Design of a Hybrid-Electric, Turboprop-Powered Regional Airliner

(Technical project)

The Effect of Greed on the Aviation Industry

(STS project)

A Thesis Prospectus
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By

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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

For my technical project, we are tasked with designing a hybrid electric regional aircraft that can carry up to 50 passengers 1000 nautical miles. Hybrid electric aircraft are planes that use a combination of electrical and gas power to propel the aircraft, with different amounts of each corresponding to various levels of hybridization (Fetcher et al., 2016). The goal of this aircraft is to develop a concept design that would produce decreased emissions compared to a standard aircraft. I chose to make my STS topic on a relevant topic to my technical project, and I am focusing on how the aviation industry has been motivated by money in many of their policies, compromising safety, comfort, and sustainability to maximize profits. I was inspired by a presentation I saw this summer at an American Institute of Aeronautics and Astronautics (AIAA) conference that discussed how small increases in the cost of flying planes could result in significant decreases on negative environmental impact (Proesmans et al., 2022).

The aviation industry is a conglomeration of private businesses, government regulators, government contractors, and government entities that contribute to the development, application, regulation, and production of aircraft. Traditionally this industry has been known to produce products with mostly cost, performance, and profits in mind, leading to an industry that has compromised some values such as environmental sustainability. Through my technical and STS projects, I am aiming to bring to light both how this has happened in the industry and ways to fix this in the future by changing the structure of the companies and the values they strive to attain.

The technical project focuses on the priority of increasing environmental sustainability in the aviation industry, and it is based on a challenge by the AIAA (AIAA, n.d.). The aviation industry contributes around 3.5% of global warming (Ritchie, 2020), so it is vital to the future that we work together to decrease this number. This project focuses on regional aircraft, which are aircraft that typically carry less than 100 people and transport people between regional airports and hubs (Regional Aircraft, 2020). My group is given a goal to design a hybrid electric aircraft, using technology that is feasible by the year 2035, that can reduce fuel consumption by 20% over a competing aircraft. This compels us to

research the technologies and systems that are currently in development by the aviation industry and use the design process to develop a culmination of the many technologies into a concept that fulfills the requirements laid out by the AIAA Hybrid Turboprop Design Challenge (Capristan et al., 2019). By developing a more sustainable aircraft that utilizes technology accessible in the future, we are hoping to encourage an increase in the use of sustainable innovation practices as well as increase efforts to use said advanced technology in other fields.

My STS project is looking to investigate the question: How has money motivated the commercial aviation industry into making decisions that compromise safety, comfort, and sustainability (Timperley, 2020)? The Britannica Encyclopedia (Editors of Encyclopaedia, 2022) defines aviation as, "the development and operation of heavier-than-air aircraft," which is an implicitly unnatural idea that needs very complex solutions. The complex industry is too large to discuss as a whole, so for this project, I am focusing on the commercial aviation industry, which encompasses both the companies that develop planes used for cargo and personnel transport, and the airline companies that operate aircrafts. This industry is rapidly advancing and changing, leaving the question, what role does the government and society play in regulating the industry?

The topics for my technical project and STS project are extremely intertwined because the future of the aviation industry sustainability wise relies on the use of electric hybridization and the responsibly use of technology. This will allow me to use the information I have learned throughout the research for my technical project to enhance research for my STS project and vice versa.

Technical Project

The project of designing a hybrid electric aircraft is a very complex design problem, and I am working with a group of eight other students to submit our design proposal. The team is led by a team

leader, and a vice team leader, while everyone else plays unique supporting role in the endeavor. We will be working the design problem from start to finish throughout the 2022-23 school year.

Starting by analyzing the requirements set forth by the competition, we will make sure we fully understand the problem and current development efforts. We will then use available literature and papers to research the many variations and design challenges for hybrid-electric aircraft (Wheeler et al., 2021). This is where we will come up with most of our ideas for the conceptual design. Some of our concepts will build upon designs by NASA such as the N3-X concept (N3-X, 2022).

The conceptual design is basically "brainstorming." Here we will develop potential solutions from our raw ideas. We can then start to filter through the potential solutions, combining them into viable aircraft "concepts." This step of the process is very much like playing with Legos, coming up with new ideas, working them through, and then choosing the best concepts and idea to mature further. The best conceptual designs will then have to be examined in greater detail. At this point we need to conduct trade studies to determine feasibility and which concepts to move forwards with. We can then choose the final concept, which will be the idea we move forwards with into actual, in-depth design.

The in-depth design will involve running system-level simulations, structural analysis, exact propulsion configuration (where we put the engines and what kinds of engines we use) and level of hybridization (how much of the engine power is provided by batteries), and putting these all together. This portion will, like most design work, be highly iterative. We will attempt to parametrize our models (assign variables to various features and run optimization functions) where possible, but ultimately it will take trial and error and making difficult design decisions to ultimately bring our aircraft to a point where wind tunnel and flight tests can be done.

Throughout this process, documentation will be crucial. We will have to explain the design decisions we made, and acknowledge and justify the ones we didn't make with both qualitative and quantitative arguments. This can come in the form of research papers, trade studies, and computational

models. It will be a priority to keep track of all the information we generate and use so that our design is as strong as possible, and capable of defending against alternatives.

Our final design will be a fully-fleshed out aircraft, complete with a CAD model showing configuration, exact dimensions, windows, and a cockpit with avionics. We will also write a report that discusses the design as a whole, along with the different decisions we made and the variables we valued during design. Although this won't be easy, I am looking forward to the challenge as well as the opportunity to use the skills I have learned at UVA in a real project.

STS Topic

The aviation industry is fundamentally linked to society as the products it develops and networks it consists of are essential to modern society, even though many people take for granted how it contributes to society. People in power are rapidly transported by planes, cargo is moved around the world overnight with planes, wars are fought by planes and airborne weapons, and supply lines are dependent on the use of planes, but society often thinks of aviation as just the airline industry. Modern society has been built with access to the aviation industry and they are now inseparable (Asquith, 2020). Since many components of the aviation industry exist outside of public eye, the aviation industry has been able to largely use its power to steer its direction in society without much input from society leading to some uncertainty of its place in the future and the rules that govern it (Belasen & Toma, 2015). Currently many parts of the aviation industry such as airlines and aerospace companies are driven by the motivation to maximize profits, and this has resulted in several catastrophes in the recent past such as the Boeing 737 MAX crashes(Langewiesche, 2019). These highlight the importance of holding the aviation industry accountable for their actions as well as redefining its position in society going forward. Traditionally, this has been done by the Federal Aviation Administration (Tyson, 2001) who is in charge of managing airspace, regulating and licensing aircraft, and research and development of aircraft in the United States.

The FAA is traditionally overlooked in society, only facing real scrutiny when an accident happens. Therefore, the FAA is a somewhat reactionary organization, while this project is hoping to highlight the problems in this and show society why this needs to be changed. To look into the role of the aviation industry in society, I will use principles of Science, Technology, and Society, primarily focusing on the use of Actor Network Theory with Configuring the User being used to support the argument as well.

Actor network Theory (ANT) (Latour, 2005) tries to focus in on how connections between actors in a network form and how these actors use the connections to exercise their power. For ANT, actors are a combination of human and non-human entities that contribute to the inner workings of a system. This theory argues that every network is different, so they can't be directly compared. This is especially relevant to the aviation industry, as it operated fundamentally different than other industries, with cut throat margins, massive overhead costs, and its importance to the global economy. ANT relies on the use of case studies and observations that focus on what is happening without applying norms or values.

The next STS framework that will be used are the ideas discussed in the essay *Configuring the User* by Steve Woolgar (Woolgar, 1991), where he discusses how technology itself can be designed in a way that limits and determines how it will be used by consumers. This is extremely important to the aviation industry because aircrafts are too complex for the majority of people to understand how they function, so the manufacturer designs the product in a way that it thinks the user wants it, regardless of that design being what the user actually wants. This gives the manufacturers and operators massive sway over the usage of the aircrafts, and passengers of the airlines. These principles will be applied to the aviation industry to define its current role in society, and potentially look at its future role in society. One of the main challenges of this approach is that these two principles are very specific with a few flaws, so they might need to be slightly modified to properly evaluate and explain their application.

Question and Methods

The primary question I am looking to answer is: How has the aviation industry been motivated to maximize profit potentially resulting in it compromising the safety and comfort of its passengers as well as its efforts for sustainability? This question is extremely important because the aviation industry has a long reach in society, by overlooking this potentially misplaced motivation, the problems will continue to compound and other industries may follow a similar model. The question was in large part motivated by the engineering failure in the Boeing 737 MAX. Therefore, one of the methods I will using to examine this question is through a case study involving the tragedy of the Boeing 737 MAX (Herkert et al., 2020). In 2019 there were two large 737 MAX crashes killing 346 people, but the problem started in 2006, when Boeing started the development of the Boeing 737 MAX. I will therefore be focusing on the time period from 2006 to 2020, and look into FAA documentation (FAA ,2021), interviews with Boeing employees, and documents published by outside organizations investigations. Since the problem is so complicated, I will try to leave as much technical language and processes out of the examination, looking only at the social and ethical evidence and ramifications. Through a careful inspection of all of the documentation and information available using ANT I hope to determine how the internal organization of Boeing allowed such a mistake to take place and used misleading policies. I will also perform a policy analysis of the FAA in the past 20 years, to look at how they have used their power to control and lead the aviation industry (Regulations & policies, 2022). For this I will be looking through published FAA documents as well as government documentation in an attempt to discover if there are any holes in the roles and policies of the FAA.

Conclusion

The intended result of my technical project is developing a design for a hybrid-electric regional aircraft that can reduce fuel use over fully gas-powered competitors. If this project is successful, it could help the aviation industry pivot to become more sustainable and future oriented in a direction that was previously unattainable due to technological limits (Button, 2021). By answered my research question of:

how does the aviation industries drive to maximize profits result in a decrease in safety, sustainability, and comfort in the aviation industry, I am hoping to give an improved understanding about the aviation industries role within society, and how this role could be changed to alleviate some of the problems. In addition, I am hoping to bring to attention how costumers and users are easily misled into valuing some experiences and features unjustly through the use of psychology (Bhattacharjee et al., 2021). This study if successful could also help the public change its stance on industries and become less complacent in how companies configure users to use products.

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