**Renewable Energy and Modularity in Autonomous Aircraft Design: SOLAR-POWERED AUTONOMOUS RECONNAISSANCE CRAFT (SPARC)**

**Out of Time: An Overview of Time Infrastructure**

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Aerospace Engineering

By
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November 4, 2024

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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

The technical and socio-technical portion of my thesis prospectus will address separate topics with distinct problem frames and methodology.

The first extensive research on solar power began in the 1970's in an effort to develop alternative energy options due to oil supply disruptions across the world (Zhu et al., 2014). As the push to reduce dependence on fossil fuels to address global warming has gained significant momentum, solar energy has gained renewed interest especially in the aviation industry. Solar powered aircraft promise significant potential, particularly for High Altitude and Long Endurance (HALE) autonomous flights. In addition to using clean energy, these aircraft can offer multiple solutions to challenges faced by similar technologies. The increasing reliance on non-reusable, monolithic aviation technology, such as satellites, contributes to higher waste and costs. With their endurance, modularity, and cost-effectiveness, solar-powered aircraft offer a valuable alternative and complement for both military and civilian operations. To address the issues of climate change and lack of aircraft modularity in both the civilian and military sects of the aviation industry, the technical portion of my thesis will consist of designing an autonomous solar-powered aircraft, emphasizing payload modularity in HALE flights.

For the sociotechnical portion of my paper, I will analyze our interactions with time as infrastructure. Time functions as a background mechanism, one whose exact operations often go unobserved. However, if our capacity to *know* the time were suddenly removed, numerous systems integral to our daily lives would cease to operate effectively. The potential impact of failure in time infrastructure was highlighted during the Year 2000 (Y2K) panic. Widespread concern arose that computer engineers had not prepared systems ready to handle the new millennium, potentially preventing computers from transitioning to the year 2000. This fear brought increased public awareness to the importance of time infrastructure, as such malfunctions can threaten the operation of vital systems such as healthcare, transportation, and cybersecurity. In my thesis, I want to explore how our social values and flawed time infrastructure can contribute to disruptions in major sociotechnical systems and explore arguments to address this issue.

**Renewable Energy and Modularity in Autonomous Aircraft Design:**
**SOLAR-POWERED AUTONOMOUS RECONNAISSANCE CRAFT (SPARC)**

The technical topic of my thesis will cover the design of a modular, solar-powered aircraft for high-altitude surveillance and exploration missions. Our aircraft, named the *Solar-Powered Autonomous Reconnaissance Craft (SPARC),* aims to provide alternative solutions to non-modular high-altitude aircraft.

Currently, aviation contributes over 4% to induced global warming (Klöwer et al., 2021), with most aircraft still relying on fossil fuels despite advances in propulsion technology. Though seemingly small in numbers, this impact remains significant as air travel demand grows, making it imperative to reduce aviation's carbon footprint. Although technological advancement makes decarbonization via solar power feasible, physical challenges like solar radiation's low energy density hinders the aircraft's transition to full-scale commercial use.

Although this integration hasn't yet been fully successful, solar-powered HALE operations in surveillance and scientific observation offer significant potential. Solar-powered aircraft can maintain extended periods of flight by harnessing solar radiation during the day and relying on batteries at night, creating a key advantage over fossil fuel-powered counterparts that are unable to sustain that required energy (Zhu et al., 2014). Additionally, high-altitude missions operate above atmospheric weather, ensuring that weather does not disrupt flight or limit solar energy acquisition. These mission requirements highlight the unique advantages of solar powered aircraft despite the initial technical challenges.

Sustainable aviation requires not only renewable energy in propulsion, but also developments in mission reusability. Surveillance and exploration systems in aviation must constantly adapt to evolving demands (Gunnar, 2002). While traditional high altitude technologies, such as satellites, are costly and rigid, the solar powered aircraft with its lightweight architecture and takeoff/landing capabilities offer a promising alternative (Symolon, 2009). Modular payloads enhance mission reusability and enable easy system upgrades, which are critical for HALE operations. Therefore, our team's focus is both on integrating renewable energy and improved mission capabilities to HALE autonomous aircraft.

Our project's electric and aerodynamic systems will be informed by the latest solar-powered aircraft designs. Our first model of reference is the *Solar Impulse II*, the first aircraft to complete solar-powered piloted flight across oceans in 2016 (Wei-Haas, 2018). While our aircraft will operate autonomously and at a higher altitude, this will provide valuable insights to our design as piloted aircraft often have more complex system design. The second model will be the *Airbus Zephyr*, which completed a record-breaking 26-day automated solar-powered flight in 2022 (Gerken & Swan, 2022). The *Airbus Zephyr* aligns closely with our HALE objectives, although our aircraft is intended for diverse mission payloads, and not just high-resolution Earth observation.

Our team, including thirteen members and a technical advisor, has two main deliverables for the year. The first is a final design review, where we will detail our objectives, vehicle design, structural and stability analyses, and a mission concept of operations to demonstrate feasibility. Our second deliverable, which is dependent on funding, will be a functional sub-scale model with benchtop tests to analyze different aircraft components. Through this process we aim to complete our mission objectives and project design by the end of Spring 2025.

**Out of Time: An Overview of Time Infrastructure**

In the sociotechnical portion of my paper, I aim to establish time technology as an infrastructure. I will then explore my problem frame within the importance of time as infrastructure in major social and technical systems and examine what occurs when it does fail. Finally, I will address the shortfall of discussion surrounding social values within time infrastructure and form arguments to potentially understand the consequences of this often deliberate oversight.

Before exploring my problem frame, I will define the term time infrastructure. In *The Ethnography of Infrastructure*, Star (1999) defines infrastructure as an embedded and transparent underlying mechanism that becomes visible upon break-down. I will explore time infrastructure within this framework, through the example of the marine chronometer.

Quantifying time has been a complex effort throughout history. Until the 18th century, while local mean time could be calculated, measuring time at sea, and therefore determining longitudes, was not possible. This made navigation and mapping challenging and often inaccurate. However, in 1735, John Harrison's invention of the marine chronometer enabled precise longitude measurements on sea (Forbes, 1966), facilitating reliable international trade and the creation of time zones. These breakthroughs laid the foundation for globalization and the modern GPS. I want to use this example to show that time is not only a linear measurement, but a complicated, foundational network that's embedded in all major social and technological systems.

What happens when time infrastructure fails? In the introduction, I briefly discussed the Year 2000 (Y2K) panic. Although this "error" did not cause global catastrophe as society had feared, it still highlighted the risks of misinterpreting and neglecting time infrastructure . According to the World Health Organization (WHO) at the time, the error in calculation of time would not only cause administrative issues, but also pose life risks to patients, "such as a wrong radiotherapy dose resulting from an incorrect calculation of the decay of a radioactive source" (THE IMPACT OF THE Y2K PROBLEM ON THE HEALTH SECTOR , 1999, p. 3). This report documents the vital importance of accurate time measurements, and proves that people and institutions understood the importance of time, knowing that such breakdown would severely disrupt systems like healthcare. However, time was still overlooked in the foundational design of these operations. What does this say about our value of time?

I want to use the events of Y2K to open my problem frame and introduce my research question. The neglect of time infrastructure disrupts social and technical systems.

Although Y2K was a hypothetical technical failure, the fact that major international organizations like WHO were conducting reports on it proves that even this theoretical scenario caused significant social disturbance. The functioning of technical and social systems depend on time, yet we still create faulty time systems, sometimes even deliberately. How and why do we consistently fail people through the misuse of time?

Although the events of Y2K occurred over two decades ago, similar oversights still happen today. We are the most technologically advanced we have ever been. Advances in transportation let us reach destinations in hours that once took months, and we can complete household chores that would require an entire day's effort by the click of a few buttons. We invent technology to save time, yet time still feels scarce. Rosa (2003) defines the paradox of time scarcity during technological advancement as *acceleration society*. STS scholar Wajcman (2008) further discusses the issues of an *acceleration society* to argue the issues of taking a deterministic approach towards temporality and technological innovations, and that a social perspective can provide deeper analysis into our relationship with current time.

In my thesis, I will expand on Wajcman's (2008) approach to temporality. Firstly, I will briefly overview key scientific and philosophical arguments on time, focusing on the debates between Bergson and Einstein on time's relativity. Using Scott's (2006) analysis of these views, I will emphasize the dual significance of metaphysical and social time, arguing that time's scientific objectivity and social relativity is inseparable. To further support this, I will discuss Greenhouse's (2018) critique of the polarization of these concepts, emphasizing that time cannot be removed from its social and scientific contexts.

After completing this discussion, I will return to the concept of the *acceleration society*. In the next stages of my thesis, I will examine cases where misguided social values deliberately contribute to time scarcity, further highlighting the social and scientific reality of time, and identifying where this misalignment causes harm. One case I plan to explore is that of immigrant asylum seekers, where social values and intentionally underdeveloped time infrastructure in bureaucratic processes lead to harmful distress to immigrants (Griffiths, 2014). Although this section requires further research, the rest of my methodology will examine similar cases aligned with my problem frame to further understand how social values and manipulated time infrastructure can result in serious, sometimes deliberate, consequences of time scarcity in current society.

In short, the sociotechnical portion of my thesis will establish time technology as a foundational infrastructure embedded within social and technical systems. Using Star's (1999) theory of infrastructure and Wacjman's (2008) analysis of the *acceleration society* I will examine the key role of flawed time infrastructure in sociotechnical systems and time scarcity. Through this frame I will further define time by scientific and philosophical perspectives in order to argue the indivisible objectivity and social context of time. Using this definition, I will examine cases where the deliberate neglect of time infrastructure contributes to the persistent distress and consequences of running out of time, and the points in which we could improve this critical infrastructure.

## Conclusion

The technical portion will focus on designing an autonomous, solar-powered, modular aircraft for HALE flights. Our goal is to reduce aviation's carbon footprint by utilizing solar energy and maximize modularity to overcome the rigidity of HALE operations. We will achieve this by studying existing designs, conducting design reviews, building a sub-scale model, and performing benchtop tests in order to assess feasibility. Our research aims to contribute to a future where air travel can be both clean and innovative.

Separately, the sociotechnical portion will examine time as a critical yet overlooked infrastructure within sociotechnical systems. By discussing existing STS theory and various discussions on time's definition, I will analyze cases where the neglect of time infrastructure causes harm. Thus, this research will propose the integration of social values reflected in time, emphasizing its crucial role in sociotechnical systems, and its potential to improve life quality by understanding the role of time in our individual lives.

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