The Politics of Aircraft Investigation and Innovation

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Since its inception in 1914, the commercial aviation industry has revolutionized the way in which society functions today. In the United States alone, nearly 2.9 million passengers entrust their lives to the engineering feats of aviation everyday. According to the Department of Transportation, air travel is the safest mode of transportation (FAA). However, this is in large part due to the mistakes which have been made over the past century and how they've been resolved. Whenever a tragedy involving aircraft occurs, two things are sure to follow: an investigation and innovation. Yet, with each of these there are intrinsic politics not too dissimilar from that which may be experienced in the House of Representatives or the Senate. When a billion dollar industry is met with a death toll: lobbyists, corruption, and red herring have, and will, undertake the justice system. Despite this, aircraft have been shaped by these disasters, making the skies safer for all who fly today.

So what are these politics? And how have they led to the safest transportation network enjoyed by modern society? These questions are crucial to understanding the diffusion of not just aircraft into society, but any technology that holds human life in its hands. This thesis will explore these questions and discuss how the tragedies that have occurred in the commercial aviation field have led to the innovations which make flying reliable today. Through three decisive incidents, the Boeing 737 max incidents in October 2018 and March 2019, the Zagreb mid-air collision in September 1976, and Alaska Airlines flight 261 in January 2020, the political nature of aircraft investigations, and the improvements made to commercial aircraft through them will be apparent.

As a corresponding technical project, myself and a team of fellow aerospace engineers are developing a regional hybrid electric turboprop airplane set to be implemented in 2035. Within the next few decades, social and political factors will force the aviation industry into electrical hybridization. A hybrid electric aircraft is one which uses both traditional jet fuel, and an electrical battery source for propulsion. This project is not so much a technical question, but a challenge. The America Institute of Aeronautics and Astronautics releases an annual design challenge which requires competitors to submit a complete design of a conceptual aircraft. It is necessary to include everything from the basics such as wing and fuselage design, to the precise, such as the type of leather used in the passenger seats. Our task is to identify the social, safety, and design features required of this conceptual regional aircraft and uphold them to the Federal Aviation Agency's (FAA) standards. In doing so, the challenges, roadblocks, and political hurdles that are required of engineers in this field will be made clear to our team.

2022 AIAA Technical Challenge: Hybrid Electrical Turboprop Aircraft - Low Rider

In order to better understand the design requirements needed to innovate in a certification intensive industry, the design aspect of this thesis will study the many facets that go into such an innovation. The American Institute of Aeronautics and Astronautics' 2022 design challenge requires just that. Given a list of aircraft characteristic limitations, teams are expected to design an aircraft that is capable of flying fifty passengers up to 1000 nautical miles. The caveat is to do so while implementing a flight architecture that has yet to be fully understood: hybrid electric turboprops. This describes an aircraft that uses conventional internal combustion engines and an electrically powered propulsion system.

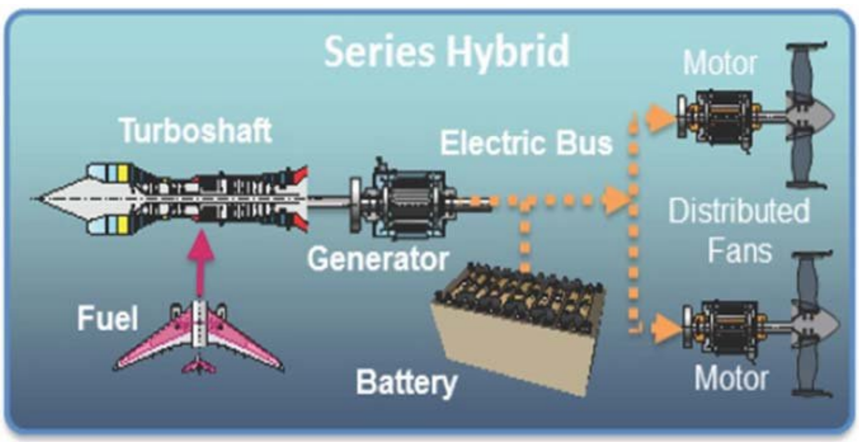

Figure 1: Illustration of Hybrid Electric Aircraft Architecture (Source: Mbarki, Saber '*The innovation of electric and hybrid aircraft*' (2020) 10.13140/RG.2.2.27570.43206

Modern regional turboprop planes play a specific and invaluable role in aviation today. As planes that generally carry less than one hundred passengers, they are limited to travel between less traveled airports, such as Charlottesville Albemarle Airport, to larger international hubs, such as Dulles International Airport. Over the last three decades, regional aircraft traffic has experienced tremendous growth, accounting for 12% of the world's available seat kilometers (the number of available seats multiplied by kilometers traveled). In terms of fleet size, there are about 5,000 regional turboprops in service today with an average age of 23 years, accounting for nearly 16% of the global fleet. Furthermore, in 2020 regional aircraft accounted for 36% of total flight hours, and an astonishing 36% of airports exclusively rely on turboprop aircraft. While these numbers just begin to touch on the importance of regional aircraft in modern aviation's infrastructure, it is widely believed that these numbers will steadily increase in the following years. Regional air traffic is expected to increase at an average yearly rate of over 4.5% (compared to a 4% rate expected in total commercial aviation) over the next twenty years. This exponential growth will garner a projected $388 billion in market value with some 8,000 new regional aircrafts being delivered (Regional Aircraft).

The business case for regional turboprops is very well documented, but why is this so? Today, the regional turboprop market is dominated by a few players: Aerei da Trasporto Regionale (ATR), Embraer, Bombardier, and De Havilland Canada (owned by Longview Aircraft Company) to name a few. While ATR and De Havilland Canada are the largest actors in the market, they both introduced their current repertoire of turboprops in the mid-1980's. As the market continues to expand and the technology continues to age, airlines and regional aircraft manufacturers will need to innovate to meet the demands of both their customers and the environmental revolution that is being realized across the globe (Justin Hayward).
Hybrid-electric regional turboprop planes will be the first to take up our efforts against climate change, hopefully as soon as 2030.

With mostly outdated technology and flight requirements which are less demanding than that of large commercial jets, an interesting experimental testing ground has emerged for the next generation of aircraft, a generation which will be defined by its environmental impact. For the industry as a whole, the advancements made in the regional turboprop sector will be monumental in the evolution of larger aircraft. In our current understanding of hybrid technology, any solution for larger planes would require huge amounts of weight to be added, providing little additional benefit. While these larger aircraft are mostly responsible for the enormous amount of carbon dioxide released by planes each year, it is nonetheless beneficial to improve our understanding and use with hybrid-electric planes now on smaller aircraft, as to better integrate this machinery once the accommodating technology is readily available for use on larger aircraft.

The main issue in such an architecture is the positive feedback loop created by batteries needed to endorse an electrical propulsor. Jet fuel is notorious for its impressive energy density, i.e. its energy per unit volume. However, batteries are both less dense and heavier. In aviation, a golden rule is to make the aircraft as light as possible to ensure a reliable lift to drag ratio and viable flight stability. Yet, the implementation of a hybrid electric architecture is sure to offset this balance. In order to realize a higher reduction in fuel consumption, more batteries are sure to be needed, thus decreasing lift, which in turn requires even more batteries. Engineering teams have to find a way to resolve this cycle in order to find success in this challenge, but this is not the only issue at hand. Batteries, especially lithium ion batteries, are infamous fire starters, especially in extreme environments.

For the future of regional hybrid turboprops, I believe the biggest challenge is going to be redefining aircraft configurations in a way that has truly tangible benefits. As per most of my research, it seems that we are on the tipping point between these new technologies being potentially huge for aviation, yet there is something missing. As engineers, I feel it is easy for us to be excited for the potential of a new variation or technology, however for those who are often making the business decisions I feel there is not enough evidence to support an overhaul of aircraft dynamics. Another large challenge facing these innovations is the actual integration into modern fleets. Most of the current regional aircraft are over two decades old, and while they still may have many flight worthy years ahead, not enough to justify integrating new hybrid-electric systems. While these issues seem condemning I believe there is no better entry point for the future of aviation than with regional turboprops. Their necessity in aviation infrastructure provides a perfect testing ground for the next generation of aircraft technology, and will surely champion the efforts for ecologically sustainable air travel.

From this brief illustration alone, it is evident that there are a multitude of obstacles with the implementation of a hybrid electric architecture alone. However, this challenge aims to not only engage our team's problem solving skills but also our understanding of mission requirements, design tradeoffs, and public perception of aircraft. It is vital that our designs uphold both the challenge's quotas and the needs of anyone who would be flying on such an aircraft. This challenge is more than a thought experiment, but an all encompassing design and administrative task to test our ability to turn an outlandish, futuristic idea from the drawing boards into a tangible model that can be described by mathematical principles and models. Yet, despite the freedom to design the aircraft how we would like, there are a multitude of FAA certifications and regulations that the team must consider and work around to find a solution to implementing their conceptual aircraft. This introduces politics into the equation.

Politics of Aircraft Investigations

On March 13th, 2019, following the second crash of a Boeing 737 Max, President Trump issued the first ever national grounding of a commercial aircraft. This was in reaction to two newly delivered planes falling from the sky just 132 days apart, killing 346 passengers. In this alone, there is an evident inherent political nature for aircraft and the need for a centralized body to monitor and ensure aircraft are held to the highest safety standards. This governing body is known as the Federal Aviation Agency or FAA. On numerous occasions the FAA has proven its worth, most notably following tragedies in the aviation field, but continuously in the monitoring and auditing of all planes flying within our airspace. The FAA is not void of politics in itself, as its responsibilities include determining fault after investigating crashes and administering the best course of action to avoid future accidents. These investigations are hampered by lobbyists, infighting, and racial and social facets which should not be seen within a court of the public interest, especially when it is often responsible for the safety adaptations which promote safe travel (Defazio, 2020). For example, in 1973 Varig Flight 820 was forced to land following an in-flight fire. The fire, which was caused by a cigarette bud dropped in the aft lavatory, led to the deaths of 123 people. Following this, regulations were placed on smoking mid-flight, yet, due to tobacco lobbyists, it wouldn't be another 17 years and a multitude of disasters later until smoking would be banned on airplanes entirely. Incidents like this prove the value of a governing body, while also highlighting its faults.

Considering that air travel is now a global commodity, it can be said that all of humanity is a relevant social group in terms of aircraft safety. While some countries and regions do not have access to the same aircraft infrastructure as others, the aircraft themselves are still supposed to uphold the international standard defined by the FAA. Despite this, there are disparities in aircraft safety that have led to tragedy, especially in poorer and less developed countries where these safety standards are often not met by governments and airlines which are hoping to save some revenue. This is yet another example of the reach of the politics of flying—developing nations are more susceptible to the follies of aircraft institutions (Whipple).

The Boeing 737 Max Crashes

A large reason for politics encapsulating the aviation industry is the main incentive of commercial air travel: profit. The goal of commercial aviation is to sell as many tickets as possible, while making the actual transportation as cheap as possible. In this there can be positives and negatives. One of the positives of high profits is the ability to fund multi-billion dollar studies on how to reduce the carbon footprint of air travel. This is not because airlines love the planet, but because they love their bottom lines. Reducing fuel emissions means reducing fueling costs, which means more profits. To examine a glaring negative of this business model, we can consider how Boeing reacted to the 737 Max's grounding in 2019. First, the manufacturing company attempted to place blame upon anything or anyone other than itself. David Calhoun, former CEO of Boeing during the Lion Air and Ethiopian Air accidents, was quoted as saying to the New York Times during the investigations that overseas pilots "don't have anywhere near the experience that they have here in the US." Reporters then asked if pilots trained in the US would have been able to resolve the issues with the defected plane, to which he responded "Forget it, you can guess the answer" (Snouwaert, 2020). Ironically enough, Lion Air flight 610's captain, Bhavye Suneja, had completed his training here in the United States. Once this failed, the company tried meeting with the American Pilots Association, where they tried bribing the association's lead officials into refusing to testify in front of the congressional committee. As a backstop for this, Boeing's lobbyists "negotiated" with the committee's members as well (Defazio, 2020). Despite their best efforts, the public outcry for the accidents was too great and Boeing had to admit to their faults. This is a rare case in the aviation industry, as too many times prior the public response has not been strong enough to warrant or demand justice for the lives lost in an accident. More times than not, the blame is dispersed amongst many parties, and the root cause is neither punished nor resolved.

Figures 2 & 3: Public protests during the 737 Max Congressional hearings (Source: Sinéad Baker (2019) 'Boeing's response to the 737 Max crisis confused and frightened people, making it hard to believe its apologies, experts say')

Anecdotes such as this are the simplest and purest way to understand the involvement of politics in the field of aviation. Tragically the only true way for us to understand shortcomings in this field is to have an event happen that is simply too egregious to ignore. For every flight that has crashed there are endless reports of every potential factor and how they must be improved upon. In these and in between their lines is where the majority of research will be conducted. Understanding the major players in the investigation, from governments and manufacturers, to the public and airlines is key to finding the politics at play. Furthermore, each of the motivations of these groups, and the power that they hold to facilitate change must be examined (Dempsey 2010). Each and every aircraft disaster acts as a crime scene with all parties unsure of the true culprit, in this there is motivation for all to hide their hand and be as deceptive as possible.

The Zagreb Mid-Air Collision

On September 10, 1976, two passenger aircraft collided mid-air near Zagreb, Yugoslavia, resulting in the deaths of all 176 people on board. The incident, which involved a British Airways Trident and a Yugoslav Airlines DC-9, was a wake-up call for the aviation industry, leading to significant safety improvements that continue to benefit commercial aviation today.

The politics surrounding this event were complex and multifaceted, as the collision occurred during a time of heightened tensions between the UK and Yugoslavia. Yugoslavia, although technically 'non-aligned' in the ongoing Cold War at the time of the crash, was formerly under the Soviet Union's Iron Curtain. Much of Yugoslavia's aviation equipment was provided to the country from the Soviet's following World War Two. Two of such instruments would fail, leading to the disaster. The first was the Zagreb VOR. A VOR, or very high frequency omni-directional station, is a short range navigation beacon for aircraft. The station emits radio signals to aircraft, leading them to it so that they can connect to the next beacon on their flight path. The outdated VOR station in Zagreb was a connecting beacon for six different air corridors, and was prone to issues emitting correct flight data. Zagreb's radar tower was also outdated. With Yugoslavia distancing itself politically from the Soviets, many regulations regarding infrastructure upkeep had been neglected, and the radar tower was now prone to providing incorrect flight level data to operators. This information coming to light via investigation led to an increase in tensions between the two states, and provided further propaganda from the West against their communist foes. Tensions reached an apex when the air traffic controller overseeing the region was found to have been issuing orders in his native tongue to the English pilots in the moments directly before the disaster, not in the international standard language for air traffic control, English. At this point, the crash had taken over western media. The fact that a western plane had fallen from the sky due to lapses in Soviet technology had outraged the western public. Yugoslavia, in an attempt to ease tensions with the West who they were slowly trying to realign with, arrested and imprisoned the air traffic controller at the time of the crash, Gradamir Tasic. By nearly all accounts, Tasic was used as a scapegoat for the Yugoslavian government's oversights.

Although politics had encapsulated the public perception of the crash, investigators still worked to identify several factors that contributed to the accident, including inadequate air traffic control procedures, poor communication between air traffic controllers and pilots, and a lack of technology to assist pilots in avoiding collisions. As a result, the aviation industry responded with a series of innovations that addressed these shortcomings. One significant innovation that emerged from the Zagreb mid-air collision was the development of the Traffic Alert and Collision Avoidance System (TCAS). TCAS is a technology that alerts pilots to the presence of other aircraft in their vicinity and provides guidance on how to avoid a collision. TCAS has since become mandatory on all commercial aircraft, and has been credited with preventing numerous mid-air collisions. Another key innovation that arose from the Zagreb mid-air collision was the implementation of new air traffic control procedures. The incident highlighted the need for better coordination between air traffic controllers and pilots, and led to the development of more standardized procedures for communication and coordination, such as determining english as the required language while coordinating flights. These procedures have been widely adopted and continue to be refined today.

The Zagreb mid-air collision also spurred increased collaboration and information sharing within the aviation industry. In the aftermath of the incident, industry stakeholders recognized the need for a more coordinated approach to safety, and established new channels for sharing information and best practices. Today, the aviation industry operates under a culture of continuous improvement and collaboration, driven in part by the lessons learned from the Zagreb mid-air collision (One Man).

Alaska Airlines Flight 261

The final case study to be explored is the flight of Alaska Airlines flight 261, which departed from San Francisco International Airport on January 31st, 2000. The flight's destination was Tacoma International Airport, in Seattle Washington. The McDonnell Douglas MD-83 aircraft was newly delivered to Alaska Airlines in 1992, and had accumulated 14,315 cycles prior to the accident. The flight crew initially realized something was amiss with their aircraft once leveling off at their cruising altitude and noticing the plane's trim to be jammed. The trim on an aircraft is used to allow a degree of freedom in the tailfin, allowing for the aircraft to fly smoothly. A few moments later, Captain Theodore Thompson correctly reset the trim mechanism, however devastating consequences ensued. The pilot lost complete control of the aircraft's aerodynamic capabilities, and the plane quickly inverted, and crashed into the pacific ocean below killing all 88 passengers on board.

Investigations proved that the aircraft's jack screw, a bolt securing the vertical stabilizer to the tailfin, had been completely threaded. Upon resetting the trim, the jackscrew experienced a load which it should have been able to support, however the threaded screw failed, and the vertical stabilizer collapsed to a full nose down position. The key component of the investigation came from an Alaska Airlines mechanic named John Liotine, who worked in the Alaska Airlines maintenance center in Oakland, California, told the FAA that supervisors were approving records of maintenance that they were not allowed to approve or that indicated work had been completed when, in fact, it had not. In 1997, Liotine had recommended that the jackscrew and gimbal nut of the accident aircraft be replaced, but had been overruled by another supervisor. Liotine began working with federal investigators by secretly audio recording his supervisors. On December 22, 1998, federal authorities raided an Alaska Airlines property and seized maintenance records. In

August 1999, Alaska Airlines put Liotine on paid leave, and in 2000, Liotine filed a libel suit against the airline. The crash of Alaska Airlines 261 became a part of the federal investigation against Alaska Airlines. In December 2001, federal prosecutors stated that they were not going to file criminal charges against Alaska Airlines. Around that time, Alaska Airlines agreed to settle the libel suit by paying about $500,000; as part of the settlement, Liotine resigned. Although the sole blame of the disaster should have fallen on the airline itself, the company deflected blame to their maintenance crews and manufactures, citing the aircraft had not reached the 15,000 cycles which is assumed to be the safety limit of the airframe. Maintenance issues have always been a large perpetrator of disaster in the aviation field. The safety factor on most equipment in aircraft is only 1.5, almost certainly the lowest value of any field of engineering. This case did however lead to improvements in the field. The FAA began overseeing a number of auditor maintenance checks across all airlines and even instituted full time supervisors in some of the countries largest facilities.

Conclusion

The politics of aircraft investigation and by causation innovation has been shown to be a balance between monetary incentives and public interests. For most accidents, there is not enough of the latter. Seldom does public outrage for an accident reach the levels seen by the 737 Max incidents. When there is not enough public backlash, it can be seen that the only factor which will contribute to the innovation of aircraft is that of monetary value. The fault for this is attributed to the field's inherent free market, and the equipment's vast cost. Airlines would rather save face in the public eye than be forced to refurbish a fleet of billions of dollars worth of aircraft. Thus, innovation is slow, and tragedies continue to occur. The FAA is responsible for monitoring and auditing all planes flying within U.S. airspace and determining fault after investigating such crashes. Its role is to ensure that all aircraft uphold the highest safety standards. However, the FAA is not immune to politics, as its responsibilities include administering the best course of action to avoid future accidents, which can be hampered by lobbyists, infighting, and racial and social issues. The politics of flying also affects developing nations, which are often more susceptible to the follies of aircraft institutions due to disparities in aircraft safety caused by governments and airlines hoping to save revenue. The aviation industry is also heavily influenced by the incentive of commercial air travel: profit. This incentive can have both positive and negative effects, such as funding studies to reduce carbon emissions, but can also lead to companies placing blame on others and attempting to bribe officials in order to avoid punishment. An understanding of the major players in the investigation, from governments and manufacturers to the public and airlines, is key to finding the politics at play.

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