Thesis Project Portfolio

Solar-Powered Fixed-Wing Aircraft Design
(Technical Report)

Addressing Increased Runway Incursions in an Aging and Overburdened National Airspace System
(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

Miles Beam
Spring, 2025
Department of Aerospace Engineering

Table of Contents

Sociotechnical Synthesis

Solar-Powered Fixed-Wing Aircraft Design

Addressing Increased Runway Incursions in an Aging and Overburdened National Airspace System

Prospectus

Sociotechnical Synthesis

In completing both a technical capstone project and an STS thesis, I had the opportunity to explore two distinct but timely issues in aerospace engineering: the pursuit of sustainable flight and the prevention of runway incursions. Though these projects are not directly linked, both address major challenges in the future of aviation—namely, reducing environmental impact and improving operational safety. While the technical project demanded practical engineering design skills, the STS research provided a systems-level understanding of how social, human, and institutional factors shape aviation outcomes. Working on both projects in parallel revealed the value of integrating engineering rigor with sociotechnical awareness to drive more responsible innovation.

The technical component of my thesis was the design and prototyping of the SPARC (Solar-Powered Autonomous Reconnaissance Craft), a high-altitude, long-endurance unmanned aerial vehicle. This aircraft was developed to provide an alternative to costly and polluting satellites and traditionally fueled systems by using solar energy for multi-day surveillance and exploration missions. The project emphasized modular payloads, aerodynamic efficiency, and advanced energy storage systems. My role as Chief Engineer involved leading aerodynamic optimization, structural design, and component testing, including wind tunnel and water tunnel experiments. Through iterative modeling using XFLR5 and CAD, we designed a rectangular wing with high lift and solar panel area, optimized control surfaces for autonomous operation, and validated the feasibility of the energy system through benchtop tests and MATLAB simulations. The SPARC project ultimately demonstrated that undergraduate engineers can contribute meaningfully to sustainable aviation research.

My STS research paper examined the problem of runway incursions in an overburdened national airspace system, using Actor-Network Theory to analyze the interplay between pilots, air traffic controllers, technologies like ASDE-X and RAAS, and institutional factors such as FAA regulations. While technological solutions exist, I argued that incursions persist due to misalignments in training, communication norms, and institutional responses to human error. Case studies, including the 2023 JFK runway incursion and others involving automation failures and human error, revealed how safety depends on a complex sociotechnical system as opposed to one key factor. My research highlights the importance of adaptive policies, cross-stakeholder communication, and innovative human-centered design in reducing these high-risk events.

Working on these two projects simultaneously helped me better appreciate the multifaceted nature of engineering challenges. The SPARC project challenged me to navigate technical constraints, lead a multidisciplinary team, and adapt to evolving design hurdles, while the STS research reminded me of the need for advanced technology to be supported by robust human and institutional systems capable of addressing the consequences of human error—both in the cockpit and in the control tower. SPARC's emphasis on reliability pushed me to consider the boundaries of automation and how systems must account for human limitations. This directly paralleled my STS research, which revealed how breakdowns in communication, training, and situational awareness—especially under stress—can compromise safety despite technological safeguards. Across both projects, the integration of ethical awareness, human factors, and system-level thinking emerged as essential to meaningful innovation. These experiences have strengthened my belief that engineers must be fluent in both technical design and sociotechnical analysis to create systems that are not only advanced, but also resilient, safe, and improve society.