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Exploring the Impact of Operational Safety on Aircraft Fleet Planning and Management Factors in a U.S. Commercial Airline Operation

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Extant research suggests that operational safety influences effective business functions of air transport operations. Aircraft fleet planning and management are key functions in a commercial airline to assure the attainment of the airline's operational and business goals. With fluctuating passenger demands due to public perceptions of air transport safety after adverse safety events, commercial airlines need to have resilient aircraft fleet plans and safety management systems (SMS). There seems to be a paucity of qualitative studies exploring the impact of operational safety on aircraft fleet planning and management factors among United States (U.S.) commercial airlines. Themes were derived from case studies on three aircraft fleet operational safety events. Questions were developed from these themes for semi-structured interviews with eight subject-matter experts to explore the impact of operational safety on fleet planning and management factors in a U.S commercial airline operation. Thematic analysis was used to identify salient codes/themes from interview transcripts and reflective notes. The findings suggest that SMS is an effective tool for managing risk associated with fleet management processes among U.S commercial airlines. Results also suggested that airline productivity, market evaluations, customer perceptions, and fleet choice behavior can be influenced by adverse safety events on an aircraft type. This study provides a conceptual framework for U.S commercial airlines to better understand the interactions between operational safety and fleet acquisition, planning, and management factors relevant to business sustainability. Further research on the study variables using a mixed-methods approach is highly recommended among multiple commercial airlines.

Keywords: operational safety, fleet planning & management, safety management systems (SMS), customer perceptions, commercial airlines, business sustainability.

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Air transport industry players such as commercial airlines continue to play a vital role in global socio-economic development. As part of the air transport industry forecast for the next 20 years, the International Air Transport Association (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 gross domestic product (GDP) (IATA, 2017; 2019). A key metric used in determining passenger traffic in air transportation is revenue passenger per kilometer (RPK) which is defined as the "number of kilometers traveled by paying passengers" and is calculated by multiplying the number of paying passengers by the distance traveled (Kenton, 2020).

Within the United States, the Federal Aviation Administration (FAA) predicted an increase in RPK of total mainline and regional air carriers up to USD 1.61 trillion by the year 2039 (FAA, 2019) and Narcizo, Oliveira, and Dresner (2020) suggest that a primary business function of an airline is its ability to plan and manage its fleet to the dynamics of passenger demand, operational costs, competitor actions, and aircraft safety events. Historical records suggest an association between the safety of an aircraft type, oversight from a regulatory entity, and impact on the aviation industry (Molin et al., 2017). An example of such an association was the post-event effects of the American Airlines (AA) 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 an 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 accident investigation findings suggested that 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 issuing an airworthiness directive that required fleet "grounding" until compliance was met (FAA, 1979). 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. 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). There was also an unfavorable perception among the traveling public following the occurrence of this high-profile accident involving the DC-10-30 (Bradsher, 1989).

Despite historical records suggesting a link between safety events related to aircraft type and its effect on operational factors such as fleet planning and management as in the DC-10-30 case in 1979, there seems to be a paucity of empirical studies that examine the role of operational safety in fleet planning and management, especially among major U.S commercial airline (Dožić,2018; Dožić, & Kalić, 2015; Müller, Kieckhäfer, & Spengler, 2018). Even though there has been extant literature on the inter-relationships between aircraft fleet planning and management factors such as fleet standardization, the influence of emission thresholds, and models based on route structure This seeming gap in literature makes it important to explore how operational safety affects fleet planning and management among U.S. major commercial airlines as the passenger throughputs seem to improve with COVID-19 mitigation strategies such as vaccinations (TSA, n.d).

Research Objectives

A review of the literature suggests a paucity of qualitative research that examines how operational safety influences fleet planning and decision-making among 14 Code of Federal Register (CFR) Part 121 certificated carriers. The objective of this study was to investigate the impact of safety on fleet planning and management in U.S. commercial airlines using a qualitative approach which Creswell (2014) defines as a method of scholarly inquiry using text and image data and consists of unique steps in data analysis.

Case-study analysis of accidents and incidents involving three aircraft types was used to understand the association between safety events and aircraft fleet planning and management factors among commercial air carriers globally. The salient themes identified in the case studies guided the development of the questions for the semi-structured interviews with eight subject matter experts (SMEs) from one of the major commercial airlines in the U. S.

Research Questions

A qualitative case-study analysis of notable aircraft accidents and incidents, along with a thematic analysis of semi-structured interviews of subject matter experts in the U.S. airline industry was used to answer 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 affects 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 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?

Commercial Airline Fleet Planning and Management

Commercial airline fleet planning and management is a complex process by which an airline acquires and manages appropriate aircraft capacity to serve anticipated markets over a variety of defined periods to maximize corporate wealth (Clark, 2007). 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; 2017) and it may depend on the various operational objectives of an airline such as marketing, development, alliance, and economic or financial objectives.

Operational factors such as flight frequencies, market demographics, airport regulations, and route characteristics may also play a role in fleet selection (Brueckner & Pai, 2007; Givoni & Rietveld, 2009). Commercial airlines also establish routes and services based

on the forecasted passenger demand at a destination airport which can be driven by factors such as airfares, regional resources, population, seasonal cycles, and economic development (Feng., Yongwu, Shaolong, & Hongtao, 2020).

In an empirical study on aircraft selection evaluation criteria using a Multi-Criteria Decision Model (MCDM), Dozic, Lutovac, and Kalic (2018) proposed a new method to evaluate aircraft types based on the model's capability to meet the market conditions and route network and suggested consideration of factors such as seat capacity, range, maintenance costs, aircraft delivery time, acquisition method, fleet commonality, operational safety, and passenger comfort in fleet selection.

Customer Perceptions on Aircraft Safety and Fleet Planning and Management

Molin, Blangé, Cats, and Chorus (2017) explored the influence of passenger perceived safety on the choice of the airline based on six factors such as perception of airline and route attributes and found out that the number of aircraft accidents involving an airline and specifically customer perception on the safety record of an aircraft type plays a vital role in the flight choice. This assertion seems to be evident in an incident involving the unearthing of cracks on the wings of a Qantas-owned Airbus A380-800 aircraft during maintenance inspection (Falzon, n.d) which led to an outcry from media outlets describing the aircraft as unsafe. It influenced the public safety perceptions of the A380 at that time (Clark, 2012). It was further elaborated that since the flying public does not receive the technical information about such events, discomfort in passengers is a common reaction to these events.

The more recent adverse safety challenges faced by the Boeing 737 Max aircraft give credence to the potential impact of safety performance on fleet management and operational viability in commercial airlines (Rice, 2020). Other researchers have also explored safety information on passenger flight choices to buttress this point (Koo, Caponecchia, & Williamson, 2015). A limitation of the Koo et al. (2015) 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) in which they suggested that understanding and interpreting consumer behavior, particularly the implications of passenger perception of safety on commercial practices in the aviation industry as important.

Airline Safety Record and Impact on Fleet Management

In an evaluation hierarchy study done by Liou and Chuang (2010) on the factors that influence the corporate image in the airline industry, the result indicates that the airline's safety record almost dominates the airline's image and reputation in the industry. The authors suggest that building confidence in the flying public on the safety and perceived safety of an airline is vital for its success. In another study that assessed the mean choice of important factors that influences a passenger's decision when choosing an airline for travel needs, the results suggest that passengers' choice is primarily influenced by the safety and reliability of the airline (Chen & Chao, 2015).

Methodology

Case-Study Analysis

A combination of primary and secondary sources was utilized to conduct a case-study analysis of the notable accidents and incidents involving aircraft types. Case studies are in-depth studies of particular situations, organizations, or kinds of events and have an epistemic contributory value of providing a comprehensive understanding of the particular phenomenon of interest using whatever data is available (Ylikoski, 2018) The case-study analysis provided an understanding of accidents related to aircraft types and the salient themes emergent from these adverse safety events. The use of public documents to collect information to conduct the case study allowed the extraction of valid, relevant, and unobstructed data sources. Appendix B contains sources for all the documents reviewed as part of the case study.

Boeing 787

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

Pending investigation, other civil aviation authorities around the world grounded the aircraft model under their jurisdiction including the Japanese Civil Aviation Authority (Ostrower, Pasztor, & Koh, 2013). It was rather interesting that a similar incident occurred in a parked and unoccupied Ethiopian Airlines B787 aircraft on July 12, 2013, at London Heathrow airport (Air Accidents Investigation Branch, 2013). The rear fuselage crown skin of the aircraft and fuselage frames was damaged by the fire and the investigation report concluded the probable cause was the result of a thermal runaway due to the failure of the lithium manganese dioxide battery in the Emergency Locator Transmitter (ELT).

ANA Holdings and Japan Airlines which operated the largest fleet of Boeing 787 Dreamliner suffered a combined loss of USD 110 million and Boeing stock market shares fell 0.6% to USD 139.87 on the New York Stock Exchange (Reuters, 2013). The FAA estimated the costs of repair for lithium batteries at USD 2.8 million (AP, 2013) and some analysts believed it cost Boeing USD 600 million due to airlines demanding compensation (Rankin, 2013). In the year 2020, eight ANA B787 were grounded upon discovering a design flaw in its fuselage that may compromise its structural integrity (Jonsson & Kotoky, 2020).

Airbus 320neos

Airbus Industrie (Airbus) of European Aeronautic Defense, another global original equipment manufacturer (OEM) has had its share of challenges with fleet type and safety issues. Airbus delivered its first A320neo aircraft to Lufthansa on January 20, 2016, and it 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 the operation of the A320 and A321 series (EASA, 2018). EASA

further issued an emergency AD to ground all Pratt and Whitney (PW) powered A320neos upon discovering damaged low-pressure turbine third stage blades in the aircraft.

According to a center for commercial 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, Shankleman & Katz, 2018), and their stock market shares dropped 1.08 points in the following months of March and April 2018 (Yahoo Finance, 2018). Following these incidents, the Directorate General of Civil Aviation (DGCA) of India ordered IndiGo which operated the world's largest fleet of A320neos (106 aircraft) to replace unmodified PW engines on its A320neo fleet (Phadnis, 2020). IndiGo faced operational disruptions due to the temporary suspension in operations to ensure compliance with engine replacements set forth by the DGCA (Kandu, 2019). Furthermore, the DGCA order impacted IndiGo's growth capacity with a 2-3% reduction in the third quarter of the fiscal year 2020 (Phadnis, 2020).

Boeing 737 Max

Boeing Airplane Company first unveiled the Boeing 737 MAX series (B737 MAX 7, B737 MAX 8) on August 30, 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 month and about 10,000 aircraft assembled at Renton, Washington State in the U.S. (Boeing, 2018). The touted success of the aircraft series was curtailed following two high-profile accidents involving the aircraft type in which the accident investigation findings 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, 2018; The Federal Democratic Republic of Ethiopia Ministry of Transport, 2020).

These fatal accidents led to a global grounding of this fast-selling aircraft pending fixes 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 a 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, the United States Federal Reserve economist Julian di Giovanni forecasted a 0.4% decline in GDP growth in the U.S. by the first quarter of 2020 due to the impact of the B737 max grounding (Giovani, 2020). Ultimately, the catastrophic nature of the accidents has created a negative perception of the B737 MAX aircraft and an 'unwillingness to fly' among the public (Rice, 2020). Boeing has since implemented changes to the B737 MAX aircraft series in terms of enhancing pilot training, software updates to the MCAS, and test flights have been conducted to recertify the aircraft for entry into service with the publication of Airworthiness Directives (AD)s to ensure compliance with design changes to the fleet type (FAA, 2020). These case studies suggest that safety issues associated with aircraft fleets can have a detrimental impact on the air travel industry and affects passenger confidence in air travel. Table 1 shows a summary of salient themes derived from the 3 case studies.

Table 1

Themes derived from case-studies

Aircraft Accident Case Study	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5
Boeing 787	Operational disruption	Financial factors	Operational safety concerns	Regulatory concerns	-
Airbus 320 Neo	Operational disruption	Financial factors	Operational safety concerns	Regulatory concerns	-
Boeing 737 Max	Operational disruption	Financial factors	Public perception of aircraft safety	Consumer confidence	Regulatory concerns

Semi-Structured Interviews

The use of semi-structured interviews allowed the researchers to obtain information about the subject matter from respondents and granted the researcher some level of control in the line of questioning. A thematic analysis was done on the data derived from the semi-structured interviews. Thematic analysis is a method of qualitative analysis that is often used for both primary research and systematic reviews. In general, thematic analysis has been defined as "a method for identifying, analyzing, and reporting patterns (themes) within data." (Braun and Clarke, 2006, p.79). Thematic analysis of interview transcripts normally consists of three stages. Firstly there is the line-by-line coding of the text in the transcript. This leads to the second stage, which is the generation of descriptive themes which are linked closely to the findings from the interviews. The third stage is the development of results into a thematic synthesis which is helpful for new interpretations, explanations, or hypotheses (Aromataris & Munn, 2020).

Approval was given by the UND Institutional Review Board (IRB) to conduct the semi-structured interviews involving SMEs. Appendix A has the semi-structured interview question items. Zoom® video conferencing was used for the interviews due to COVID-19 safety protocols and the sessions lasted an average of 50 minutes, and all audio files from the recorded sessions were saved in password-protected folders. The eight participants were recruited by researchers through a formal request to the airline using a focal point-person in the flight operations department. Each of the SMEs was provided with an invitation letter providing details about the study and the interview process.

Upon their acceptance to participate in the interview, 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 at least 2 weeks before the scheduled interview date to familiarize themselves with the study and the questions. During the interviews, reflective notes were taken to highlight points that required a review or further

clarification. Before concluding the interview, participants were informed that interview transcripts would be sent to them for member checking and validation.

Research Participants

The participants in the semi-structured interviews were from a major air carrier in the U.S. operating under Part 121 certification. The airline primarily operates within the continental U.S. while serving a few international routes for leisure travel and is recognized as a large carrier that operates with over 60,000 employees. The eight SMEs invited to participate in the study represented departments that play a crucial role in aircraft fleet planning and management processes in the airline.

These departments include Safety, Fleet Acquisition and Management, Engineering, Network Planning, and Flight Operations. The participants were all above 30 years of age with an average of 20 years of operational experience in the airline. These participants were chosen based on their expertise and level of experience within their respective departments. Table 2 contains demographic details related to years in the industry of SMEs and the time spent interviewing them.

Table 2

Demographic Details of Participants (Age, Experience, Interview Duration)

Participant	Age over 30	Years of experience in Airline X	Interview duration (minutes)
Participant 001	Yes	8	47
Participant 002	Yes	23	48
Participant 003	Yes	19	44
Participant 004	Yes	20	46
Participant 005	Yes	25	46
Participant 006	Yes	8	62
Participants 007	Yes	30	66
Participant 008	Yes	25	57

Data Saturation and Trustworthiness

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 the eight interviews,

no new information was derived from the data concluding that the study reached its saturation level. The trustworthiness of qualitative content analysis is defined in terms of credibility, dependability, conformability, transferability, and authenticity (Elo et al., 2014).

The case-studies analyses were considered trustworthy due to the use of credible sources such as official aircraft accident investigation reports and the semi-structured interview data meets the trustworthiness factors based on the background of the SMEs including top-management designations and number of years of service in the airline industry. Also, the interview transcripts were verified for trustworthiness using member-checking. Deductive manual coding was performed on the verified transcripts. In deductive or Theory-driven coding participants' words are interpreted according to categories or constructs from the existing literature (Creswell, 2014).

Coding and Theming Process

The verified transcripts were read thoroughly by each researcher independently to have a general feel and understanding of the viewpoints of the respondents. After the initial reading was done, the transcripts were marked up by underlining sentences and sometimes entire paragraphs that appeared meaningful to researchers and related to the research questions. Color coding was used to highlight relevance with green marking noteworthy quotes. Some of the information in the transcripts deemed tangential and irrelevant to the research questions were left unmarked. A code was created for marked passages that focus on a single idea.

Relevant codes were corroborated by some quotes from the respondents. The codes that were found to be recurring were clustered together. After a cluster of codes was analyzed, they were assigned to themes based on theoretical guidance from the literature review and case-study analysis themes. The reflective notes assisted the researchers to assess learning experiences from the interviews and added context to deriving codes and themes.

A paragraph describing each theme and the relevant direct quotations from the transcript was used for further analyses. The process outlined earlier was done for each respondent’s transcript “within-participant” analysis and then a final consolidation of themes from all participants was done to show emergent themes found in the data. An example of the codebook developed by the researcher as part of the manual coding process is shown in Appendix C.

Agreeability of Themes

To ensure agreeability among the researchers for themes that emerged, each of the authors worked independently on the transcripts and the final themes that emerged were compared. Even though there was theory-driven guidance in assigning codes to themes, there were variations related to semantics for two emergent themes. An example was one researcher coming up with an emergent theme of *cost drivers* instead of *financial factor*s. The other variation was related to the adopted theme of “manufacturers and regulatory aspect”. The other researcher came up with “regulatory and certification standards”.

The emergent themes were discussed with an SME with extensive experience in Part 121 airline fleet management and acquisition and currently a senior management person at a Part 121 airline. The suggestions from the SME were helpful in the adoption of themes that better reflected the research questions. Overall, there was consistency with eight themes

among the researchers and the SME reviewer and subsequent reconciliation over two which suggests about 80% agreeability.

Results and Discussion

Financial Factors

This theme was emergent during the discussions with the SMEs as key to the fleet planning process and was associated with cost structures and financial objectives. The participants noted costs associated with training and maintenance are vital financial criteria assessed before aircraft acquisition. Training costs include training for pilots, flight attendants, and mechanics. Maintenance costs were of notable mention in the decision-making process as air carriers evaluate the aircraft's potential to cause service disruptions or downtime.

Participants also iterated that 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 for in the overall financial plan of an airline inclusive of certain regulatory actions that impact the aircraft's overall operating costs and can make an aircraft 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 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 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.

Aircraft Economics

According to the interview participants, before investing in an aircraft type, crucial components of the aircraft such as its capabilities, deficiencies, usability, 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 mentioned by participants included payload range, capacity, configuration, efficiency, reliability, and availability. A participant from the flight operations department stated that:

> "During *the preliminary analysis for getting a new aircraft type, the economics and the return on investments are critical. Which airline worth its salt will plow ahead and get an aircraft that will not meet its operational capabilities, ensure high optimization and performance, and provide a highly competitive edge over rivals? That is the essence of serious economic risk analysis during the preliminary phase of fleet acquisition and planning"*

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 aircraft are assigned based on their capacity and size. Access to the aircraft, technology onboard, service hours, and fleet variations are a few other variables that configure into the acquisition process. The age of the aircraft, condition (new or used), and maintenance profiles are included in the decision related to aircraft economic criteria.

Airline Operations and Business Continuity

The interviewees stated that 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 the overall growth of the airline. A flight operations SME intimated that using a business continuity plan by the airline can assist in re-strategize and re-prioritize its assets to continue services in non-normal situations. A statement by a respondent highlights the point on business continuity:

> *"We use our operational safety risk management system to develop contingency plans that will enable our operations to continue even when there are disruptions due to a safety event. The reality is that if it involves a regulatory standdown it becomes difficult to implement such plans and every effort is made to work with all stakeholders to restore normal operations"*

Some of these resilient actions may involve training of flight crew in alternate aircraft, revisions to established policies and procedures, and changes to aircraft operating conditions. According to the SME, these plans are based on precedence and possible scenarios expected to occur in the future. The SME noted that a significant drawback to an air carrier such as theirs with a single fleet type is that aircraft downtime may affect pilot proficiencies which may increase the cost of training once the aircraft resume service.

Market Evaluation and Network Planning

Participants noted that the initial stage of forming an airline consists of establishing destinations to fly to, the type of operation, and the frequency of flights conducted in an operational period. Concerning 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".*

Another respondent stated that:

> *"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 are 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 go get used aircraft or older technology for a far lower price. In that might allow you to bridge the gap to that new technology".*

The participant from flight operations also explained that the development of new technologies for aircraft potentially can alter an airline's decision to acquire or delay an 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 will be the initial aspect of operations to be affected. In the case of fleet grounding, the network operations personnel are tasked with maintaining the airline's commercial footprint with fewer aircraft. 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.

A participant noted that 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. A participant from fleet planning noted that airlines may identify their least profitable routes to eliminate to maintain operations. With significant impacts on 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 Events

With safety being the primary focus of this study, it was evident the significance of this theme was displayed throughout all the interview sessions. Interviewees 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. In terms of the fleet acquisition, both participants from fleet management and acquisition and safety noted that air carriers choose aircraft with the highest level of safety in addition to their efficiency, resiliency, and reliability. A direct quote from the SME from the safety department 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 of their operational plan and integrated into 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.

Safety Management System (SMS)

An emergent theme that was extensively highlighted by all the SMEs was the element of risk assessment in airlines with aircraft safety, safety events, and a resilient Safety Management System (SMS) which is defined as a systematic approach to managing safety including the necessary organizational structures, accountabilities, policies, and procedures (ICAO, 2018). SMS was regarded as a key driver in analyzing various airline strategic decisions including the acquisition and management of aircraft and resiliency of operational safety controls.

Participants mentioned how safety is pervasive in all departments within their airline. And SMS is required to be in place to evaluate the levels of safety within each department. A 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, as 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*".

Participants stated that safety risk management teams within each department identify associated safety hazards and their impact on the top function of the department using SMS before envisaged adverse safety events and an 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.

Participants also noted that a resilient SMS can be used as a tool to evaluate decisions such as introducing a new fleet type or considering diversification of the fleet portfolio. Furthermore, the respondents noted that an airline may opt to introduce proactive risk mitigation controls to reduce operational risk to acceptable levels. Some of the proactive safety mitigations include revisions of operational specifications and standard operating procedures.

The SME from the safety department stated that 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 handling 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.

Finally, participants highlighted how customer perception of aircraft safety should be integrated into aircraft acquisition and fleet planning processes. The participants noted that customer perception of aircraft safety may increase in significance, especially after the occurrence of a safety event concerning 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.

Manufacturers and Regulatory Aspects

The participants in the study discussed how much trust airlines place in the original equipment manufacturers (OEMs) 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".

An SME noted that air carriers rely on the Original Equipment Manufacturer (OEM) to introduce into the market a product that meets the certification criteria for safe operation set by the regulatory agencies. Instead 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.

The SMEs noted that 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 a 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. All participants agreed that any regulatory decision can have an impact on the overall function within various departments in the airline.

Rebranding of Fleet Types after Safety Incidents

The SMEs discussed the business technique of rebranding or remarketing used by manufacturers and air carriers to resume the operation of an aircraft type that has been subjected to safety concerns in the industry. According to the SMEs, common techniques of rebranding involve the actions of repainting the aircraft, changing the name, and changing the tail registrations of the aircraft in question. Below, are two direct quotes obtained from the interview session that 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. 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 of 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.

Fleet Acquisition Decisions and Diversity

According to the participants, in the event of 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 before 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 of 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 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”.*

Another quote from a respondent buttresses the point:

> *"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 avoid retiring aircraft for a couple of years to 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 confirm this perspective:

> *"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".*

The SMEs stated that a diversified air fleet allows the air carrier to operate alternate aircraft types 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. According to respondents, the cost of maintaining a diverse fleet mix including the cost of spares and facilities can be significant. Interviewees also stated that a mixed fleet may incur long-term risks in terms of regulatory and compliance risks. The direct quotes presented below validate this viewpoint:

> "*I think the challenge becomes at what level of multiple airframe types do you have to have multiple aircraft types to 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 a flight crew to transition between variants of fleet types appears to be seamless. Additionally, the cost of training is kept minimal. Lastly, it was agreed among the participants that despite the implications of regulatory decisions that affect a specific fleet type, it can have a 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.

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 technical engineering you know, mathematical standpoint, is it safe. What is public perception? Historically, it's always been much more of this, the practical nature or is it a safe aircraft. Was it designed well, was there oversight, were all the governing bodies involved? But now it's broader. It's not just that, it's also the perception of that*".

A participant 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. The comfortability factor also plays a role in the airline's decision to invest in an aircraft type. Typically, customer perception of the safety of a flight may increase significantly following an adverse safety event. The participant suggested that 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 participant also suggested that an air carrier may conduct validation flights to display the airline's confidence in an aircraft type after safety events involving a fleet type. The SME from network planning recommended that air carriers use surveys, polls, and focus groups to gain insight into possible improvements required to alleviate customer apprehensions. Moreover, the airline's history of operating the aircraft in question may have some influence on the choice of the airline by customers. The direct quote provided below addresses 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".

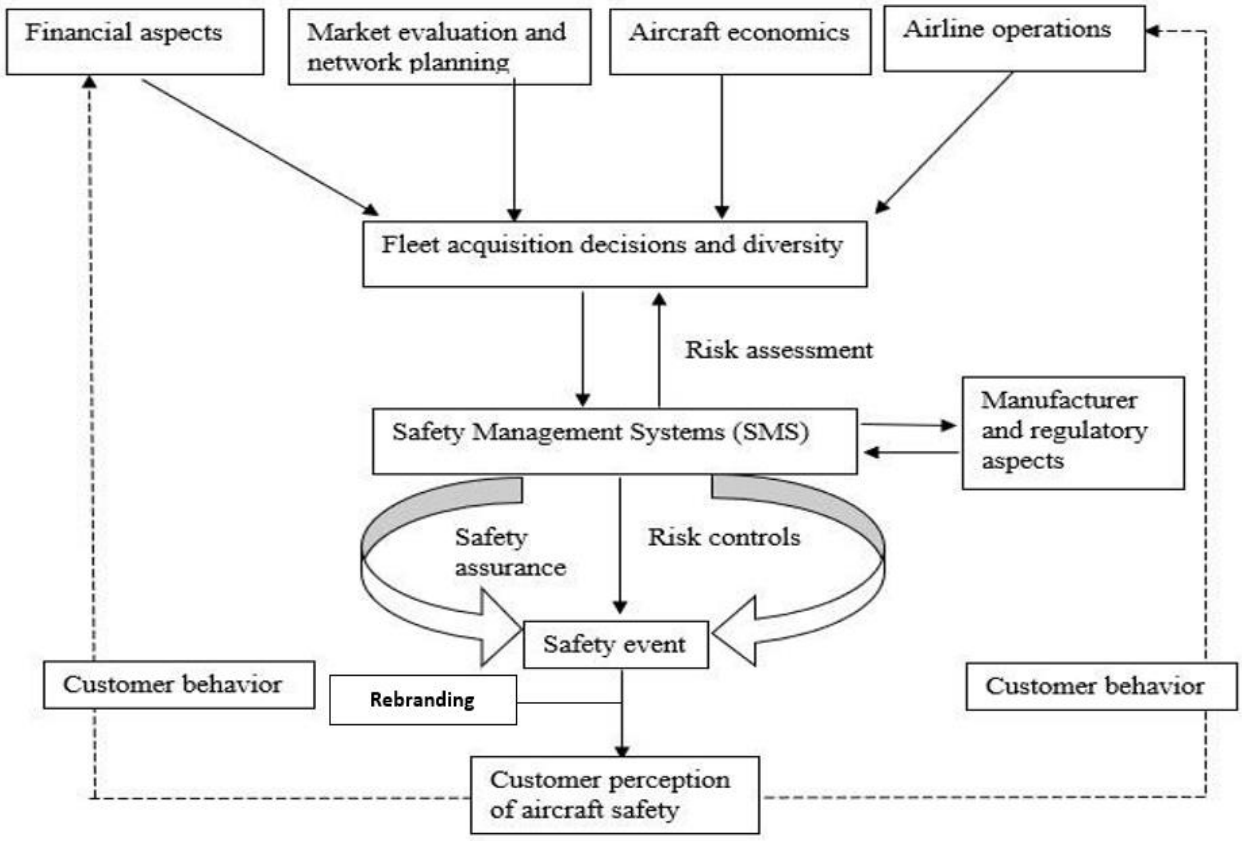
The SMEs agreed that the flying public may closely assess the airline in terms of accident history and level of trust in the brand. However, certain customers may choose to differentiate the air carrier from the aircraft when assessing the occurrence of such safety events. Another avenue explored by airlines to build confidence with the flying public is to instill confidence in their 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.

To maintain honest and open communication, the participants stated that it was vital to inform customers of the aircraft type that will be traveling 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 traveling 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 customer confidence.

Lastly, SMEs noted that from a business standpoint, air carriers need to maintain a healthy balance between customer perception and aircraft benefits. In summary, the results revealed the association between relevant themes that influences the fleet planning and management process and operational safety considerations. Figure 1 shows a thematic network highlighting findings and discussions.

Figure 1

Thematic network of findings and discussion



Note: Conceptualization of the Thematic Network was done by the authors

Summary of Thematic Network, Implications for Practices and Further Research

Findings from the study brought into light the significance of operational safety and its impact on strategic decisions such as aircraft acquisition and fleet management. Therefore, significant themes from this study such as risk management and customer perception of aircraft safety have implications for practice and research. The findings from this study suggest that in the aftermath of a safety event that requires changes to the fleet plan, commercial airlines may be guided by the thematic network. The thematic network provides significant themes relevant to exploring 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 their impact on a fleet mix. If airlines consider the addition of a new aircraft type to their fleet plan, the findings could guide corporate decision-makers to evaluate how financial aspects, market evaluation, and network planning, aircraft economics, airline operations, rebranding of fleet type would weigh into the fleet acquisition decisions and diversity matrix.

As part of a robust SMS, safety assurance tools such as flight data monitoring and proactive risk controls such as user-centric standard operating procedures (SOPs) can be used to reduce operational risk to acceptable levels which can influence the likelihood and severity of safety events. The results suggest that the nature and scope of the safety event can influence customer perception of aircraft safety which invariably could affect customer behaviors on airline fleet choice for travel. Customer behavior may be related to the patronage of airline services and can influence airline operations and financial aspects.

Some of the proactive safety mitigations include revisions of operational specifications and standard operating procedures due to airworthiness directives (AD) issued by aviation regulators following safety events. In the opinion of the respondents, an AD can influence the operations and financial aspects of the airline. Practically, if an OEM of the affected fleet type does not have an immediate fix that will enable an airline to comply with the AD, the aircraft may be taken out of service and may result in a domino effect in which fleet plans and network schedules would require revisions and changes with alternate fleets to continue operations.

Conclusion

The study highlighted the significance of safety and its impact on aircraft fleet planning and management activities in a Part 121 airline. The findings highlighted the use of Safety Management Systems (SMS) as a tool to evaluate the risks associated with strategic decisions such as aircraft acquisition and fleet diversity and to develop resiliency for business continuity. Furthermore, findings suggest 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.

Customer perception of aircraft safety was a recurrent theme and findings suggested that such perceptions can influence consumer behavior in terms of airline selection. Customers may not immediately feel confident traveling 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 customer confidence. Findings suggest that transparency is vital following adverse safety events in aircraft fleets. The findings also suggested that during return to flight for such

fleet, airlines should demonstrate the success of such changes by conducting validation flights to assure the customers of the aircraft's safety.

It was also recommended by respondents that 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 The findings also suggest that from a business standpoint, air carriers need to maintain a healthy balance between customer perception of aircraft safety and operational benefits since passenger behavior can influence variables that are relevant to fleet acquisition and planning decisions in commercial airline operations.

A limitation of the study was assessing the perceptions of respondents from only one major U.S. airline due to the exploratory nature of the study and the challenges of recruiting more research participants from multiple airlines. Also, company policy and confidentiality may have restricted the participants from being overly candid in the interview sessions. A future study using mixed-method research is recommended to holistically assess airline fleet planning processes and the role of safety.

APPENDIX A

Semi-Structured Interview 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 a 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 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?

APPENDIX B
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APPENDIX C

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

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