Thesis Project Portfolio

Solar-Powered Fixed-Wing Aircraft Design

(Technical Report)

The Aviation Industry's Transition to a Sustainable Future:

A Multi-Level Perspective Analysis

(STS Research Paper)

An Undergraduate Thesis

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Introduction

Over the course of this year, I focused on how innovations in aircraft technology can make the aviation industry more environmentally sustainable. For my senior capstone, my team and I designed a solar-powered aircraft, hoping to further our experiential learning as students while also demonstrating the feasibility of using renewable energy to power long endurance aerial missions. Over two semesters, we conducted analytical and computational analyses to iterate through various design stages. We have performed several studies indicating that our aircraft will be operational for autonomous flight and meets high-level requirements, though we were not able to complete all simulations and tests necessary to fully verify this. In my ethics class, I conducted a research project to assess connections between society and new aircraft technologies that enhance sustainability. I combined my background in aerospace engineering with a literature review on the topic to perform a multi-level perspective analysis. I focused separately on small-scale technologies, large-scale industry regimes, and the aviation landscape to determine what our sustainability goals are and what we must do, as a society, to achieve them.

Capstone Project: SPARC Aircraft Design

My capstone team designed SPARC, the Solar Powered Autonomous Reconnaissance Craft, over this academic year. Our 12-member team set out to design an aircraft that could harness solar power to sustain high-endurance flight and support a wide range of missions. To differentiate our aircraft from other existing designs, we prioritized developing a flexible payload module that can be quickly and easily swapped out between missions. Example uses of the payload bay include hosting cameras for reconnaissance, surveillance, or imaging, or hosting sensors and probes for scientific research.

Our team split into three subteams: aerostructures, aircraft systems, and power. The aerostructures team used CAD and FEA software to optimize the aircraft structure. They designed lightweight wing, fuselage, horizontal stabilizer, and vertical stabilizer structures which supported high stresses, and then integrated these structures together. The aircraft systems team designed the aircraft's avionics system, selecting the necessary components for autonomous, long-range flight. This team also designed the aircraft planforms and configuration using conceptual design software and performed basic CFD simulations to assess performance and stability. The power team designed and simulated the configuration of solar cells, batteries, and motors to ensure that the aircraft could generate sufficient power and thrust to operate continuously.

Our team conducted several experiments, including a water tunnel PIV study on winglets, airfoil analysis in a low-speed wind tunnel, and electrical component testing for the powertrain. We hope that the project can be continued next year, so the aircraft can be fully integrated, analyzed, modeled, and tested.

Research Project: Sustainability in the Aviation Industry

My research project for my STS ethics course is titled *The Aviation Industry's Transition to a Sustainable Future: A Multi-Level Perspective Analysis*. In this paper, I sought to determine what the aviation industry is currently doing to become more environmentally sustainable and what different parties' motivations are in this transition. Aviation is responsible for a significant quantity of carbon and greenhouse gas emissions, and new technologies can reduce the harmful impacts of global flight.

I conducted my research through a review of online literature, including journals, reports, and academic papers. I organized my research through the multi-level perspective STS framework, allowing me to assess macro-scale landscape changes by examining micro-scale technological developments and their implementation within meso-scale industry regimes. The technologies I researched include sustainable aviation fuels (SAFs), hydrogen jet engines, hydrogen fuel cells, and improvements in efficiency and operations. I studied industry regimes such as commercial aviation, general aviation, maintenance, repair, and overhaul (MRO), and urban air mobility (UAM).

I found that SAFs and hydrogen technologies offer high potential for aviation, as these could greatly reduce emissions and perhaps even improve aircraft performance if implemented in future designs. These two technologies could be implemented in most flight routes in the commercial aviation industry. Electric power could serve a smaller flight envelope in regional air travel and general aviation. The UAM industry promises a future with short-range air travel and zero emissions using electric aircraft. However, each of these technologies lacks the maturity and readiness to be used on any significant scale in our society. They are generally not profitable investments in the immediate future, as environmental sustainability does not directly increase revenue for airlines and aircraft developers. Our society needs to increase incentives for the uptake of such technologies if we want to achieve the widespread goal of a zero-emissions aviation industry by 2050. I encourage future research to explore possible mechanisms for incentivization to give sustainable flight technologies the attention that they require.

Conclusion

These two projects have been eye-opening for me as an aerospace engineer. They have given me a glimpse into the challenges of creating technologies that can decarbonize air travel and the societal roadblocks that restrict their large-scale implementation. I honed my research and writing skills through the research project. I also learned new methods of aircraft analysis and practiced technical communications through the capstone project. I hope both projects serve as inspiration for future engineers, as I believe they represent crucial steps toward making today's aviation industry sustainable for future generations.