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

Technical and STS Thesis Prospectus

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

Ian McAninley

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Technical Team Members:
Benjamin Koeppen, Lobsang Dawa, William Jones, and Arlee Christian

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.

TECHNICAL ADVISOR

Chris Goyne, Department of Mechanical and Aerospace Engineering

Technical Thesis Prospectus

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. (Vergun, 2023) Hypersonic 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) in which 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 sub team of the HEDGE CubeSat design. The S&I sub team 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.

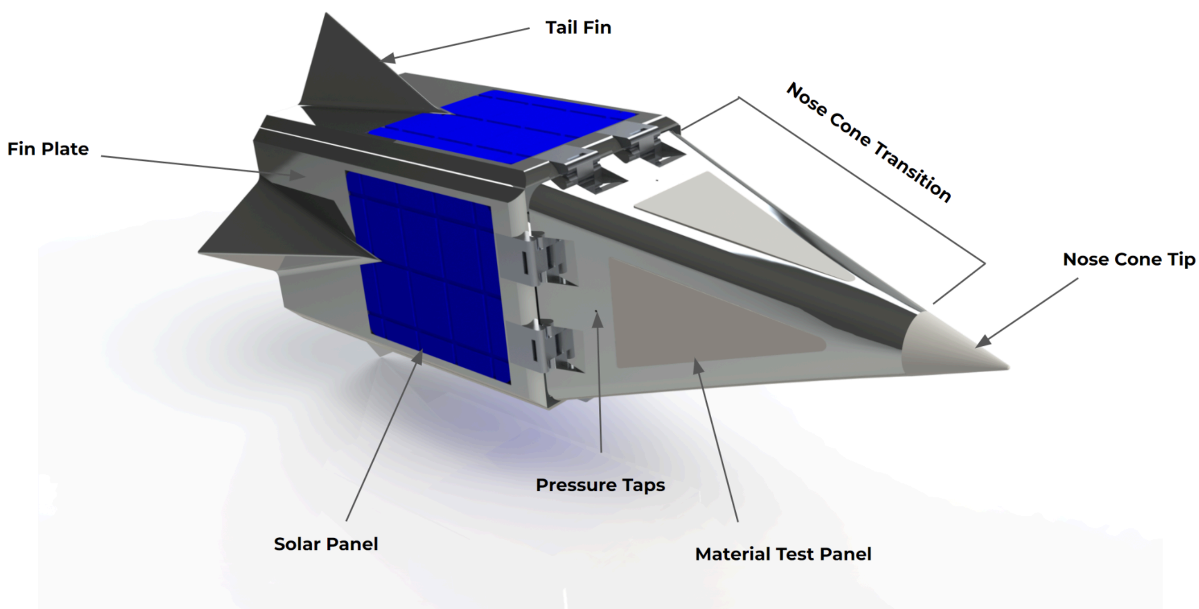

Figure 1. 3D modeled design of HEDGE that lists each major component (2022)

Methods

HEDGE will be receiving new components from each sub team 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 sub teams is crucial to the longevity of the spacecraft. Along with the standard sub teams, 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 the 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.

We plan to use CAD and FEA software (SolidWorks and ANSYS) to alleviate current structural designs such as solar panel location, cable management, location of internal components, hinge design, and transceiver and thermocouple layout. This software will also aid in the risk management of the structural integrity and capabilities of the spacecraft.

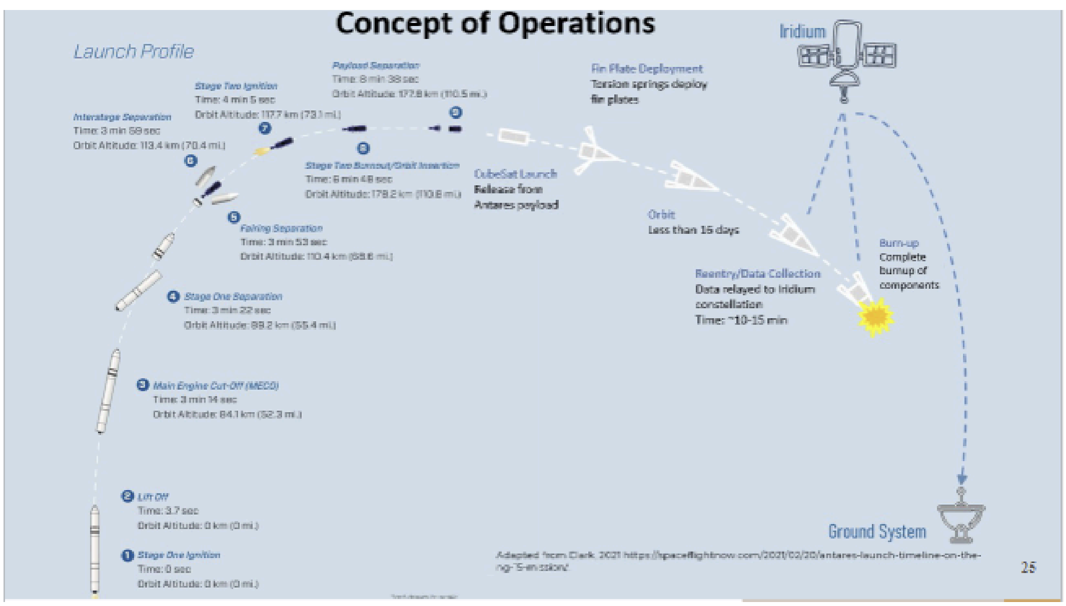

Figure 2. Concept of Operations for the Hedge Mission (2022)

Available resources

There are many resources that have been made available for HEDGE and our sub team. 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 CAD software that will be a huge asset for us as we work to better the structural design and organize the interior components to optimize space and balance of the CubeSat. Ansys is an immensely helpful 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 inconel prototype. The technical advisor for the HEDGE project, Professor Christopher Goyne, has been working to obtain funding from the US Navy. Another possible avenue that has been explored is collaborating with various materials manufacturers and requesting 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. Another goal is to garner greater appreciation and attention for aerospace and hypersonic research for other undergraduate students

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 Thesis Prospectus

What are the practical applications of hypersonic weapons and how do they impact global relations and diplomacy?

Global conflict has always accelerated the progression of technological development. The Second World War produced several technologies that still play large roles in our lives today. The atomic bomb was the most impactful example and played a significant role in the onset of the Cold War and global tensions throughout the remainder of the 20th century. More recently, the Israeli-Palestinian conflict as well as the Russian-Ukrainian war have both played roles in flaring up global tensions. Throughout history, the constant theme that peace-seeking diplomats sought to maintain was a global balance of power. In the nuclear age, this theme is represented by a different term. This new term has been coined as mutually assured destruction. Although the wording has changed, the general theme of balance has not. These recent global conflicts serve to remind us of the importance of balance. This is because once one global superpower believes that they can launch attacks upon other countries without retaliation, the start of another world war becomes inevitable. The goal of my STS research is to better understand the role that hypersonic weapons could fulfill for the purpose of national defense. Is this new realm of weapons purposeful, or is it another example of obsolete, cost inefficient technology?

The balance of global power is not static and never has been. It can be better described as a pendulum that swings back and forth as new technologies are developed to counter the previous new technology. Global power can be characterized by military strength and technological capabilities. This research topic plays a larger role in the technological capabilities' hemisphere of global power. The most recent groundbreaking technological advancement that has been utilized in real world applications is the anti-missile and anti-ICBM weapon systems. This technology is being utilized by Israel in the form of their "Iron Dome" in response to HAMAS's deployment of missile strikes. Although this technology serves a defensive purpose, it threatens to throw off the balance of global power because it nullifies the concept of mutually assured destruction. It does so because it allows for one country to have the ability to launch potentially nuclear strikes on another country while not being struck with nuclear strikes themselves since they have the ability to neutralize the ICBMs that have been launched in response. The development of anti-missile technologies is the motivation for the development of hypersonic weapons. Hypersonic weapons provide the potential capabilities necessary to invalidate anti-missile systems. These capabilities include a "combination of speed, accuracy, range, and survivability (the ability to reach a target without being intercepted)" (CBO) that would be useful in military applications and are not currently possessed by other forms of strike ordinances such as ICBMs or cruise missiles.

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