STRUCTURES AND INTEGRATION FOR HYPERSONIC REENTRY DEPLOYABLE GLIDER EXPERIMENT (HEDGE)

WHAT ARE THE CURRENT ATTITUDES TOWARDS OUTER SPACE TOURISM TECHNOLOGY?

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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October 10, 2023

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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

Space exploration has been a greatly expanding field for many years now, however only recently have the improvements in technology made it feasible for humans to travel to space without needing to be a trained professional. Regardless of these new opportunities, there are still numerous concerns with significant implications associated with this new enterprise. Space can also be seen as a new environment area to perform testing that is not feasible on our Earth. In this prospectus there will be two projects examining two current prominent modes of space flight.

My technical project will be focused on the structural aspects of a hypersonic glider vehicle. This small spacecraft is known as the hypersonic reentry deployable glider experiment (HEDGE) and it is a CubeSat. CubeSats are nanosatellites that have a specific standard dimension so that they can easily be launched from space. The intention behind this design in particular is to collect hypersonic reentry data while in flight in the atmosphere before it decelerates and burns up.

My STS investigation will focus on current social attitudes towards space commercialization by private companies such as Virgin Galactic, SpaceX and Blue Origin. Specifically I will focus on Blue Origin's recent commercial space flights with New Shepard. My fundamental research question concerns what the current attitudes towards the technological expansion of the tourism industry into outer space are and why. This question is important because recently there has been backlash against the surge of billionaires attempting to capitalize on the excitement surrounding space travel. Determining whether or not this increase in the tourism market is actually doing something positive or not is crucial for the future of space exploration and the public perception of continued investment into space.

These two projects mentioned will examine two sides of the same coin, the technical portion of constructing a hypersonic spacecraft for the purposes of scientific knowledge and the social implications of private investors' increased interest in space exploration. Both of my projects relate to space travel vehicles, however one focuses on building a hypersonic flight glider and the other concerns the technology that has been used to send people into space for the purpose of tourism. The rest of this prospectus will go into depth on each project and its technology as well as a description of the key texts and sources utilized within it.

Technical Project

Problem

The field of hypersonic flight technology has been an extremely important research topic in recent years. This research is especially critical to the United States Department of Defense as well as to the aerospace and defense industry as a whole. Hypersonics refers to the field of study of projectiles that fly through the air at speeds at or exceeding five times the speed of sound (Seldin, 2022). This includes both offensive and defensive missiles as well as high speed aircraft and spacecrafts. This speed allows for quicker reaction times by the government for important matters of defense. This technical project will examine hypersonic flight through the use of a miniature satellite. This miniature satellite is known as a CubeSat and is made up of cubes with a standard dimension of 10 cm on each side for ease of application and launch capability. CubeSats are often used for educational purposes due to their lower relative cost and will be able to enter low earth orbit as well as maintain hypersonic flight speeds. (NASA, 2023)

The goal of this technical project will be to create a hypersonic CubeSat glider capable of obtaining flight research data while in orbit. This design is known as the Hypersonic ReEntry

Deployable Glider Experiment (HEDGE), and builds off of the design specifications established in prior year's spacecraft class. The HEDGE mission implements the deployment of a CubeSat into Low Earth Orbit (LEO) where it will collect and transmit data. At the conclusion of the CubeSat's orbit lifetime, it will re-enter the atmosphere to collect data before it burns up.

Significance

The following prospectus outlines the significance, objectives, resources, and future of this design, specifically related to the structure and integration subteam of the HEDGE CubeSat design. The S&I subteam is tasked with providing the overall mechanical integrity of the spacecraft, ensuring that all components are securely enclosed and protected, and guaranteeing that inner components can withstand the loads endured in handling, launch, and flight in freefall (Garino, 2009). The team must also collaborate with other subsystems within HEDGE to ensure the most efficient and effective configuration of the spacecraft is achieved.

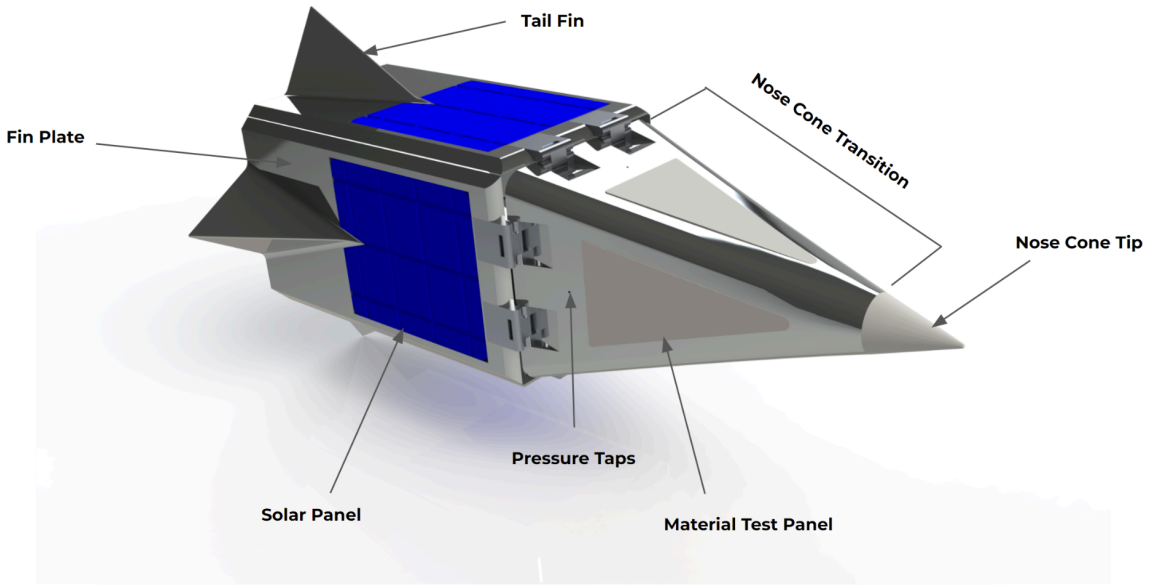

Figure 1. 3D modeled design of HEDGE that lists each major component (UVA 2022)

Methods

HEDGE will be receiving new components from each subteam this year. This changes the design laid out by previous S&I teams. Components must be placed in a method that allows for a large enough static margin. Having the correct static margin is important because it ensures the stability of the spacecraft during reentry (Coleman and Faruqi, 2009). Thus effective communication between the subteams is crucial to the longevity of the spacecraft. Along with the standard subteams, HEDGE also employs the help of future electrical engineers to create the circuit boards and software. A method we will employ to ensure proper and clear communication with other teams is delegation of a specific teammate or group of teammates to collaborate with a specific team. Our team must work closely with the Software and Avionics team to determine placement, wiring, and logistics of the solar panels on the spacecraft. In determining the static margin of the spacecraft, we are required to work with the ADACS and Orbits team, Software and Avionics team, and Communications team. Each team is responsible for hardware that will affect the center of gravity of the spacecraft, in which we will determine orientation.

In accordance with the expected loads endured, we plan to employ analytical calculations, CAD, and FEA software (SolidWorks and ANSYS) to ensure the structural integrity of the spacecraft meets its required capabilities. We will collaborate with the Power, Thermal, and Environment team - they will be completing thermal simulations and analysis while we will perform the structural analysis.

Aside from the structural ability of HEDGE, we will alleviate current structural design needs such as solar panel location, cable management, location of internal components, hinge design, and transceiver and thermocouple layout.

Available resources

Many resources have been made available for HEDGE and our subteam. The CubeSat lab is available for us to ask questions and make progress on our established goals. The computers located in the Mechanical and Aerospace Engineering building are equipped with helpful software for our purposes. SolidWorks is a CAD software that will be a massive asset for us as we work to better the structural design and organize the interior components to optimize the space and balance of the CubeSat. Ansys is a beneficial software that will allow us to perform finite element analysis and simulate the reentry conditions that the CubeSat will experience. These simulations will help us estimate the current state of our structural design in terms of its strength and temperature distribution. A member of our team has a connection to an individual with a machine shop, and this could potentially be an extremely valuable resource for us once we have the plastic prototype. The plastic prototype will come from the MAE RPL room. The technical advisor for the HEDGE project, Professor Christopher Goyne, has been working to obtain funding from the US Navy. Various materials manufacturers could also theoretically partner with our team to provide financial support in exchange for installing material test slabs to the CubeSat.

Objectives for Spring semester

The goal of this project in the upcoming spring semester is to finalize and 3D print the HEDGE CubeSat design in order to create a functional model following the Technical Interchange Meeting (TIM) that will occur during the fall semester.. This model should be able to perform all of the functions that the final CubeSat design will be able to, including deploying the fins, collecting reentry data, transmit and receive signal using Iridium satellites, as well as

test materials under hypersonic conditions. This technical project's mission will rely on certain events occurring successfully, such as the deployment of the CubeSat and hypersonic glider as a unit, the stability of the glider during flight, and data being properly relayed during reentry. By creating and demonstrating the feasibility of CubeSats for hypersonic glider flight tests, this technical project will open new doors for low-cost hypersonic research with conditions that are not achievable from the ground.

Type of Technical Paper

The final paper will be a comprehensive description of the design creation that will be sent to coordinators, Professor Goyne, and the University of Virginia detailing our creation of a hypersonic glider vehicle experiment using a CubeSat for submission to the Navy for funding. The class will be finalized by a System Integration Review (SIR) that will go over each team's work throughout the semester.

STS Project

Space tourism, as the words indicate, is space travel for the purposes of novelty seeking, recreation, leisure and knowledge pursuit (FutureLearn, 2022). The concept of space tourism sells a dream that many people share, the ability to fly among the stars. However this dream, which was previously thought to be unattainable, has become much more realistic. There has been heated debate in recent years surrounding the equity of space tourism, what was once solely under the government's purview has become largely overtaken by development in the private sector.

Technology

The technology that I will examine in this project is the more recent space tourism technology, specifically Blue Origin's reusable suborbital rocket system, New Shepard. Blue Origin is headed by billionaire Jeff Bezos and was founded in 2000, it was the predecessor to the creation of multiple other private companies owned and operated by billionaires. Following this, billionaires Elon Musk and Richard Branson created their own space companies, SpaceX and Virgin Galactic respectively (Kariuki, 2021). This led to what some have called "the billionaire space race" due to the fact that these billionaires are all seeking to influence space exploration and space tourism opportunities. However, these companies have been attracting a lot of attention and backlash. Blue Origin in particular has been the target of many people's ire, with some saying that due to the extremely high ticket prices "it is a dangerous, elitist frivolity for the rich" (Hopkins, 2008).

The technology that Blue Origin has created is intended to be entirely reusable. This reusability is key since the potential market of space tourists is large enough and uncertain enough that there is a need for reusable, lower-cost space access. The Blue Origin space tourist will take off vertically in a capsule on the top of a New Shepard rocket. The capsule then separates, and the tourists will descend to the Earth by parachute. Meanwhile, the rocket booster also returns to base to a vertical landing on its launch pad (Webber, 2019).

The overarching question I seek to answer in my research is, what are the current attitudes towards space tourism technology and why? At the pace of our current advancement into space commercialization, most professionals predict a not so distant future with space flight as a viable option for many for travel and vacation. However, alternate perspectives offer that continued human expansion into space would be a colossal, long, and extended project that

would cut into Earth's resources, therefore diverting them from alternative uses. (Cohen, 2019). 58% of Americans said they would not want to orbit the Earth aboard a spacecraft, citing reasons such as it would be "too expensive," too scary, or that their age or health wouldn't allow it (Strauss, 2018). It is very important to the future of the space industry what the public's opinion of space exploration is. Additionally, alienating those who are less well off will only cause more animosity towards any expenditure into space travel.

Relevant Social Groups

The social groups that are relevant to my research topic include the billionaires themselves, the private space industry workers, space tourism supporters, space tourism critics, and the underprivileged people who feel the most hurt by money being used for this purpose. The billionaire I am examining specifically is Jeff Bezos. While he does not run the Amazon company personally anymore, following the post flight conference of NS-16, Jeff Bezos made the following comment: "I would like to thank all Amazon customers and Amazon employees. Because you paid for all this" (Marshall, 2022). I will be using the accounts from Jose Hernandez as representation for the supporters of space tourism. He was an astronaut on the International Space Station in 2009 and he became a role model for many kids who have dreams of one day going to space. He sees the commercial space race as a positive and thinks that it will bring in high-paying engineering jobs to the U.S. as well as technological developments could benefit everyone on earth (Thorbecke, 2021). On the other side of the argument I will be using accounts from Chris Smalls, an activist and former Amazon fulfillment center worker, as the representation for the critics of space tourism. Smalls, who is black, called the billionaire space race "whitewashed" and "a slap in the face" to workers (Thorbecke, 2021).

All of these social groups are important to my research into the public opinion of space tourism since they will all be impacted by this technology's success or failure.

Other groups related to my research topic include the government, the space part manufacturers, and the multitude of business people involved in the space tourism process. I feel that these groups are not the main focus of this research since the government involvement in the private sector is mainly focused on contract work and does not connect to the public opinion on the continued investment into private space tourism efforts. Similarly, the manufacturers of the materials and spacecraft parts are important to the creation of space tourism technology and their job safety may also depend on the success of the industry. However, there are a great number of these manufacturers and they are not the most vital group when it comes to the social aspects of space tourism.

Methods

In order to further research my topic, I will be talking to people by hopefully having one-on-one talks with some Amazon employees to see whether they approve or disapprove of Bezos' continued expenditure into space tourism. I want to ask specifically about how they have been impacted in any way by the Amazon unions or if they themselves are a part of it and if they support or oppose space tourism and has it been influenced at all by their company's founder playing such a large role. I hope to get these interviews sometime before the Spring semester and I plan on reaching out to a couple possible participants shortly. I also plan to read more personal statements made by people about the future of space tourism. The story of space tourism shifts greatly depending on whoever is describing it. To many within the working class, it feels frivolous and the entirety of the private sector are the villains. But to someone involved in space

science and exploration, the increase of space tourism may be for the better no matter who is pioneering it. A majority of people find space tourism to be beneficial but have trouble reconciling it with the rich white benefactors that are standing behind it.

Framework

The framework I will be using to answer my research question is the Actor-Network Theory (ANT) theoretical framework of science and technology studies. The central premise of Actor-Network Theory is that everything in the social and natural worlds exists in a network of interconnected actors. Actor-Network Theory is a good framework to pick for this research in particular because it considers all of the social and technical aspects of space tourism and places them all in an interconnected network. These actors can feasibly be anything that has agency and can influence or be influenced by other actors. For my STS project specifically, these actors include each of my relevant social groups and the people representing each group such as Jeff Bezos, Jose Hernandez, Chris Smalls, and the current Amazon employees. The theory will emphasize each actor's role. This research will go into depth on the process of technological advancement of Blue Origin's space tourism capabilities as well as the current social climate that has led to backlash. This research will include multiple human and non-human elements that makes ANT valuable for analysis due to its inclusive perspective on actors, its socio-technical focus, and its capacity to capture the complex interactions and dynamics within networks.

Timeline

For my technical portion, our team will begin research by examining the work done by last year's structures subteam and working on any necessary changes. These changes will be

carried through into the 3D model we will create using the computer-aided design software, SolidWorks. In the upcoming semester, the structures team and I will be working on creating a physical working model of the HEDGE design through the 3D printing of parts. For the STS portion, this semester will include more research and polishing of the prospectus with a final product being written by the end of the semester. Then the next semester will consist of writing and completing my final STS thesis paper.

Key Texts

"Introduction, Space Tourism" (Cohen, 2019)

This book introduction was written by two people and was intended to give a historical overview and explanation of space tourism. It provided good information on the creation of space tourism and how the technology has advanced to where it is today from its first occurrence in 1990. This was important to my research project as it was able to give a good overview of the technological history of space tourism.

"Current Space Tourism Developments" (Webber, 2019)

This book chapter provides an update on the state of space tourism in 2019. This was before Blue Origin had officially flown a crewed space mission. The information given in this chapter was very helpful in determining the current actors and companies involved in space tourism. This chapter argued about the need for reusability which is central to my prospectus topic and the technology used. The chapter also goes into detail about comparing the mission steps for both Virgin Galactic and Blue Origin's space flights.

"Psychology of space tourism marketing, technology, and sustainable development: From a literature review to an integrative framework" (Mehran, 2023)

This source investigated space tourism marketing and behavioral responses of space tourists themselves. It did this by providing an analysis of public viewpoints on space‐faring in order to gauge their alignment with academic views on space tourism. This was very closely related to what I wanted to research with respect to the social aspects and the public attitudes towards space tourism.

“The Space Movement: Space Settlement and Space Tourism” (Hopkins, 2008)

This statement by the National Space Society argues for the nobility of space tourism as an industry. This argument was important since it also acknowledges the issues that many take with space tourism. Having a source that argues for the good things about space tourism technology is necessary because it provides a better understanding of the debate as a whole. The statement discusses how space tourism is special in that a lot of the private technology is not derived from government creation and is instead invented for the purposes of the private sector. This is argued to be better for the future of space exploration and settlement.

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