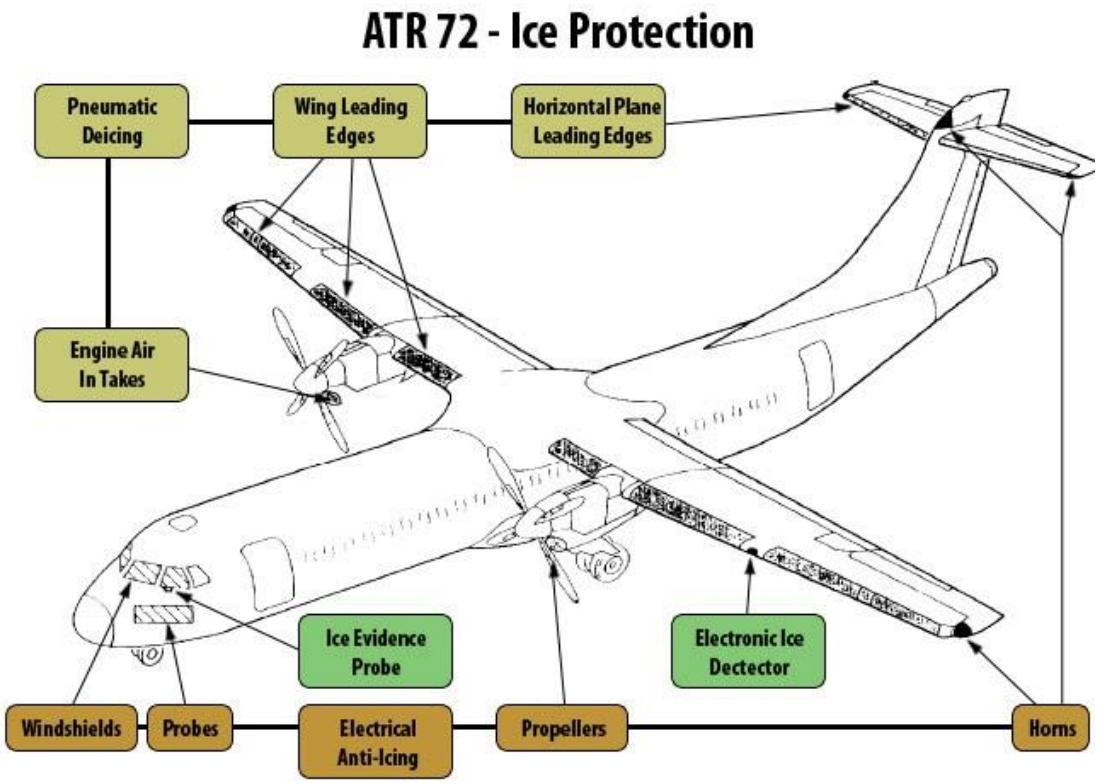
A significant accident involving the ATR-72-212 aircraft occurred on October 31st 1994 in an American Eagle Flight 4184 in Roselawn, Indiana, U.S (NTSB, 1994, p. 1). Flight 4184 was in a holding pattern and descending to assigned altitude of 8,000 ft when an uncommanded roll occurred. The maneuver resulted in a rapid decent and the flight crashed to terrain, destroying the aircraft and leaving occupants with fatal injuries. Icing conditions prevailed during the time of the accident (NTSB, 1994, p. 1).

The NTSB report revealed the probable cause of the accident as the loss of control due to a sudden and unexpected aileron hinge moment reversal that occurred after

a ridge of ice formed beyond the deice boots (NTSB, 1994, p. 210). Figure 15 below indicates the ice protection system on the ATR-72 aircraft.

Figure 15

Ice Protection on ATR 72 (FAA, n.d)



Furthermore, the NTSB noted that the French Directorate General for Civil Aviation's (DGAC) lack of oversight of ATR-42 and ATR-72 aircrafts and the agency's failure in ensuring continued airworthiness of the aircraft in icing conditions (NTSB, 1994, p. a-2). The accident report also revealed that the DGAC failed to provide the FAA with timely airworthiness information about previous ATR accidents that occured in icing conditions. It also indicated that ATR failed to communicate to the operators of the aircrafts on the known effects of freezing precipitation on the flight controls. Finally, the

report showed lack of regulatory oversight from the FAA to ensure the aircraft type was certified to fly in icing conditions.

Following the accident, the NTSB issued safety recommendations to the FAA to require all 14 CFR Part 121 carriers' dispatchers to disclose vital information such as meteorological conditions, and mandate all aircraft manufacturers to provide pertinent information to the FAA and operators about undesirable characteristics of flight beyond the protected flight regime (NTSB, 1994, p. 211). Furthermore, the NTSB recommended to revise the Federal Aviation Regulations icing certification requirements.

The FAA issued a grounding order for the ATR-42 and ATR-72 fleets from flying in certain icing conditions in autopilot configuration (FAA, 1995). The severity of the accident drew significant attention to the safety of the aircraft type with certain organizations such as the International Airline Passengers Association advising the flying public to avoid traveling in ATR aircrafts (Jackson, 1994). U.S operators flew 7% of its short haul regional flights in ATR aircrafts which created 15% regional seat capacity in the domestic travel segment (Jackson, 1994). Even though the grounding did not incur significant socio-economic impacts, the regional air travel sector within the U.S was impacted. Moreover, majority of the ATR operators in the U.S moved the aircraft for operations to the southern regions of the country during winter seasons (Jackson, 1994). Following the crash of American Eagles Flight 4184 and the upswing of regional jets in the U.S, ATR aircraft orders were also impacted (Russel, 2017). The ATR-42 series has been involved in a total of 34 hull-loss accidents, majority of these accidents took place in icing conditions (ASN, n.d).

On February 4th 2015, TransAsia Airways registered ATR-72-212A Flight GE 235 impacted the Keelung River 3 minutes after takeoff from runway 10 of Songshan airport (Aviation Safety Council, 2016, p. 1). The aircraft was destroyed on impact and all occupants survived with fatal injuries. The accident investigation report concluded the cause to be due to the uncommanded auto feathering of engine 2 caused by the soldering joints inside the auto feathering unit (Aviation Safety Council, 2016, p. 147).

The report also indicated the crew did not abort the take off when the automatic take off power control system ARM pushbutton did not light (Aviation Safety Council, 2016, p. 147). With loss of power from both engines, the aircraft stalled and crashed into the river. Following the accident, TransAsia Airways grounded its ATR-72 aircrafts in order to perform safety checks on the aircrafts and its flight controls (Hsu et al., 2015). Being a popular choice among the Asia-Pacific domestic market, the grounding of the ATR aircraft significantly impacted airlines that operated the fleet type (McKirdy, 2015). The grounding lasted 2 days which led to cancellation of 90 domestic flights in TransAsia Airways (Hsu et al., 2015).

The ATR-72 fleet has encountered multiple accidents which created substantial concern over its safety. Aseman Airlines Flight IRC 3704 departed from Mehrabad to Yasouj Airport on February 18th 2018 (Accident & Incident Investigation Board (AIIB), 2019 p. 8). The accident investigation report stated that the aircraft lost altitude while conducting an approach to Yasouj airport and impacted Mount Dena. The aircraft was destroyed on impact and all 66 occupants perished in the accident. The aircraft type involved in the crash was an ATR-72-212 (AIIB, 2019, p. 8). Moderate icing conditions prevailed during the time of the accident (AIIB, 2019, p. 96). Findings from the

investigation revealed that the main cause of the accident was human factor in which the flight crew displayed poor Crew Resource Management (CRM), conducting flight in dangerous conditions, and making multiple operational errors during decent (AIIB, 2019, p. 96).

However, the accident report also highlighted the air carrier's failure to consider an airworthiness directive issued by European Union Aviation Safety Agency (EASA) prohibiting operations that exposed the airframe for prolong periods of time in ATR-42 and ATR-72 series aircrafts in inadvertent severe icing conditions (AIIB, 2019, p. 98). The Iranian Civil Aviation Organization grounded all ATR-72s operated by Aseman Airline following the accident on February 18th 2018 for precautionary measures and to allow a comprehensive investigation of the crash (Prokopovic, 2018). Following this accident, AIIB proposed safety recommendations to the Civil Aviation Organization of Islamic Republic of Iran (CAOIRI) to improve procedures to verify technical requirements on aircraft airworthiness (AIIB, 2019, p. 99). Even though the reputation nor the socio-economic variables were affected by this grounding, Aseman airlines suffered service disruptions as its only operational fleet type were ATR-72-200 and ATR-72-500 aircrafts (Prokopovic, 2018). Below, Table 2 summarizes the overall themes generated from this case study.

Table 2

Themes from Aerei da Transporto Regionale ATR-42/72 Case Study

Aircraft accident case	Theme 1	Theme 2	Theme 3	Theme 4
ATR-42/72	Operational factors	Financial aspects	Public perception elements	Regulatory concerns

Boeing B787 Dreamliner Case Study

Boeing Aircraft Company (Boeing) rolled out the B787 Dreamliner on December 15th 2009 (Boeing, n.d). The B787 Dreamliner family consists of B787- 8, B787-9, B787-10 Dreamliner series. B787-7 has the capability to transport 210 to 250 passengers up to 15,186 kilometers with its unmatched fuel economy and speeds up to Mach 0.85 (Boeing, n.d). All Nippon Airways (ANA) was the aircraft's launch customer of 50 B787 Dreamliner aircrafts on September 26th 2011 (Boeing, n.d).

On January 7th 2013, smoke was discovered in the aft cabin of a Japan Airlines (JAL) B787-8 aircraft in General Edward Lawrence Logan International Airport (BOS) in Boston, Massachusetts (NTSB, 2013, p. vii). The aircraft was parked at the gate and no passengers were on board. With the automatic shutdown of the Auxiliary Power Unit (APU), heavy smoke and a small fire was seen in in the aft electronic equipment bay. Firefighters and aircraft rescue personnel successfully contained the fire. The NTSB report published on the incident revealed the probable cause of the accident to be internal short circuit within a cell of the APU lithium-ion battery, leading to thermal runaway to adjacent cells and causing a fire (NTSB, 2013, p. 79).

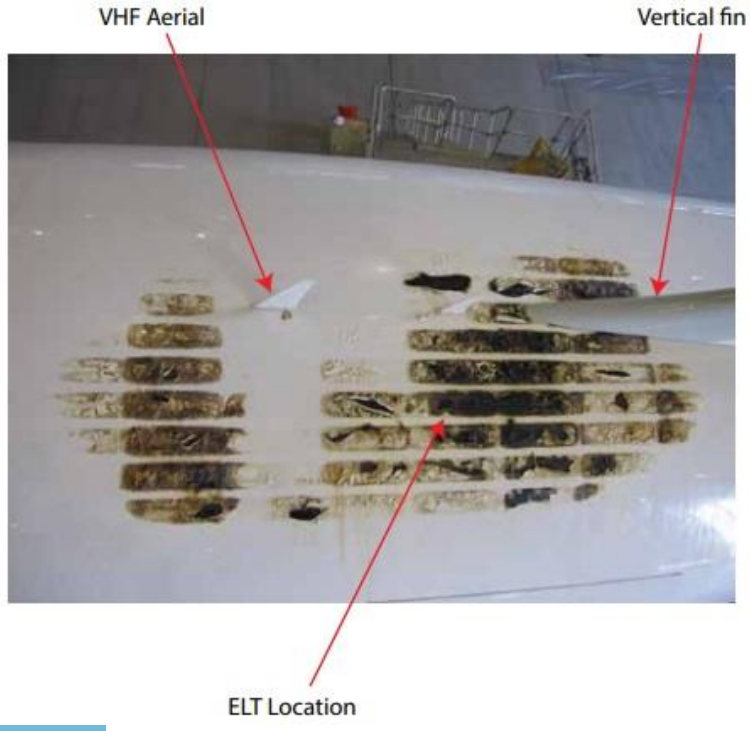
On January 16th 2013, All Nippon Airways (ANA) Flight 692 operating from Yamaguchi-Ube airport conducted an emergency landing to Takamatsu airport after observing illumination of the Engine Indicating and Crew Alerting System (EICAS) battery failure message accompanied by an unusual smell (Japan Transport Safety Board (JTSB), 2014, p. 4). The flight crew declared an emergency and diverted to Takamatsu airport and landed on runway 26 (JTSB, 2014, p. 5). JTSB investigation report concluded the probable cause of the accident to be cell-to-cell heat propagation caused by internal

heat generation, eventually leading to failure of the main battery (JTSB, 2014, p. 69). Following the incidents, JAL and ANA grounded its B787 fleets until the aircrafts have been deemed safe for operation (McCurry, 2013).

Another incident involving a fire induced by lithium-ion battery occurred in a parked and unoccupied Ethiopian Airlines registered B787 aircraft on July 12th 2013 in London Heathrow airport (Air Accidents Investigation Branch (AAIB), 2013, p. 1). The rear fuselage crown skin of the aircraft and fuselage frames was damaged by the fire. The incident investigation report concluded the probable cause as the result of thermal runaway due to failure of the lithium manganese dioxide battery in the Emergency Locator Transmitter (ELT) (AAIB, 2013, p. 2). Figure 16 below illustrates the fuselage damage of the B787 aircraft.

Figure 16

Fuselage Damage on B787 ET-AOP (AAIB, 2013, p. 5)



Following the ANA incident, the FAA issued an emergency Airworthiness Directive (AD) to temporarily cease operations of the B787 Dreamliner aircrafts within the U.S until the Boeing Company has installed main and APU battery enclosures, included Environmental Control Systems (ECS) ducts, and replaced the main and APU batteries (FAA, 2013).

JAL and ANA being the largest operators of the B787 Dreamliner, suffered a combined revenue loss of USD 110 million following the grounding in Japan (Reuters, 2013). The FAA estimated the costs of repair for lithium battery at USD 2.8 million (USA Today, 2013). Some analysts believed it would cost Boeing USD 600 million due to airlines demanding compensation (Rankin, 2013). Lastly, Boeing Co. stock market shares fell 0.6% to USD 139.87 on the New York Stock Exchange (Reuters, 2013). Table 3 below displays the themes derived from this case study analysis.

Table 3

Themes from Boeing B787 Dreamliner Case Study

Aircraft Accident Case	Theme 1	Theme 2	Theme 4
B787 Dreamliner	Operational factors	Financial aspects	Regulatory concerns

Airbus A320neo Case Study

Airbus Industry of European Aeronautic Defense (EAD) first launched the A320neo on December 1st 2010 and operated its maiden voyage on September 25th 2014 (Aircraft Compare, n.d). The A320neo was initially operated by Lufthansa on January 25th 2016. The aircraft model is a derivative of the Airbus A321 with an added new

engine option (neo) of Pratt and Whitney PW1100G engines (Airbus, n.d). The manufacturer marketed the A320neo for having unbeatable fuel economy with its 'Sharklets' and the option of two engines. Unfortunately, the success of the aircraft model was cut short following multiple incidents of in-flight engine shutdowns and rejected take offs (EASA, 2018).

Indian budget carrier IndiGo encountered multiple incidents when its A320neo aircraft suffered engine issues on departure when a 43% reduction in thrust in engine 1 on takeoff roll forced the flight crew to abort the takeoff (ASN, 2017). In another instance, IndiGo flight 6E395 performed an emergency landing following an in-flight engine shutdown (ASN, 2018). Following these incidents, the Directorate General of Civil Aviation (DGCA) ordered IndiGo to replace unmodified PW engines on its A320neo fleet (Phadnis, 2020). Additionally, EASA, regulatory agency in Europe issued an emergency AD to ground all Pratt and Whitney powered A320neos upon discovering damaged low pressure turbine third stage blades in the aircrafts (EASA, 2018).

IndiGo, which operates the world's largest fleet of A320neo of 106 aircrafts, faced operational disruptions due to the temporary suspension in operations to ensure compliance of engine replacements set forth by the DGCA (Kundu, 2019). Furthermore, the DGCA order impacted IndiGo growth capacity with a 2-3% reduction in the third quarter of its Fiscal Year 2020 (Phandis, 2020). According to the Center for Aviation Database, 19 aircraft were grounded following this directive (CAPA, 2018). Airbus reported a halt in deliveries following the disclosure of the design flaw and operational delays from airlines operating the fleet type (Kotoky et al., 2018). Furthermore, Airbus stock market shares dropped 1.08 points in the following months of March and April

2018 (Yahoo Finance, 2018). Table 4 below displays the main themes associated with this case study.

Table 4

Themes from Airbus A320neo Case Study

Aircraft Accident Case	Theme 1	Theme 2	Theme 4
A320neo	Operational factors	Financial aspects	Regulatory concerns

Boeing B737 MAX Case Study

The Boeing Company first introduced the B737, a short-range twin jet aircraft, on January 17th 1967 (Boeing, n.d). The model consisted of upper deck cargo pallets and later adopted convertible features to carry passengers and cargo. Since then, the B737 underwent numerous transformations in terms of engine mount positions, changes to seating capacity, and introduction of new technology (Boeing, n.d). The latest variant of the B737 family includes B737 MAX 7, MAX 8, and MAX 9. The B737 MAX series offers a sleeker design, lower engine thrust, low maintenance costs, quieter engines, and reduced emissions (Boeing, n.d). The Boeing assembly plant in Washington State in U.S initially produced 52 planes a month for its launch customers garnering itself a Guinness World Record for the 'highest production large commercial jet' in March 2018 (Boeing, 2018).

On October 29th 2018, Lion Air Flight 610 crashed off the coast of Indonesia killing all 189 occupants on board (Komite Nasional Keselamatan Transportasi (KNKT), 2019). The flight was a regular scheduled passenger flight from Soekarno-Hatta

International Airport in Indonesia. The aircraft involved in the accident was a PK-LQP registered B737 MAX 8. According to the Digital Flight Data Recorder (DFDR) findings, prior to takeoff, there were significant discrepancies between Indicated Airspeeds (IAS) on the captain's Primary Flight Display (PFD) and first officer's PFD. There were also differences the angle of attack (AoA) captured by AoA sensors outside the aircraft. Following departure from Soekarno-Hatta International Airport, the crew struggled to operate the aircraft with altitude and airspeed disagreements between their instruments, leading to the activation of the stick shaker.

Upon retraction of the flaps, the Maneuvering Characteristics Augmented System (MCAS) was reported to have activated several times throughout the flight. The MCAS is a flight control law housed in the B737 to improve aircraft handling characteristics and decrease pitch-up tendencies at elevated angles of attack (Skrybrary, 2019). MCAS uses measurements from two AoA sensors in the aircraft to be fed into the flight control computer (Boeing, n.d). The MCAS is activated when the aircraft is in three configurations; manual flying, airplane nose in higher-than-normal angle, and flaps retracted (Boeing, n.d). The findings from the Lion Air Flight 610 revealed that multiple activations of the MCAS throughout the flight, coupled with faulty information from the AoA sensors, affected the flight crew's understanding of the situation and decreased their ability to recover the aircraft from the undesired state (KNKT, 2019, p. 197).

On March 10th 2019, Ethiopian Airlines Flight 302 crashed near Ejere, Ethiopia after takeoff from Addis Ababa Bole International Airport (The Federal Democratic Republic of Ethiopia Ministry of Transport, 2020, p. 9). All 157 souls on board perished in the crash. The aircraft involved in the accident was a B737 MAX 8. According to the

preliminary report, the DFDR indicated a deviation in the left and right AoA values. This prompted activation of the stick shaker and deviations in airspeed, altitude and pitch levels on the left side of the flight deck.

Two minutes after takeoff, the autopilot disengaged and the flaps were retracted, triggering the MCAS activation. The MCAS trim was active sporadically throughout the flight and the crew initiated the Stab Trim Cut Out switches. With the aircraft far out of trim and travelling at a speed of 340 knots at 14,000ft, the flight crew were unable to recover the aircraft and the impacted the ground (The Federal Democratic Republic of Ethiopia Ministry of Transport, 2020).

Following the fatal crash, Ethiopian Airlines suspended operations of B737 MAX 8 aircraft (The Federal Democratic Republic of Ethiopia Ministry of Transport, 2020, p. 25). Consequently, Boeing recommended to ground operations of the B737 MAX aircraft for cautionary measures (Boeing Newsroom, 2019). In response to this recommendation, 50 countries grounded the aircraft with U.S being the last nation to join the rest of the world (Isidor, 2019). On March 13th 2019, the FAA issued an Emergency Order of Prohibition to immediately cease operations of all B737 MAX 8 and B737 MAX 9 series aircrafts in the U.S (FAA, 2019, p.1).

The grounding of the B737 MAX created disruption in operations and significantly impacted the financial aspects of operators of the aircraft type. Southwest Airlines, the largest operator of the aircraft with 34 planes in its fleet, revealed that the grounding cost the airline USD 210 million loss in revenue in its last quarter and USD 435 million loss in the year 2019 (Josephs, 2019). Upon canceling 175 weekday flights

and incurring high fuel costs due to operating less fuel-efficient aircraft, Southwest reached a settlement with Boeing of USD 125 million (Isidore, 2019).

American Airlines, another U.S carrier with heavy investment in the B737 MAX, informed that the airline reduced its pre-tax income to USD 540 million and experienced a drop in revenue of USD 11.91 billion (Josephs, 2019). Internationally, Ryan Air forecasted its growth rate to drop from 7% to 3% in the summer of 2020 following the fleet grounding (Topham & Kollewe, 2019). During this time, the airline reported its plan to cut 30,000 flights and carry 5 million fewer passengers in the following year due to delayed deliveries from Boeing. Boeing slowed down the production of its most profitable aircraft and faced a financial toll of USD 900 million (Bogaisky, 2019). Several airlines including Flyadeal, Oman Air, Fly Dubai, and Ethiopian Airlines reported to have cancelled orders of the B737 MAX aircrafts with Boeing (Layne, 2019).

Apart from the air carriers, Boeing Company's major component suppliers such as Spirit Aerosystems and General Electric were also impacted by the B737 MAX grounding. The shares of Spirit Aerosystems dropped 4.8% while shares of General Electric fell 1.9% following the grounding (Josephs, 2019). With air transportation playing a vital role in the country's GDP, Federal Reserve economist forecasted the U.S GDP to decline by 0.4% by the beginning of year 2020.

Given the severity and catastrophic nature of the accidents involving the B737 MAX aircraft, the public perception on the aircraft has not fared well. However, this has not been the case for the entire flying public. The Union Bank of Switzerland (UBS) conducted a survey on the public perception of B737 MAX's potential return to service with a sample of 1000 U.S residents (Bertorelli, 2019). The results indicated that 70% of

the population surveyed would have some hesitation to fly in the aircraft while 12% stated that their worries cannot be addressed with continued safe operation of the B737 MAX aircraft. However, the hesitancy is not guaranteed to linger as shown by a passenger survey conducted by Barclays Bank that indicated the flying public would wait at least a year before returning to the aircraft (Bertorelli, 2019). Furthermore, in a study conducted by Rian Mehta (2020) on the willingness to fly in B737 MAX aircraft was it to be re-certified and re-entered into operational service, 61.5% of the population surveyed stated they were unwilling or not confident to fly in the aircraft (Mehta, 2020; Rice, 2020). Currently, the FAA had rescinded the grounding of the B737 MAX in the U.S pending issuance of ADs to ensure compliance with modifications to the aircraft's design (FAA, 2020). Table 5 below illustrates the themes derived from the case study analysis.

Table 5

Themes from Boeing 737 MAX Case Study

Aircraft accident case	Theme 1	Theme 2	Theme 3	Theme 4
Boeing 737 MAX	Operational factors	Financial aspects	Public perception elements	Regulatory concerns

CHAPTER III

Methodology

The objective of the study was to investigate the impact of safety on fleet acquisition and management in U.S commercial airlines. The use of case-study analysis of notable aircraft accidents and incidents involving aircraft types was to establish the relationship between safety events and aircraft acquisition and subsequent utilization among air carriers. Following the case-study analysis, manual coding was conducted on the consequences associated with the events. Utilizing the common codes, overarching themes that were prevalent in the events were determined and recorded. This process laid the groundwork to formulate a semi-structured interview for the next phase of the study. A semi-structured interview was conducted with 6 Subject Matter Experts (SME) from a 14 CFR Part 121 commercial airline. The interview was conducted to gain perspective into how adverse safety events related to aircraft types may influence aircraft acquisition and fleet planning decisions.

The rationale for using case study analysis was to provide a comprehensive description of the events that took place related to the aircraft types and compromised its safety. The use of public documents to collect information to conduct the case study analysis allowed for the extraction of valid, relevant, and unobstructed source of data. However, some limitations associated with this method includes the articulate ability of the data source, restricted access to certain material, and potential for inaccurate information published in the documents (Creswell, 2014, p. 191). The use of a semi-structured interviews allowed the researcher to obtain historical information about the

subject matter from respondents and granted the researcher with some level of control in line of questioning. Another advantage for using this line of inquiry was that it provided the researcher with access to respondents when observation was restricted. However, utilizing interview method may introduce potential biases to the data due to respondent's own opinions and presence of the researcher (Creswell, 2014, p. 191).

Data Collection

For the initial phase of the study, a combination of primary and secondary sources was utilized to analyze the case studies of the notable accidents and incidents involving aircraft type. The second phase of the study utilized semi-structured interviews via Zoom video conferencing. The sessions lasted an average of 45 minutes with all sessions being end-to-end encrypted and password protected in the interest of cyber security. The interviews were recorded with audio and transcript files obtained at the end of each interview.

The semi-structured interviews followed a style guide which is found in Appendix A. The participants were provided with the interview guide at least 2 weeks prior to the scheduled interview date to familiarize themselves with the study and the questions. The questions used are as follows:

1. In your expert opinion, what are the important variables of interest in fleet planning and management?
2. As a follow up to the first question, what role does operational safety play?
3. In your opinion, how do adverse safety events related to a particular aircraft type influence the acquisition of similar aircraft type in your airline?

4. How does each department within an airline plan and prepare for acquisitions following such adverse safety events?
5. In your experience, how does an airline re-strategize after a major operations change such as taking a fleet offline due to safety issues?
6. What are the remarketing and rebranding techniques used by airlines to bring a fleet that has experienced safety concerns back online?
7. How can airlines restore faith and consumer confidence in air travelers when returning a fleet to operations after encountering safety issues with the aircraft model/type?
8. What are some of the effects of regulatory decision-making such as fleet groundings on airlines and what are the specific consequences in each department if any?

Ethical Considerations

The study received approval from the UND Institutional Review Board (IRB) to conduct the semi-structured interviews involving SMEs. A copy of the IRB approval form is found in Annex B. In the interest of privacy, no personal information about the participants were revealed. All recordings and field notes were forwarded to the participants for verification prior to being used in the study. There was minimal to no risk associated with the study.

The original signed consent forms will be permanently destroyed three years after the completion of the study in accordance with UND document disposal policy. The individuals with access to the interview recordings, field notes, and consent forms are the principal investigator and those listed in the Key Personnel Listing.

Participant Recruitment Process

Initially, the participants were recruited by the principal investigator through a formal request to the airline using a focal point-person in the flight operations department. Each of the SMEs were provided with an invitation letter providing details about the study and the interview process. Upon their voluntary acceptance to participate, each participant received a copy of the interview guide containing the planned interview questions and a copy of the IRB Informed Consent form requiring their signature.

Following the receipt of the signed IRB Informed Consent form, a date and time for interview sessions was agreed upon. The interview sessions took place between the months of June and July 2020. Prior to commencing each session, participants were notified that the session was being recorded. The interviewees were also informed of the anticipated duration of the interview to be an hour and they reserved the right to stop and withdraw from the interview at any time if needed. During the interview, field notes were taken to note down any points that required a review or further clarification. Prior to concluding the interview, participants were informed of the forwarding of transcripts obtained from the interviews for their perusal and validation. All transcripts obtained from the interviews were verified and personal identifying information were removed.

Participants

The SMEs that participated in the semi-structured interviews were from a domestic carrier in the U.S operating under 14 CFR Part 121 certification. The carrier operates its 747 aircrafts, primarily B737 aircraft models, to 101 destinations. The airline primarily operates within the continental U.S while serving a few international routes for

leisure travel. The airline is recognized as a large carrier that operates with over 60,000 employees (Airline X, n.d).

Six SMEs were invited to participate in the study, each representing departments that play a crucial role in aircraft acquisition and fleet management processes in the airline. These departments include Safety, Fleet Acquisition and Management, Engineering, Network Planning, and Flight Operations. The participants were approximately over the age of 30 with an average of 20 years of airline experience with a few participants with 9 years of experience. These participants were chosen based on their expertise and level of experience within their respective departments. The participants possessed the knowledge that is representative of the key players in the process of fleet planning and management in commercial airlines. Saturation in qualitative research is defined as a criterion to discontinue data collection as current results are sufficient to confirm emerging themes and further data collection would not yield new information (Faulkner & Trotter, 2017). Upon conducting 6 interviews, no new themes were derived from the data concluding that the study reached its saturation level.

Trustworthiness of qualitative content analysis is defined in terms of credibility, dependability, conformability, transferability, and authenticity (Elo et al., 2014). The qualitative content analysis of the case-studies examined satisfies the trustworthiness factors due to the use of credible sources such as accident investigation reports. A table including all sources used for the case study analysis can be founded in Appendix C. The semi-structured interview data gathered from the SMEs meets the trustworthiness factors based on the background of the SMEs including top-management designations, average

age, and number of years of service in the airline industry. An interview log displaying background information of the SMEs including interview time duration and airline experience is provided in Appendix D.

Data Analysis

For the case study analysis, respective themes were manually derived by analyzing regulatory directives, accident investigation reports, and media accounts to collect common elements prevalent in each event. Following each case-study analysis, tables illustrating emergent themes were incorporated to display the association of the event and the aircraft type. A table containing the sources utilized in the case-study analysis is found in Appendix C.

A combination of inductive and deductive manual coding was performed on the verified transcripts. The codes were derived from the common concepts discussed in the interview sessions and formulated into associated themes. A codebook developed by the researcher for the manual coding process is found in Appendix E. The themes and codes derived from the interviews are arranged in respective tables and is referenced in the following section.

CHAPTER IV

Findings

Existing literature on the subject of fleet planning and management primarily covers concepts such as fleet standardization, influence of emission thresholds, and fleet models based on route structure (Narcizo et al., 2020; Muller et al., 2018; Dozic & Kalic, 2015). In a research study conducted by Koo et al (2015), the authors investigate the role of safety information on passenger choice of an airline along with several other factors such as price, schedule, travel time, and quality of inflight service (p. 1). The findings from the study concluded that presentation of safety information plays a vital factor in passenger decision when choosing an airline. An extension of this study was conducted involving a wider demographic of participants which revealed a similar conclusion on the implications of perception of safety on commercial practices in the industry (Koo et al., 2018). Both studies used number of accidents in a given aircraft type to convey safety information to respondents to evaluate its influence on flight choice.

The authors suggested that understanding the impact of safety on passengers' choice of flight can be utilized in commercial practices such as building the safety record of an airline and for "transport planning" which implies the aircraft acquisition and fleet planning procedures in an airline (Koo et al., 2018, p. 160). The findings from these studies lays the groundwork for the current study to explore the role of safety on aircraft acquisition and fleet management procedures in U.S commercial airlines. It is envisaged the results from this study will provide answers for the following research questions:

1. What are the operational, economical and safety variables involved in airline fleet planning and management?
2. What is the role of a fleet's operational safety according to SMEs? How does the historical safety or perceived safety of a fleet type affect the choices for acquisition at the management level?
3. What are the processes and procedures in place to acquire or re-fleet aircraft following an adverse safety event?
4. How does an airline re-strategize following a major operations change such as the grounding of a fleet due to safety concerns?
5. What remarketing and rebranding techniques are utilized by airlines to resume operations of a fleet that has been grounded?
6. How can airlines restore faith and consumer confidence in air travelers when returning an aircraft to operations after adverse safety events related to the aircraft model?
7. What are the effects of regulatory decisions such as fleet groundings on airlines and what are the specific consequences in each department?

The initial phase of the study entailed a case study analysis of notable incidents and accidents associated with aircraft fleet types. The analysis yielded major themes that identified the relationship between safety events and aircraft acquisition and utilization in airlines. The themes from the analysis included variables that were significant such as operational, financial, and public perception.

Following the case study analysis, a semi-structured interview was conducted with 6 subject matter experts from a 14 CFR Part 121 commercial airline to gauge the airline perspective on the impact of such adverse safety events on aircraft acquisition and fleet planning decisions. The subject matter experts (SME) shared valuable expertise from key departments involved in the fleet planning and management process in the airline such as flight operations, fleet management, asset management, engineering, network planning, and safety.

Upon verifying the interview transcripts to de-identify personal information, manual thematic coding was used to analyze the qualitative data. Inductive coding process was used to solidify themes that were initially derived from the case study analysis, and deductive coding to generate new codes. Subsequently, the codes were grouped into common themes and expanded. This section discusses the underlying themes drawn from the semi-structured interviews along with direct quotes from the SMEs that illuminate the significance of aircraft safety on aircraft acquisition process and contributary variables that play a role in the fleet management process.

Financial aspects

Common elements discussed among the SMEs as a key variable in the fleet planning process were associated with cost structures and financial objectives. Table 6 below illustrates the common codes unearthed from the interview to formulate the first theme.

Table 6

Theme 1: Financial Aspects

Question	Code	Theme
1	**Cost** per seat, cost per trip, **fuel efficiency**, training costs, costs due to service disruptions and downtime, inefficiency costs, maintenance costs, and cost of spares. **Leasing/purchasing decisions**, cost of acquisition, comparative costs with other available aircraft, **capital** constraints.	
5	Associated costs with risk mitigation.	Financial aspects
8	Certain regulatory actions make **aircraft uneconomical**. Affects overall operating cost of aircraft. Costs associated with additional scrutiny on manufacturers. Techniques to mitigate costs	

The participants noted costs associated with seats, trip, training, and maintenance are vital financial criteria assessed prior to aircraft acquisition. Training costs include training for pilots, flight attendants, and mechanics. Maintenance costs are a significant driver in the decision-making process as air carriers evaluate the aircraft's potential to cause service disruptions or downtime. Aircraft operators also analyze the importance of aircraft features that influence the airline financial resources such as fuel economy, the cost of spare parts, and inefficiency costs associated with a mixed fleet.

The acquisition type in terms of leasing or purchasing the aircraft is a key decision that influences the overall financial structure of the air carrier as fleet investments are a long-term commitment. Additionally, participants noted comparative

costs, evaluating differences in cost of acquisition among other aircraft in the industry, as a valuable assessment criterion. With the element of safety playing a role in the air transportation industry, expenses associated with mitigating safety hazards were accounted in the overall financial plan in an airline.

Furthermore, SMEs stated certain regulatory actions are of the nature that impacts the aircraft's overall operating costs leading to aircraft becoming uneconomical due to required maintenance or grounding actions. A direct quote from a participant based on this statement can be found below:

"There could be regulatory things that basically make certain aircraft types so economically unattractive that you get rid of them, whether it's either because either the OEM or third party providers have not provided technology in order to upgrade the older technology to meet new regulations".

This could potentially cause a significant impact on the financial aspects of an airline due to aircraft downtime. According to the participants, changes to safety standards and features from manufacturers induced by regulators can trickle down to airlines as added expenditures in mitigating hazards. Internally, the air carrier is responsible to find efficient operating techniques to mitigate those costs.

Aircraft economics

A distinct and crucial component of the fleet acquisition process is the economics of the aircraft. The respondents explained the myriad features that are assessed prior to acquisition of an aircraft. A few of these criteria have been displayed below in table 7.

Table 7

Theme 2: Aircraft Economics

Question	Code	Theme
1	**Fuel efficiency**, piloting of aircraft, **capacity**, **performance**, **payload range**, aircraft **configurations**, requirements, crew complements, **efficiency**, **reliability**, availability, **age** of aircraft, **technology** onboard, **retirement** plans, heavy checks, **maintenance** profile. New or used aircraft, fleet commonality.	Aircraft economics
2	Aircraft capability, **operational safety rules and regulations.**	

According to the interview participants, prior to investing in an aircraft type, crucial components of the aircraft such as its capabilities, deficiencies, useability, capacity, and performance are analyzed. Fuel efficiency is a common code that is found to overlap multiple themes emphasizing its relevance to the fleet acquisition process. Other aircraft variables examined include payload range, capacity, configuration, efficiency, reliability, and availability. The payload range consists of the aircraft's ability to carry passengers and cargo over a distance, while configuration is the aerodynamic layout.

Participants noted the significance of having an aircraft that can operate to its highest efficiency yet needs to be reliable to maintain optimal service. The SMEs stated the influence of capacity on other functions of the airline including crew scheduling. Crew complements to aircrafts are assigned based on its capacity and size. Access to the

aircrafts, technology on board, service hours, and fleet variations are few other variables that configure into the acquisition process. As mentioned, maintenance of the aircraft places a significant weight on the evaluation criteria. The age of the aircraft, condition (new or used), and maintenance profiles are included in the decision. Lastly, every air carrier operates under its own operational specifications and procedures in addition to manufacturer recommended guidelines which also adds to the cumulative criteria of aircraft economics.

Market evaluation and network planning

The respondents acknowledged that market evaluation and network planning play a vital role in the fleet acquisition and planning procedures. Evaluating the market conditions and planning a network are a few of the primary phases of initiating operations in an air carrier. Table 8 below displays the codes and themes derived in relation to market evaluation and network operations.

Table 8

Theme 3: Market Evaluation and Network Planning

Question	Code	Theme
1	**Destinations, frequency, mission types**. Markets to serve, time in **economic cycle**, time in **technology cycle**, **market conditions**. Where an airline is located dictates the focus.	Market evaluation and network planning
5	Maintain **commercial footprint** with fewer airplanes, **changes to network**, elimination of lines of flying, impact on frequency, least profitable routes, **rebuild schedules**, crew scheduling, supply chain impacts.	

Table 8 continued

Theme 3: Market Evaluation and Network Planning

Question	Code	Theme
8	Impact on network and markets operated. Rewrite schedules with different aircraft/less aircraft. Exit some markets.	Market evaluation and network planning

Participants noted that the initial stages of forming an airline consists of establishing destinations to fly to, the type of operation, and frequency of flights conducted in an operational time period. In relation to acquiring a fleet to carry out this operation, a thorough evaluation of the market conditions is required. One participant emphasized that the stage of the economic cycle and technology cycle may dictate the air carrier's access to the equipment. A direct quote highlighting this assertion can be found below:

"There's just no one right answer. And you have to take into account, where you're at in the economic cycle, where you're at in the technology cycle".

"If you're looking for new aircraft today, you've got that new or the latest and greatest technology available to you. When you know you're thinking about aircraft you have to look at where are we in the cycle, where we in the market. You may want a new aircraft or you may want new technology, but the market may be depressed and such that you could actually go get used aircraft or older technology for far lower price. In that might allow you to bridge the gap to that new technology".

The economic cycle consists of various fluctuations between growth and recession in the industry which can impact the overall operation plan of the airline. The

participant also explained that the development of new technologies for aircrafts potentially can alter an airline's decision to acquire or delay acquisition of the aircraft to keep in tune with the technology cycle. The interviews also revealed that the geographical location of the airline may dictate the focus of the airline's operation and its access to desired markets.

According to the common codes derived from the interviews, in the event of an adverse safety event related to an aircraft type, network operations maybe the initial aspect of operations to be affected. In the case of a fleet grounding, the network operations personnel are tasked with maintaining the airline's commercial footprint with fewer aircrafts. This action may take several forms such as replacing the routes with aircraft of similar size and extending the length of operating days of useable aircraft. If an airline consists of the same fleet types, such adverse safety events may force the air carrier to eliminate those lines of operation and exit the market they can no longer serve. Participants also noted that airlines may identify its least profitable routes to eliminate in order to maintain operations. With significant impacts to frequency and overall network structure, the air carrier may be required to rebuild schedules, alter crew scheduling based on its capacity, and maintain a strong supply chain.

Safety

With safety being the primary focus of this study, it was evident the significance of this theme was displayed throughout all the interview sessions. Some of the recurrent codes that were highlighted throughout the interviews formulated its dominating position in the decision-making process. The relevance of safety progresses into multiple themes throughout the study including risk management and key fleet decision making criteria.

In table 9 below, the codes and themes revolving around the influence of safety in strategic decisions is demonstrated.

Table 9

Theme 4: Safety

Question	Code	Themes
1	**Highest level** of aircraft safety.	
2	Safety is a **major** factor, should never be in question or compromised, integrated in every step of decision-making process. **Core** of all operations, **strong safety culture** and compliance.	Safety
3	**Influences** and affects perception, connection, and plays a factor in decision-making.	

Participants noted that the industry has had a long-standing history of being safe, especially within the United States. They placed safety as one of the highest priorities in the overall strategy of an airline. The interviewees emphasized that the priority placed on safety is such that it is never compromised. Safety is engrained within all processes that safety culture has become prevalent in the airline industry. In terms of fleet acquisition, participants note that air carriers choose aircrafts with the highest level of safety in addition to its efficiency and reliability. A direct quote from the interview emphasizing the role of safety can be found below:

"And what I mean by that is, for an aircraft you don't want to question the safety of an airplane. You want to be sure that the certification process is adequate and that the airplane meets form, fit, and function and can operate for line operations safely. So if

there's a doubt in that space, it's a hesitation if you're going to get involved in that airplane".

The SMEs regarded the role of safety to be an integral component to their operational plan and is integrated in every step of the decision-making process. When acquiring an aircraft, the airline ensures its safety against the certification criteria set by regulatory agencies and manufacturers. Additionally, the participants stated that the implementation of Safety Management System (SMS) has revolutionized the analysis of strategic decisions within airlines.

Safety Management Systems (SMS)

The next theme that drew significant attention is the element of risk assessment in airlines in relation aircraft safety and safety events. Safety Management Systems (SMS) is defined as a systematic approach to managing safety including the necessary organizational structures, accountabilities, policies, and procedures (ICAO, 2018). The objective of an SMS is to provide a structured management approach to identify control safety risks in operations. The SMS framework utilized by the FAA comprises of 4 components: safety policy and objectives, safety risk management, safety assurance, and safety promotion (Oatman, 2010).

Safety policy and objectives component establishes the senior management's commitment to continually improve safety in terms of methods, processes, and organizational structure to meet safety goals (Oatman, 2010). The component of safety risk management consists of processes to identify hazards, analyze risks, and implement risk controls. Safety assurance evaluates the effectiveness of the risk control strategies

being implemented and supports the identification of new hazards. Lastly, safety promotion comprises of training, communications, and other actions that can create a positive safety culture in all levels of the workforce (Oatman, 2010).

SMS was regarded to be a key driver in the analyzing various airline strategic decisions including the acquisition and management of aircrafts. Below, table 10 highlights some of the codes derived from the interviews that threw light into the overarching theme of SMS in the airline industry.

Table 10

Theme 5: Safety Management Systems (SMS)

Question	Code	Theme
1	**Evaluate risks** associated using Safety Management Systems (SMS), **risk controls**.	Safety Management Systems (SMS)
3	14 CFR Part 5, using SMS to evaluate new fleet type with **risk analysis**. **Long-term risks** with different fleet types, regulatory, and compliance risk. Does it increase overall risk to system, acceptable/unacceptable levels of risk.	
4	Departmental safety risk management teams, **identify hazard**, its **impact** on department top function, certain departments interface with manufacturer and regulator, **identify cause, propose controls** to mitigate risk, internal additional controls, **reducing risk** to acceptable level for operation, unintended consequences, corporate project team to evaluate overall activity.	

SMS is a theme that stemmed from the discussion of safety during the interview sessions with SMEs. Participants mentioned how safety is pervasive in all departments

within an airline. Subsequently, respondents stated that a SMS is required to be in place to evaluate the levels of safety within each department, along with the airline's strategic decisions and functions. One participant provided the usefulness of SMS in a strategic decision such as acquiring a new fleet type. The direct quote from the participant can be found below:

"Through our safety management system or SMS, we start to evaluate the risk factors associated with that. And then what kind of mitigations will be required. That's where we really, I think in today's environment we've gotten a lot better with our safety management system, is you start to evaluate on the front end all of those risk controls that may be necessary due to a mixed fleet. And then that subsequently will help you understand what the cost is associated with that. So in the past I think we didn't have as clear of an economic picture going into decisions about new fleet types. And now we have a better picture, so when we are making an economic decision those safety risks are already factored into that economic decision. With SMS, the safety aspects are front and center of our decision about introducing a new aircraft type".

Following the occurrence of an adverse safety event, the risk management teams within each department may identify a hazard and its impact to the top function of the department using SMS. Subsequently, the operator may work with associated groups such as regulatory agencies and manufacturers to diagnose the safety issue, its root cause, and propose risk mitigation controls. Furthermore, the respondents note that an airline may opt to introduce additional risk mitigation controls in order to reduce the risk to acceptable levels for operation. However, air carriers should be cognizant of unintended consequences with the implementation of risk controls and further evaluation of these

actions may be required. One participant mentioned the existence of project management teams that are in place as an overarching body that provides oversight and ensures the success of such activities.

With regards to aircraft acquisition and management, air carriers conduct a thorough risk analysis using SMS under 14 CFR Part 5 when introducing new fleet types. The gravity of this decision lies in the long-term impacts of acquiring an aircraft type and associated risks. According to the SMEs, introduction of new fleet types to a fleet plan can potentially increase financial, regulatory, and compliance risks. Therefore, SMS proves to be a valuable and necessary tool to utilize in aircraft acquisition and fleet management process in airlines.

Fleet acquisition decisions and diversity

During the discussion of safety in an airline fleet plan, a popular topic of conversation was the role of safety in relation to acquisition decisions and diversity in fleet types. Majority of the participants elaborated on various criteria involving the selection of aircraft, the concept of fleet commonality, its impact on operations and overall safety. Table 11 below indicates codes from the interview data that have been grouped under the theme of fleet acquisition decisions and diversity.

Table 11

Theme 6: Fleet Acquisition Decisions and Diversity

Question	Code	Theme
2	**Fleet commonality** in procedures such as flight crew, ground operations, and maintenance. Minimize potential hazards and risks from differences in aircraft using SMS. Consequences of introducing a new aircraft type.	Fleet acquisition decisions and diversity
3	**Airline introspection**, review of current policies and procedures. Advantages of diversity: fleet type grounding, **business continuity**, safety concern in fleet type, mitigates subset of risk, and reduced severity of regulatory decisions. Disadvantages of diversity: **inefficiency costs**, training costs, maintenance and spares costs. **Long-term risk**, regulatory, and compliance risk. Safety concern affects business despite diversity, duopoly in industry (limited production capabilities). Tailoring fleet to airline operational plan, alterations to fleet and retirement plans	
5	Extending length of operating day with similar capacity aircrafts, **alternative fleet types**.	
8	Buy more airplanes or delay selling/retiring existing airplanes. Extending lease dates. AD: **cost, timeliness**. Adjustments to fleet plans, retire uneconomical aircraft. Changes to maintenance schedules.	

According to the participants, in the event of a safety issue associated with an aircraft type, the airline may conduct an internal review on their current policies and procedures to reflect on its activities. In the event of a regulatory compliance such as a

fleet grounding in connection to a safety issue or an emergency airworthiness directive, the airline would initially evaluate the size of the fleet affected by the regulatory decision. The airline would also evaluate the cost and timeliness of compliance with the directive prior to adjusting the fleet plan.

Consequently, the air carrier may opt to purchase new aircraft or delay the retirement of existing aircraft to accommodate for the loss in serviceable aircraft. The direct quote below addresses these processes as mentioned by the participants:

"Let's say for instance you ground a quarter of the fleet. Well, in fleet management, the big things we were able to go do is we can buy more airplanes and we can sell airplanes. So we'll either go and try to buy more airplanes that aren't grounded, or we'll delay selling and retiring our aircraft that are not grounded. So you basically have to deal with the other aircraft that are viable candidates".

"So let's say for instance, there's a requirement to do like an AD. We might, for instance, an AD takes two months to accomplish per airplane. We may go buy a few more airplanes or basically avoid retiring aircraft for a couple years to basically cover the time required to do those upgrades".

In addition, fleet planners may extend the lease or sell existing aircraft to overcome the financial costs incurred from service disruptions. Participants in the study noted that there are both benefits and drawbacks in maintaining a mixed fleet in an airline. The following direct quotes obtain from the interview transcripts confirms this perspective:

"When you when you have something like this that grounds your fleet, hopefully it's not putting you out of business. So that's where some diversity, obviously helps out from a business continuity standpoint".

Following an adverse safety event that leads to grounding of an aircraft type, a diversified portfolio allows the air carrier to operate the alternate aircraft types in order to continue operations. In addition to business continuity, a mixed fleet also cushions the severity of regulatory decisions such as airworthiness directives that may require a fleet type to undergo required maintenance activities causing service disruptions.

Even though diversity in the fleet plan mitigates a certain amount of financial risk, the participants credit the advantages of fleet commonality to be evident in aspects such as training, costs, and safety. The direct quotes presented below validates this viewpoint:

"I think the challenge becomes at what level of multiple airframe types do you have to have multiple aircraft types to really reap the benefit because you quickly start losing on economies of scale when it comes to training".

"When it comes time to have to reduce the size of your operation and furlough, you for really most junior pilots, which tend to be on your narrow body equipment. Airlines today are parking their wide body equipment. So you're going to furlough your narrow body pilots and then you're going to have to retrain all the people that are in the wide body aircraft. And so having a multiple fleet type creates a huge amount of training costs and training support for reducing your size. Whereas an airline like us has one aircraft type, it's pretty benign".

The participants noted when maintaining fleet commonality, the training process for flight crew and mechanics is less complex and the ability for flight crew to transition between variants of fleet types appears to be seamless. Additionally, the cost of training is kept minimal.

According to respondents, the cost of maintaining a diverse fleet mix including the cost for spares and facilities can be significant. Interviewees also stated that a mixed fleet may incur long-term risk in terms of regulatory and compliance risks. A major outcome of acquiring a new fleet type introduces potential hazards and risks from differences in aircraft. Therefore, SMEs recommend the use of SMS to conduct a comprehensive evaluation on the consequences of new fleet acquisition. Lastly, it was agreed among the participants that despite the implications of regulatory decisions that affect a specific fleet type, it can inflict significant impact regardless of a diversified portfolio. Therefore, participants recommended tailoring the acquisition process to the operational plan of the airline and altering fleet plans and maintenance schedules as needed.

Airline operations aspects

The theme of airline operations houses a myriad of codes that reflect the overarching functions of operational objectives of an airline. The codes generated from the interviews revealed the influence of safety on the overall operational plan of an air carrier. Table 12 below illustrates the various codes grouped under the theme of airline operations.

Table 12

Theme 7: Airline Operations Aspects

Question	Code	Theme
1	Airline **objective**, operational constraints/ **service disruptions**, business product, matching capacity with demand.	Airline operations aspects
5	Affects **operational strategy**. **Re-strategize** using business continuity plans. Playbooks for issues in the past and or future. Strategic decisions and **re-prioritize**. **Training plans**, changes to procedures, aircraft operating conditions, potential solutions.	
8	**Impact growth** and operational strategy. Changes/additional training. Training flight crew in variants of fleet types. Impact on **pilot proficiency**.	

The SMEs stated the purpose of acquiring aircraft is to accomplish an airline's operational objectives and to deliver its services. The operational objective of airlines may take various forms such as matching capacity with demand and capturing routes most valued by customers. As noted by the interviewees, the occurrence of safety incidents and accidents can have a direct impact on the operational strategy of an airline and its services.

Firstly, the temporary elimination of fleets from routes can cause service disruptions. During aircraft downtime, the operational strategy is significantly altered hindering overall growth of the airline. Within flight operations, SMEs mention the use of business continuity plans implemented by air carriers to re-strategize and reprioritize its assets to continue service. Some of these actions may involve training of flight crew in

alternate aircrafts, revisions to established policies and procedures, and changes to aircraft operating conditions. According to the SMEs, these plans are based on precedence and possible scenarios expected to occur in the future. A significant drawback to air carriers with a single fleet type is that aircraft downtime may affect pilot proficiencies which may increase the cost of training once the aircrafts resume service.

Manufacturer and regulatory aspects

The manufacturer and regulatory lenses are a mandatory perspective to explore when investigating the factors that influence aircraft acquisition and fleet management processes. All the participants in the study stated the influence of regulatory agencies and manufacturer reliability on airline operations, especially within flight operations and fleet management functions. In table 13 below, prevalent codes derived from the interview sessions have been grouped together under the overarching theme of manufacturer and regulatory aspects.

Table 13

Theme 8: Manufacturer and Regulatory Aspects

Question	Code	Theme
1	Meets **certification criteria** by regulatory authority.	Manufacturer and regulatory aspects
2	**Reliable** manufacturers, **trust** in nation certification process for aircraft to meet fit, form, and function. **Safe products** required for manufacturer survival.	
3	Manufacturer trust. Regulator for safety certification criteria and standards. Post-accident: root causes, fixes, and refinements.	

Table 13 continued

Theme 8: Manufacturer and Regulatory Aspects

Question	Code	Theme
4	Identify cause, fixes, refinements. Regulatory **recertification process.**	Manufacturer and regulatory aspects
8	New technology unavailable (by manufacturer or third-party providers) to meet new regulations from regulator.	

The participants in the study discussed the weight of trust airlines place in the manufacturer to produce a safe product. A direct quote presented below by a participant establishes this viewpoint:

"So, and I think both the major OEMs, [redacted], I think have a rich history in building and providing various aircraft to consumers and airlines. So it starts there with your OEMs. And obviously they have to provide a safe product, otherwise they won't survive".

Air carriers rely on the Original Equipment Manufacturer (OEM) to produce a safe product to market that meets the certification criteria for safe operation as set by the regulatory agencies. In lieu of the OEM, air carriers also rely on the host nation certification process to consist of updated and accurate safety standards to certify a product in fit, form, and function for safe operation. Following an adverse safety event, air carriers work alongside OEMs and regulators to diagnose the probable causes of the event, identify fixes and implement risk mitigation controls.

The participants state that regulatory agencies may set new certification standards upon diagnosis of the root causes of an accident and conduct recertification process of the enhanced aircraft. Some regulatory decisions may appear in the form of airworthiness directives that can influence the operations and financial aspects of the airline. If the manufacturer or third-party providers lack the technology or structural fixes to comply with the regulatory decisions, the aircraft may be taken out of service and prove to be uneconomical in the fleet plan. This will result in a 'domino-effect' in which fleet plans and network schedules would require revisions and changes with alternate fleets to continue operations.

From an OEM perspective, the manufacturer would be tasked with implementing the fixes and refinements based on the diagnosis of the adverse safety event and have the aircraft recertified for operation. All participants agreed that any regulatory decision can have impact the overall function within various departments in the airline.

Rebranding and remarketing

During interview sessions, the SMEs discussed the business technique of rebranding or remarketing used by manufacturers and air carriers in order to resume operation of an aircraft type that has been subjected to safety concerns in the industry. The codes from the interview data has been obtained and grouped under the theme of rebranding and remarketing in table 14 below.

Table 14

Theme 9: Rebranding and Remarketing

Question	Code	Theme
6	Playing with **consumer minds**. With time, people forget. Techniques: **repainting**, **new name**, changing **tail registrations**. Disadvantages: evolution of **social media**, technology, customers will seek it through, detrimental to airline. Alternate plan: due diligence, **honest communication**, display **confidence**, logical explanation of mitigations, **demonstration** of safety.	Rebranding and remarketing

According to the SMEs, common techniques of rebranding involve the actions of repainting the aircraft, changing the name, and changing tail registrations of the aircraft in question. Below, two direct quotes obtained from the interview session highlights this practice along with an example and the consequences associated with the technique:

"Given enough time, I think people kind of forgot that that was [redacted] way back when. So perhaps over time and again, depending on what you're doing, it works out from a public perception standpoint, I think in that case it did. Obviously, those of us that were in the industry, understand that that's really still [redacted], they just put a different label on the airline".

"I think in this day and age of the social media coverage we have and internet access, and then the 24-hour news cycle we have, I don't know that there's really a lot of room to try to play some of those games with rebranding. I think in many ways that might be more detrimental than it is helpful that folks will see through it. I think folks are better off when you walk them through what the issue is".

The respondents regarded that the sole success from this technique may only yield in the long-term when given enough time, customers forget about the safety concerns associated with the aircraft type. However, the participants note the use of rebranding to play with consumer minds may be detrimental rather than helpful as knowledgeable travelers and those industry professionals will see through the technique. Participants also call attention to the development of technology and platforms such as social media that may inhibit the success of such techniques.

Customer perception of aircraft safety

A theme that has been recurrent and emphasized throughout the interviews has been the concept of customer perception of aircraft safety and its influence on airline operations, especially in relation to aircraft acquisition and safety events. Table 15 below indicates the common phrases that were discussed and formulation of codes.

Table 15

Theme 10: Customer Perception of Aircraft Safety

Question	Code	Theme
2	Safety has evolved from benefits, design, and regulatory oversight to the **public perception** of aircraft safety. Impact on **airline economies** (decision to choose airline).	
3	Customer perception of safety, impact on choosing airline, **balance** between customer perception and aircraft benefits. **Comfortability** factor, controls to alleviate concerns about safety.	Customer perception of aircraft safety

Table 15 continued

Theme 10: Customer Perception of Aircraft Safety

Question	Code	Theme
5	Impact of **employee confidence** in customers. **Educating public** on fixes to aircraft with safety concerns, ensure safety sustainability. Balancing priorities of customers. History of operating aircraft safely.	
7	Use polls, surveys, focus groups, net promoter score to gauge **customer sentiment**. Transparent, honest, and **open communication** with customers (which aircraft they are flying in). Building **customer confidence**, perception, media marketing, demonstrate additions, refinements to safety (training, validation flights), accommodating, empathetic, **assurance of reliability**, display engagement with manufacturer and regulatory agencies. Successful history of safe airline. Experience operating specific aircraft. **Trusting brand**. Differentiation of safety issues with airplane and operators **Time** with no accidents or incidents to build up confidence in travelers. Time required to build up comfortability factor.	Customer perception of aircraft safety

Participants in the study recognized a notable shift in the idea of aircraft safety in the air transportation industry. Historically, the concept of safety was associated with aircraft design, capabilities, benefits, and regulatory involvement. However, this view has shifted to the perception of safety and the customer's viewpoint of aircraft safety. The direct quote below confirms this assertion:

"It's a question of does the public think it's safe. And that may be also I think the new thing that's coming into it now is it's not necessarily just a question of from a technical engineering you know, mathematical standpoint, is it safe. What is the public perception? Historically, it's always been much more of this, the practical nature of is it a safe aircraft. Was it designed well, was there oversight, were all the governing bodies and involved? But now it's actually broader. It's not just that, it's also the perception of that".

The participants indicated the reasons for this shift in focus being the influence of customer perception on the overall economics of an airline. Customer perception of safety may dictate which airline passengers choose to book a ticket and which aircraft they feel comfortable in. This change may have an impact on how an air carrier acquires aircrafts depending on if the customer views the airplane to be safe.

The comfortability factor also plays a role in the airline's decision to invest in an aircraft type. Typically, customer perception of safety may increase in significance following an adverse safety event. Therefore, the participants believe it is vital to educate customers on the logical process of implementing safety measures, revisions to current procedures, and involvement with OEMs and regulatory agencies to build passenger confidence and comfortability in the aircraft and with the airline. The air carrier may also not only state but demonstrate these measures by action such as conducting validation flights to display the airline's confidence in the aircraft type.

The SMEs stated the use of net promoter score, a tool used to measure customer experience and likelihood of recommendation, to gauge the customer perception of the airline. Air carriers may use surveys, polls, and focus groups to gain insight into possible

improvements required, points of concern, and recommend controls to be placed in order to alleviate these apprehensions. Moreover, the airline's history of operating the aircraft in question may have some influence in the choice of airline by customers. The direct quote provided below address this claim:

"I think the best thing we can do is make people aware of our safety record, our commitment to safety, our people's trust in the aircraft, our history of flying aircraft without incident".

Interviewees expressed that the flying public may closely assess the airline in terms of accident history and level of trust in the brand. However, certain customers may choose to differentiate the air carrier from the aircraft when assessing occurrence of such safety events.

Another avenue explored by airlines to build confidence with the flying public is to instill confidence in its employees. SMEs believe the display of confidence in employees such as pilots, flight attendants, and mechanics may have a significant impact on the confidence level of customers. In order to maintain honest and open communication, the participants state that it is vital to inform customers the aircraft type that will be travelling on and instill a sense of safety and reliability in the aircraft.

Additionally, the participants believe it is also important to be empathetic and accommodating to customer concerns and doubts. Customers may not immediately feel confident to travel in an aircraft that has faced safety concerns in the past. Therefore, the element of time with no incidents or accidents in the aircraft type is key in building up

the customer confidence. Lastly, SMEs note from a business standpoint, air carriers need to maintain a healthy balance between customer perception and aircraft benefits.

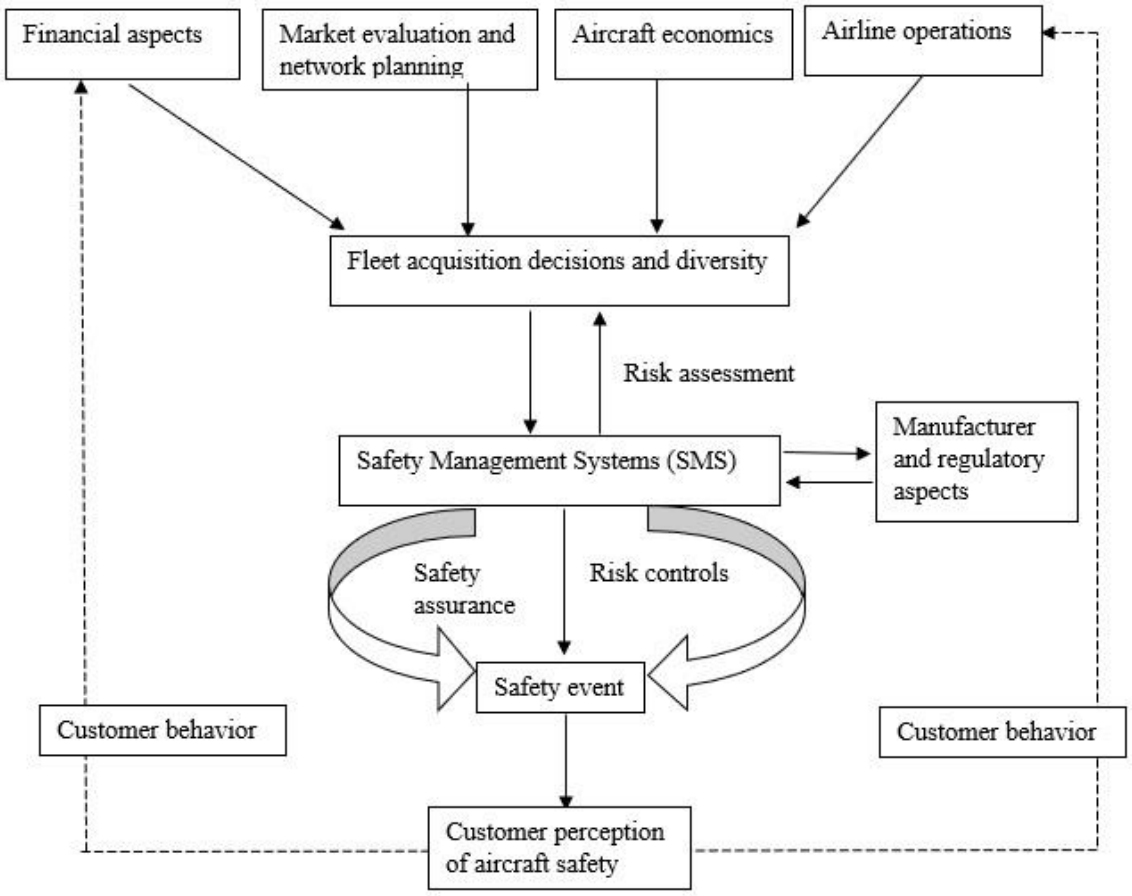
CHAPTER V

Discussion

The findings from the case-study analysis and semi-structured interviews suggests that safety impacts the aircraft acquisition and fleet management procedures in U.S commercial airlines. The results also revealed the underlying variables that affect the fleet acquisition process. The overarching and relevant themes from findings were gathered and formulated into a thematic network displayed in figure 17 below.

Figure 17

Thematic Network of Findings and Discussion (author's concept).



The significant variables that impact the aircraft acquisition and fleet planning process in commercial airlines are financial aspects, market evaluation and network planning, aircraft economics, and airline operations. These variables input information into the fleet acquisition and diversity planning decisions. Following the occurrence of an adverse safety event in relation to a particular aircraft type, these key variables involved would endure significant impacts in terms of service disruptions, financial loses, reduction in markets served, and loss of operational aircraft.

Due to the strategic nature of fleet planning and aircraft acquisition decisions, an airline may use Safety Management Systems (SMS) as a tool to evaluate these decisions such as introducing a new fleet type or considering diversification of the fleet portfolio. Additionally, SMS may be utilized to diagnose safety issues and revise operational specifications when working in conjunction with the equipment manufacturer and regulator. Two prominent components of SMS that contribute to this study are the safety assurance and safety risk assessment components. For example, from a safety assurance standpoint, an airline may monitor the overall health and wellness of its aircraft fleet using flight data monitoring which affords the airline a proactive approach to handle its operations during an adverse safety event.

Due to inadequate risk assessment, certain hazards may slip through the holes in implemented risk controls that lead to the occurrence of a safety event. In such circumstances, the safety risk assessment component of SMS may be utilized to diagnose the issue. These risk assessments conducted may be integrated into future fleet acquisition and diversity decisions of the airline. Consequently, the air carrier may

implement added risk controls to minimize the level of risk associated with the safety event.

Finally, the component of customer perception of aircraft safety should be integrated into aircraft acquisition and fleet planning processes. The customer perception of aircraft safety may increase in significance especially after the occurrence of a safety event in relation to an aircraft type. This perception component has an impact on the overall economics of the airline in the form of customer behavior such as passenger decision to choose a certain airline over another. These decisions eventually impact the financial aspects and airline operations of the airline.

In this study, seven research questions were formulated to explore the impact of safety in aircraft acquisition and fleet management processes in U.S commercial airlines. The findings from the study illuminated the problem statement and adequately answered the research questions posed.

Research Question 1

What are the operational, economical, and safety variables involved in airline fleet planning and management?

Based on the findings, the operational variables involved in the fleet planning and management process in airlines include the operational plan, mission type, crew training plans, and safety policies and procedures associated with aircraft type. The airline mission type may vary from short haul or long-haul international operations, Extended-range Twin-engine Operational Performance Standards (ETOPS), or seasonal and leisure travel. Based on the type of aircraft acquired, air carriers may device training plans for

flight crew, ground operations personnel, and aircraft mechanics to safely operate and handle the aircraft according to its operational specifications.

The economic variables in airline fleet management may consist of two forms: financial aspects and aircraft economics. The financial aspects of fleet management comprise of cost of acquisition, operating costs, maintenance costs, capital constraints, inefficiency costs, training expenditures, and risk mitigation costs.

Aircraft economics contribute to the fleet planning process in airlines in terms of fuel efficiency, performance, capacity, payload range, availability, efficiency, reliability, and maintenance profiles. Lastly, safety variables factored into the aircraft acquisition and fleet management process include the operational safety of the aircraft, its ability to meet certification standards, and public perception of aircraft safety.

Research Question 2

What is the role of a fleet's operational safety according to SMEs? How does the historical safety or perceived safety of a fleet type affect the choices for acquisition at the management level?

Based on the findings, operational safety of a fleet has significant impact on strategic airline functions. Safety is highly regarded within all departments of an air carrier. Operational safety also depends on the manufacturer and its compliance with safety and certification standards set forth by the regulator. The view of operational safety has evolved to encompass the public perception of safety into its core. Currently, the notion of operational safety refers largely to how the public perceives the safety of an aircraft type.

The public perception of safety weighs heavily on the economics of an airline as it may dictate a passenger's decision in choosing the carrier. However, most tend to differentiate the aircraft safety record from the operator following safety events in relation to certain aircraft types. Ultimately, air carriers often rely on the manufacturer to provide a safe product and trust regulatory standards to certify aircrafts for safe operation. The perception of safety may influence the type of aircraft to be acquired due to the passenger confidence and comfortability in an aircraft.

Research Question 3

What are the processes and procedures in place to acquire or re-fleet aircraft following an adverse safety event?

Air carriers would conduct internal risk assessments prior to undertaking strategic decisions following an adverse safety event. Some airlines may house risk assessments teams within each department to identify if the safety event affects its overall function. Depending on the nature of the event, risk assessments would be conducted in union with regulators and manufacturers to identify the causal factors of the safety event. The analysis results may propose risk mitigations and risk controls in terms of modifications to aircraft configurations, implementation of revision of procedures, and refinements to safety measures. If a safety event associated with a fleet type leads to a disruption in operations of that type, airlines may exercise other resources such as extending operations of alternate aircraft, extending lease agreements, delaying retirement of existing aircraft, altering maintenance schedules and selling aircraft.

Research Question 4

How does an airline re-strategize following a major operations change such as the grounding of a fleet due to safety concerns?

The general understanding is that most airlines would execute business continuity plans, which are plans and procedures to continue operations based on precedence of events or probabilities of safety events in the future. In terms of fleet management, air carriers will re-strategize and reposition its fleet such as operating the network using fleet of similar capacity and extend its operational time period. Departments such as flight operations would alter their training plans for flight crew to transition to alternative aircraft types. If the airline operates a single fleet type, it may be forced to make structural changes to its network and schedules, exit markets they can no longer operate, and eliminate its least profitable routes. The goal of such actions is to maintain the airline's commercial footprint and to prevent the alteration of its position in the market.

Research Question 5

What remarketing and rebranding techniques are utilized by airlines to resume operations of a fleet that has been grounded?

Common rebranding and remarketing techniques include repainting aircrafts, changing its name, and changing tail registrations on aircraft. Rebranding techniques often play with consumer minds and may only prove to benefit a company in the long-term when customers forget the safety issues associated with the aircraft. Given the development of technology, and the scope of news coverage, rebranding and remarketing may be detrimental to airlines as these techniques may compromise its integrity. Instead,

it is advised to maintain honest communication with the flying public about the issues and hazard mitigations of the aircraft in question.

Research Question 6

How can airlines restore faith and consumer confidence in air travelers when returning an aircraft to operations after adverse safety events related to the aircraft model?

A vital element in restoring confidence and faith in customers is to remain honest about the airline process following adverse safety events. Airlines may educate passengers on the implementation of risk controls, safety measures and configuration changes to the aircraft. Additionally, airlines must demonstrate the success of such changes by conducting validation flights to assure the customers of the aircraft's safety. Airlines need to remain empathetic and accommodating to passengers when operating an aircraft type that has experienced safety concerns. Instilling employee confidence in the aircraft is crucial in building consumer trust as passengers tend to rely on the displayed confidence from flight crews. Eventually, time with no safety incidents or accidents is essential to gradually build confidence and restore customer faith in the aircraft.

Research Question 7

What are the effects of regulatory decisions such as fleet groundings on airlines and what are the specific consequences in each department?

Regulatory decisions such as airworthiness directives and fleet groundings have significant impacts on airline function and growth. Underlying regulatory actions such as certain airworthiness directives may result in aircrafts becoming uneconomical due to

lack of resources and technologies available to meet the revised regulatory certification standards. Fleet groundings may require airlines to significantly alter their fleet plans and make structural changes to network schedules. Due to loss of operational aircraft, air carriers may need rely on existing aircrafts or variants of the grounded fleet to maintain its commercial footprint. Moreover, fleet managers may delay retirement of existing aircraft and alter the maintenance schedules to accommodate the change in operations.

Implications

The element of aircraft safety is an extensively discussed topic across all domains in the airline industry. Findings from the study brought into light the significance of safety in the airline industry and its impact on strategic decisions such as aircraft acquisition and fleet management. Therefore, significant themes from this study such as risk management, fleet decisions on diversity, and customer perception of aircraft safety has implications on practice and research.

In the event of an adverse safety issue that requires changes to the fleet plan, commercial airlines (with or without an SMS) may use the thematic network highlighting significant themes to explore possible solutions, consequences and alternatives to decisions involving fleet management. These actions may integrate the use of risk management teams that carefully identify and analyze potential risks with various aircraft types and its impact on a fleet mix.

If airlines consider addition of a new aircraft type to its fleet plan, the findings could guide corporate decision makers to evaluate how safety and financial aspects would weigh into the decision matrix in terms of crew training, ground operations, maintenance

costs, and inefficiency costs. The possible introduction of risk would be assessed and reduced to acceptable levels for operation with implementation of risk controls. Additionally, these teams may utilize the historical performance of aircrafts to gauge operational safety of the aircrafts being evaluated. Eventually, customer perception of aircraft safety is a vital element in the decision matrix as this drives consumer behavior and impacts the overall economics of the airline.

Furthermore, the findings could be used as a conceptual framework for those desiring to conduct similar studies to better understand the various elements involved in the airline fleet planning activities and the role of safety in aircraft acquiring processes.

Limitations

Some limitations associated with this study include the scope of the study and sample size. The semi-structured interviews focused on perspectives from one U.S airline and one type of airline operation which may have introduced biases to the study. Additionally, the sample size obtained could have been increased to gain more precise and significant results. Another limitation found in the study was expectation bias from the interviewer in which the researcher may have a preconceived idea of the information to be expected based on the participant and their role in the fleet management process. Furthermore, company policy and confidentiality may have restricted the participants from appearing candid in the interview sessions. Lastly, with the component of risk assessment playing a vital role in the overall outcome of the study, the findings may not be as applicable to those airlines operating without an SMS.

Conclusion

The current study was conducted to investigate the impact of safety on fleet acquisition and management procedures in U.S commercial airlines. The study consisted of two phases: a case-study analysis of notable accidents and incidents that involved specific aircraft types, and semi-structured interviews with Subject Matter Experts (SMEs) from a 14 CFR Part 121 carrier in the U.S to evaluate their perspectives on the influence of safety in fleet management procedures.

Significant findings from the study included emergent themes from the semi-structured interviews that drew attention to the significance of aircraft safety and its impact on aircraft acquisition and fleet management activities in airlines. The study also generated contributory variables that affect the fleet management process. In the event of a safety issue associated with a fleet type, all contributory variables of fleet planning which include financial, aircraft economics, airline operations, and market and network planning would be affected. The results concluded that aircraft safety is a crucial driver in aircraft acquisition and fleet management processes in U.S commercial airlines. It is conclusive that the element of safety should be thoroughly investigated before undertaking strategic decisions in airlines such as acquiring a new aircraft type or introducing diversity to the fleet plan.

The findings highlighted the use of Safety Management Systems (SMS) as a tool evaluate the risks associated with strategic decisions such as aircraft acquisition and fleet diversity. The risk management component of SMS allows for identification of hazards,

assessing potential risks affiliated with such decisions, and implementing controls to reduce risk to acceptable levels for safe operation.

Furthermore, it was discovered that adverse safety events may result in regulatory decisions such as airworthiness directives and fleet type groundings that can significantly impact the overall operation of a commercial airline. Regulatory decisions would require airlines to be flexible in their fleet management practices to accommodate such changes to operations. Lastly, customer perception of aircraft safety was a recurrent theme that indicated a heavy influence on aircraft selection for acquisition in airlines. Passenger comfortability and confidence in the aircraft proved to be a driving factor in fleet planning and it influenced consumer behavior in terms of airline selection. This association proved to be of great significance to airlines as passenger choice and consumer behavior impacts the economics of an airline.

The findings from this study not only benefits the operator, but also impacts aircraft manufacturers and the aviation regulatory agencies. From an equipment manufacturer perspective, the understanding of the significant themes from this study may provide insight into the purchasing behavior of its customers. This insight may be used to alter safety standards of its aircrafts and build a stronger safety record that may result in a dominating position in the market. From a regulatory perspective, awareness of operational safety of aircraft types that operate under its jurisdiction is vital to the regulator's responsibilities of ensuring safe operations and may influence the commercial aspects of regulatory oversight.

Eventually, the findings from this study adds to existing literature and may be used as a foundation for further research studies on the impact of safety in aircraft

acquisition and fleet management activities in airlines. Findings from this study may be replicated in a mixed-method approach using a survey instrument to collect quantitative data from customers and SMEs to gain an extensive understanding of the subject matter. By broadening the scope, future studies could gather perspectives and data from various types of airline operations such as leisure travel, long-haul international, and commuter operations.

APPENDIX A

Semi-Structured Interview Session Guide

Date:

Time:

Interview Code Number:

Location of Interview:

Parts of the Interview	Interview Questions
Introduction	Hello, I am Dinusha Gunarathna, the principal investigator for this study. I am a graduate student pursuing Masters of Science in Aviation at the University of North Dakota. This research study is a vital component for my thesis which is on the impact of safety on fleet acquisition and management in U.S commercial airlines. Thank you for agreeing to be a participant in this semi-structured interview and providing your valuable expertise. As indicated in the invitation email, the purpose of this interview is to assess your perceptions on how adverse safety events related to a particular aircraft fleet can influence acquisition decisions. The duration of this interview would be about an hour. The interview session will be audio-recorded, and field notes will be written down. After completing the interview, I will de-identify your personal information to protect your privacy and transcribe the audio recording. Upon doing so, I will forward the transcript to you for verification purposes. After the transcript has been obtained, the audio recordings will be permanently deleted. Please keep in mind that I will ensure that no personal identifying information about you will be mentioned during the session. At any point during this interview, you can decide to stop the interview or choose to not answer a question you feel uncomfortable answering. I have received your signed informed consent. Do you have any questions before we begin? Are you ready to begin?

Part A	Questions
	1. In your expert opinion, what are the important variables of interest in airline fleet planning and management? 2. As a follow up to the first question what role does operational safety play? 3. In your opinion, how does adverse safety events related to a particular aircraft type influence the acquisition of similar aircraft type in your airline? 4. How does each department within an airline plan and prepare for acquisitions following such adverse safety events? 5. In your experience, how does an airline re-strategize after a major operations change such as taking a fleet offline due to safety issues? 6. What are the remarketing and rebranding techniques used by airlines to bring a fleet that experienced safety concerns back online? 7. How can airlines restore faith and consumer confidence in air travelers when returning a fleet to operations after encountering safety issues with the aircraft model/type? 8. What are some of the effects of regulatory decision-making such as fleet groundings on airlines and what are the specific consequences in each department if any?
Part B	**Close**
Close	9. Do you have anything else you would like to add before we conclude this interview? 10. Do you have any questions for me? Thank you for your time. Goodbye.

APPENDIX B

UNIVERSITY OF NORTH DAKOTA

DIVISION OF RESEARCH & ECONOMIC DEVELOPMENT

UND.edu

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April 14, 2020

Principal Investigator:	Dinusha Gunarathna
Project Title:	The Impact of Safety on Fleet Acquisition and Management in the U.S. Commercial Airlines
IRB Project Number:	IRB-202004-271
Project Review Level:	Expedited 5, 6, 7
Date of IRB Approval:	03/30/2020
Expiration Date of This Approval:	03/29/2021
Consent Form Approval Date:	03/30/2020

The application form and all included documentation for the above-referenced project have been reviewed and approved via the procedures of the University of North Dakota Institutional Review Board.

Attached is your original consent form that has been stamped with the UND IRB approval and expiration dates. Please maintain this original on file. ***You must use this original, stamped consent form to make copies for participant enrollment. No other consent form should be used.*** It must be signed by each participant prior to initiation of any research procedures. In addition, each participant must be given a copy of the consent form.

Prior to implementation, submit any changes to or departures from the protocol or consent form to the IRB for approval. No changes to approved research may take place without prior IRB approval.

You have approval for this project through the above-listed expiration date. When this research is completed, please submit a termination form to the IRB. If the research will last longer than one year, an annual review and progress report must be submitted to the IRB prior to the submission deadline to ensure adequate time for IRB review.

The forms to assist you in filing your project termination, annual review and progress report, adverse event/unanticipated problem, protocol change, etc. may be accessed on the IRB website: http://und.edu/research/resources/human-subjects/

Sincerely,

Michelle Bowles

Michelle L. Bowles, M.P.A., CIP
IRB Manager

APPENDIX C

Case Study analysis sources

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APPENDIX D

Interview Log

Participant	Age over 30	Years of experience in Airline X	Interview duration (minutes)
Participant 001	Yes	8	27
Participant 002	Yes	23	38
Participant 003	Yes	19	24
Participant 004	Yes	20	26
Participant 005	Yes	unknown	26
Participant 006	Yes	8	62

APPENDIX E

Code Book and Reflective Notes

Variables in aircraft acquisition and fleet planning:

Cost per seat and the cost for a trip, size the aircraft, whether it's the fuel efficiency of the aircraft, where you planning to fly the aircraft, how many times a day do you plan to fly the aircraft, actual piloting of the aircraft or and safety, economics of the aircraft.

Important: trip costs, seat cost, cost of acquisition, comparative cost of acquisition or comparative trips and seat costs across all the different aircraft

What is it that I want to do as an airline? What market do I want to serve right at one point? What's kind of the area that in which I want to operate. Where an airline is particularly starting up or located might dictate kind of look they're trying to focus on. What's that capacity? From an aircraft performance standpoint you would call it a payload range curve (how much can I carry and how far can I carry it). Costs of all those things from crew training and pilots, flight attendant training, mechanic training, what are the costs to operate from a fuel efficiency stand point. All the way down to maintaining the airplane. What kind of investment do I have to put in for spares and mechanic training. Fleet commonality (especially trained crews and specially trained mechanics, a whole different set of spare parts. You got to schedule it differently to be able to take care of crew compliments and the ability to operate separately).

Mission types and strategy of airline. What you're trying to accomplish with your mission type: strategy of airline. Match capacity with demand. Business product. Aircraft configurations, requirements, crew complement. Aircraft economics in line with business model?

Highest level of safety for flying public. Meets certification criteria by regulatory authority. Efficient and reliable aircraft. Maintenance costs and loss due to downtime.

Aircraft economics and availability. Maintaining fleet commonality and cost structure. Economical and safe? Age of aircraft. Risk factors through SMS and mitigations. Risk controls that may be necessary due to a mixed fleet and associated costs.

What are you trying to accomplish? Where your customers want to go and what's the most efficient equipment available to get them there? What is my access to the equipment, are the aircraft available to me? Do I want to buy them, do I want to lease them? Do I want a new aircraft, or do I want a used aircraft? And do I have the capital constraints? Operating constraints? New technology available. Retirement plans, heavy checks, age of aircraft may cause time on ground or service disruptions. Comparative analysis: about what are the complexities of bringing in a second narrow body fleet type. inefficiency costs, makings, fuel burn is obviously a huge element, airframe maintenance, APU, engines, maintenance profile, cost of the maintenance, how long is the engine going to stay on wing. Time period and where are we in the economic cycle, where we in

the market, where we are at the technology cycle. About replacing aircraft and when is the right time to do that.

Legend:

Safety Financial objectives Operational objectives Aircraft economics Market objectives

Regulatory

Role of operational safety:

The industry has been very, very safe at least in the United States for a very long time. Manufacturers [*Redacted]* tend to be so reliable and how their safety is in the past. Perception of safety. Does the public think it's safe? Is that going to impact the economics of running an airline because you have passengers that will be reluctant to get on an airplane, buying a ticket, deciding to go off and fly one airline versus another airline. Historically, it's always been much more of this, the practical nature of is it a safe aircraft. Was it designed well, was there oversight, were all the governing bodies involved.

Safety of flight crew procedures, safety of ground procedures and safety of mechanics. We want to keep things as similar as possible because every time you introduce something that's different, you introduce a potential risk. What are the potential hazards? By putting procedures into place, or maybe change existing procedures to make sure that we're minimizing that as much as possible.

Playing out missions with different aircraft types to operate this fleet in this mission safely. Have to understand the real capabilities of that airplane and what you're needing to do from a mission standpoint. Every airline has a different set of operational safety rules and regulations that evolves. And guidelines and recommendations. Safety piece plays a huge factor in what model, you would choose from or what type of you and you'd be interested in.

Don't want to question the safety of an airplane. Be sure that the certification process is adequate and that the airplane meets form, fit, and function and can operate for line operations safely. Initial risk for new aircraft for new entrant, rely on your host nation certification process. Work with the manufacturer before it's released for line services is safe.

Safety hits integrated right in the very beginning of the decision. In the past I think what an airline would do is they would look at the benefits associated with getting a new fleet type, look at the all of the consequences associated with that fleet type. Differences in the aircraft, potentially creating a safety hazard. With SMS, safety aspects are front and center of our decision about introducing a new aircraft type.

If you don't provide a safe product you won't survive. Safety is at the core of everything we do. Instill a tremendous amount of culture of safety and compliance, you can never compromise safety. Importance of SMS.

Legend:

Industry record, manufacturer reputation, regulatory certification and oversight

Perception and public perception of safety, impact on airline economics

Evolution of safety Safety Fleet commonality Priority of safety SMS Flight Ops

Influence of adverse safety events on acquisition of similar aircraft:

Customer perception. How is that impacting customer desire to fly on an airplane. That will evolve over time. Customer forgets that certain events happened. Does the weighing of the customer perception of the safety outweigh other benefits of the aircraft. If the aircraft's inherently unsafe, you don't want it.

Definitely has some influence. There other things that they were unaware of, do we need to diversify somehow as a result of that? Let's review our current procedures, our current policies. Introspection. Aare we doing absolutely the best that we can?. Decide, do we keep going down this path or not? you trust the regulators are certifying their aircraft to the proper safety standards and that you know they've got all the procedures in place for the flight to be operated safely.

It would play a factor. there's mitigating circumstances. So what's been done to fix it. What was the original problem? what's been changed, what was the original root cause, was it completely operational was it an operational error.

There's a connection. if you had two airframes to consider and there was a safety concern with one or the other, I think that would be an immediate red flag. under Safety Management System under 14 CFR Part five, if I'm going to introduce, if I'm going to make a change in my system, I think you're going to have a pretty tough argument, if you're going to increase your overall risk level at a carrier by bringing on an airframe that would I think at a minimum be at least a object of concern not only for you, but for the regulator as well. there's not a lot of room for error in that space.

Definitely a factor. Internal safety risk assessment to determine if this is a credible adverse condition that we would not want to accept in terms of risk. Is this something that would affect our customers. make sure that our customers feel comfortable in aircraft that's been involved in some type of adverse safety event. internally feel okay that operating the aircraft is acceptable and safe, the next decision is even with that we may not elect to buy an aircraft, if we haven't already started operating it. customer's perspective what their needs are. Do we have mechanisms or controls that we think could alleviate that.

Affect our view. Look at the process from paper to production. R&D, all the engineering work to develop and bring to market a new aircraft. Major OEMs have a rich history in building and providing various aircraft to consumers and airlines. They have to provide a safe product, otherwise they won't survive. Or refine. Regulators provides oversight along the way, providing you know additional checks and balances to the safety culture and the safety of the product. As an airline we provide input and guidance. Product safety is always just assumed and implied that of course they are. Tremendous amount of trust in the OEM and the government regulatory agencies that oversee those aircraft and trust that when an aircraft comes to comes to market, it is in fact safe. It's built off of an already established, very safe platform. Safety was never in question. Naturally for them to migrate from 737 into the max would be a seamless transition less distractions for learning a new aircraft just a function of familiarity.

Legend:

Customer perception Fleet decision on new fleets OEM and regulators Risk Assessment and SMS

Advantage, disadvantage or both in having a diverse fleet during this situation:

Advantage: diversified portfolio, having one fleet type can be a problem during a grounding. Disadvantage: cost of operating multiple fleet types is also very, very high, inefficiencies and having crews go back and forth and training

Neither/unaffected: major issue no matter what. Risk of introducing another fleet type or flying only one fleet type.

Advantage: from a business continuity standpoint, some diversity obviously helps out in a situation like a fleet grounding. If the aircraft returning to service encounters another grounding, economically disadvantageous in the long run. do we want to put ourselves into this potential situation again in the future: long term risk analysis

Disadvantage: also depends on how much of the grounded fleet was being operated. Introduction of risk. limited production capability the length of orders for new aircraft.

Disadvantage of having variants of the fleet: much of the fleet is exposed.
Advantage of smaller fleet: cost advantage parts, or pilots, or training perspective.

Advantage: any event that impacts one fleet versus another in relation to adverse safety event.
Disadvantage: losing on economies of scale when it comes to training. maybe mitigated some level of risk by having multiple fleet types. But again at 50 and 50, neither one of which can fully support your operation.

Tailoring your fleet to your operational plan is probably a more logical decision than diversifying fleet.

Advantage: it can mitigate a specific subset of risk.
Disadvantage: can also introduce another type of risk. don't really mitigate fully the financial risk. create a gigantic regulatory compliance risk, training costs, and there are other consequences associated with that. Seniority heavy system. having a multiple fleet

type creates a huge amount of training costs and training support for reducing your size. Whereas an airline like us has one aircraft type, it's pretty benign. if you were to furlough the training costs would be absolutely minimal.

Neither: will still be devastating to our airline to have one of those large types be grounded.

Advantage: severity of a grounding would be less. Also depends on the number affected aircraft in operation.
In specific grounding circumstances, single fleet type is disadvantageous.
Neither: there's really a duopoly in this business, even if we had a diversified fleet, we would have still been impacted. make adjustments to our fleet plans and retirement plans to accommodate that.

Legend:

Advantage Cost Risk Still an impact Production capability Plan moving forward

How does each department within an airline plan and prepare for acquisitions following such adverse safety events:
Planning gets involved, operations gets involved, obviously tech ops maintenance, things like that gets involved, flight OPS gets involved. There's always commercial things that happened after afterwards and fleet manager gets involved in that. making future decisions do risk assessments, you know, obviously, if the aircraft has inherent risk and it's not going to mitigate it is not to be fixed, you're not going to buy the airplane. customer reaction, government oversight stopping unsafe aircrafts from flying.

everybody really has a role in this. group effort. collectively try and understand these things. identify the concerns and identify the unintended consequences that we haven't thought about, go through the what if scenarios. collective recommendation, pass on up to senior leadership. systems issues and things like that, we're definitely involved in that. We'd get involved whenever there's any type of you know aircraft accident and trying to terms of understanding what happened and what the cause of it is.

tech ops (technical operations) would have a piece of that, operations (flight operations) there's a training, maybe an operational, your network operations control center. Analyze it as a change to our system. we would probably not take the aircraft on until you know obviously it was complete with certification and that issue was complete with the regulator. look back using your SMS as your lens and try to understand what happened to understand if that changes your risk level. everything is about mitigating risk and getting risk down to the lowest acceptable level of risk for the operation.

each department has their own safety risk management teams. we identify new hazard or anything related to an adverse trend, then each department will look at their aspects of the operation, whether that hazard directly relates to their top function. so the Flight Ops with the right expertise interfacing with Boeing would identify what the hazard is, we would evaluate what the proposed controls are both from the manufacturer and the FAA. And then we would independently assess whether or not we want to implement any additional controls. corporate project team that manages all of that activity, just to make sure that

there's nothing that slips through the cracks. So we have an overarching umbrella that reviews, both the risk management work, but also the project work with anything like that.

you have to get the frontline comfortable. work with you with the OEM, the regulators to understand the problem, the issue.

Legend:

Group effort Regulatory oversight Customer perception Department process Risk assessment

How does an airline re strategize after major operations change?

network side, figure out how do I maintain much of my network as I had previously with fewer airplanes. airplanes are roughly the same size and capability that they can just go off and reposition. If not, extend the length of your operating day, make just structural changes the network in order to keep your commercial you know footprint the same. operation standpoint, re accommodate passengers, deal with cancel-, missed connections. Flight ops, start working on training plans, you know, help the OEMs with risk analysis around what happened. Tech ops, when do you park the aircraft, where you put them.

what are the other alternatives, whether it's a change in fleet type, is it a change in our procedures or we need to change our training, ops change like park it, retire it. risk mitigation and how can you reduce the risk as much as possible. With SMS, change what does that potentially introduce new hazards that we didn't have previously? what was the root cause? let's see if we can identify potential solutions. what types of hazards could be associated, can we mitigate those hazards? there's costs associated?

PR and public perception. educating the public on what's been changed and what's being improved and even to an extent of where we believe the airplane was even before this. FAA impacts. What's our what's our training perspective, what do we need to do to get training done, what's our ramp up plan to bring these back in.

Most airlines have basic continuity of operations plans. They tried to develop playbooks for issues that we've seen in the past or issues that we might see you know as we go forward. help the regulator, the OEM diagnose, understand and then remedy, whatever that problem is. carriers work closely with the OEM or other tier one, tier two suppliers to give more data back to them about how their products work than they ever develop during their testing programs. Plans both dealing with the regulator, local, and then as well as at the national level. with the OEM and with those suppliers that you quickly can assess, you can quickly get together and share information, share notes. use your SMS to determine this change, how impactful. overall risk. can we continue to operate or do we need to cease operations till we could mitigate a higher level of risk?

re prioritize and manage. running the operation is how many assets you have, how many cities you serve, how many flights. strategic decisions. Are you going to eliminate banks

of lines of flying, which is typically what we do and how do you prioritize what you're going to have to cancel? affects our operational strategy in terms of what cities we're going to serve, what frequency we're going to serve. we're balancing the priorities of our customers. put the assets that are most valued by our customers. And then we look for underperforming areas as areas where we potentially could reduce service.

robust marketing and communication plan, address. flight crews, they've got to feel confident in the aircraft and they trust that whatever concerns raised are addressed and fixed. operating in on board equipment, we all have to be confident in it and trust it. educate people on what's been done and what we're doing to ensure that safety is going to be sustainable. training flight crews. good history of operating the aircraft safely and we think we're going to be offering you know more safely as a result of changes Boeing has made to the airplane. instill that confidence with your people first. display that confidence because they're going to be talking to customers. make sure that the aircraft is in a good of operating condition as it can be, so that you minimize the disruptions to that aircraft. additional oversight and rigor0020put on the OEMs. highlighted some areas where maybe you know we call it lacks or the need for more oversight.

You've got to be transparent with your employees. they've got to be confident in the aircraft. You got to get out to the customers. accommodating to the customers. coordinate with crews and customers and basically all the employees that interface with the customers. There's marketing efforts, communication plan. Network planning, Having to go in and rebuild schedules on the fly or NOC. dispatch center. quickly adjust and deal with cancellations aircraft around to support. flight crew or scheduling impact. finance organization, running multiple scenarios as a result of all of that, a lot of 'what if' planning. supply chain and making sure that supply chain stays healthy. start writing flight schedules and crew assignments that match taking the aircraft out of the plan. marketing and revenue management and where do you pull those flights from. Because now you're short on airplanes. can you just strip your least profitable routes or do you say I'm just going to call my frequency is in certain markets

Legend:

Customers and PR Operations continuity plans Flight ops and training Risk analysis Tech ops Addressing employees

What do you think are some of the re-marketing and rebranding techniques used by airlines to bring back a fleet that's experienced maybe safety concerns?

rebranding, remarketing techniques is really more of convincing the customers you fixed the airplane. you try to repaint it and you try to basically gloss over it and put a new name on it. Or you approach it head on,. not try to hide things. show that you've done the due diligence to fix it and justify them that you shouldn't be worried about getting on the airplane. why we're confident in the aircraft and why you should be confident in the aircraft.

playing with consumer minds. Changing the name, changing tail registrations, repainting. playing a little bit with consumer minds, given enough time people kind of forget. savvy travelers and those of us that were in the industry, understand that that's really still Value Jet. Sometimes it doesn't work out.

there's benefit to rebranding, or there is somewhat deceptive practice. this day and age of the social media coverage we have and internet access and 24hr news cycle, there's not a lot of room to try to play some of those games with rebranding. might be more detrimental than it is helpful that folks will see through it. better off when you walk them through what the issue is. You logically talk about the risk, you talk about what mitigations you've used, and then you demonstrate that the airplane is air worthy and safe.

maybe a little deceiving. instill confidence. you are booking in this case on the max. If that's problem then hey, here are some other option. be very accommodating, very compassionate towards customers. Initially, schedule the aircraft not too far away from say a maintenance base.

Legend:

Idea/opinion Techniques Benefits/how its worked Disadvantages Alternate plans

How can airlines restore the faith and customer confidence in air travelers when returning a fleet back to operations?

Survey data. Most of the public won't be comfortable to get on the aircraft right away. Time, time with no incidents. showing people what did you do to fix it, that's the due diligence. being transparent. track history of being a very safe airline. weight that goes behind people in their trusting of a brand.

talk about the safety of it. building up the confidence in customers and flight crews (biggest impact to the passengers). trying to build public perception. two, three years until before comfortable with it. media marketing.

educate our customers, marketing effort. flying public getting used to it.

what is the customers general view around the safety level of the various airlines? folks differentiate the problem with the airplane with the folks who then go to operate it. perception of safety level of the airlines know that you're going to manage that problem. demonstrate that you've managed the issue. Different configuration, adds in multiple layers of protection, training, maintenance. Doing validation flights.

gauge our customer sentiment with the net promoter score. very open and honest communication. make sure our customers feel that we think it's a good airplane. Customers need all groups (flight crew, mechanics) to tell them it's a safe aircraft. lot of trust in our pilots to deliver a safe service. Make it clear you understand that you're booking a flight on that aircraft. Very empathetic and accommodating. over time as we get more confidence. make sure the aircraft are operating at the absolute highest levels of

reliability. very high confidence in our specific ability (in airline) to operate that aircraft. Experience in the aircraft. to take time.

most important element is going to be time in which no incidents happen. Trained crew to the new differences. marketing and communications things to get people comfortable with the aircraft. strong brand, a very trusting brand. be very accommodating, very compassionate towards customers. you are booking in this case on the max. here's our history of operating the aircraft and we've had a very successful history. We've made those changes, fixes to the aircraft and we believe our pilots are the most trained. Show confidence from flight crew. Show our engagement with Boeing and FAA.

Legend:

Tools Time Trust in airline, overall safety record and its history with aircraft PR, marketing, procedures

What are some of the effects of that regulatory decision making?

Grounding: we'll either go and try to buy more airplanes that aren't grounded, or we'll delay selling and retiring our aircraft that are not grounded. AD: we typically won't do much unless the requirement to or the (assess) cost or the time required to go and perform the ad is so large. adjusting our fleet plan slightly in order to avoid having to reduce flights in order to go and do the maintenance work required. could be regulatory things that basically make certain aircraft types so economically unattractive that you get rid of them. because either the OEM or third party providers have not provided technology in order to upgrade the older technology to meet new regulations that you decided it's cheaper for me just to go buy a new plane, or ground aircraft. underlying regulatory actions that will impact the overall total operating costs of the aircraft that will make you make different decisions in the long term the fleet. Government mandates, may make an aircraft completely cost ineffective, you decide to make different decisions.

How big is the regulatory decision. those pilots, how do they maintain their proficiency now that they're not getting in the airplane? You know what kind of training do they have to do once they start back up again? Trying to spread out the crew but frequency is down. Maybe advantageous to have pilots flying multiple variants of same fleet type. Multiple fleet types, grounding one type, those pilots are not working (financial issues). Making changes to schedules, extending retirement dates on some, extend lease.

Depending on what airplane it is it can ground certain markets and you've got to exit those markets. Depending on what size of the fleet, it is substantially impactful to your strategy and your growth. rewrite the schedules.

Depends on the severity and timeliness. impact your strategy and your network plans and how you're going to implement and maybe what your maintenance schedules look like. put experts from each of the departments together as part of the ingestion process.

change our training or flight crew training. There will be additional scrutiny and oversight put on OEMs and airlines. additional work for the OEM to bring a new aircraft to market. more expensive for airlines, which means you know we have to pass that cost along and figure out more efficient ways to operate in order to mitigate that cost. add complexity in time and costs to any new development or new aircraft type.

Legend:

Depending criteria Fleet decision making Flight ops consequences Network 3and market position Cost

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