HEDGE
Hypersonic ReEntry Deployable Glider Experiment
(Technical Paper)

The Benefits of Space Colonization
(STS Paper)

A Thesis Prospectus
In STS 4500
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By
Joseph Abbe

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Technical Team Members:
Daniel Fisher
Danielle Ashbahian
Kevin Nguyen
Samuel Kristy
Spencer Harris

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.

ADVISORS

Christopher P. Goyne, PhD, Department of Mechanical and Aerospace Engineering

Bryn E. Seabrook, PhD, Department of Engineering and Society

Introduction

Under the intense drag in Earth's atmosphere, travelling at hypersonic speeds can lead to temperatures exceeding up to 5,000ºF (Cedillos-Barraza et al., 2016). The intense conditions of hypersonic travel, encountered either in extremely fast travel on Earth or in atmospheric reentry, are challenging to simulate and have limited case studies available. With an increased understanding of hypersonic spacecraft, reusable launch vehicles are able to be designed and produced, which will foster increased and cheaper space travel. Cost of launch and lack of reusability in spacecraft are major barriers to space travel, and decreasing this barrier allows a greater expansion into space. With this evolution into space, there comes technological development and improvement in the systems and technology available on earth. The original space race in the 1960's and future space programs are the reason for many technological innovations used in modern society (https://www.jpl.nasa.gov, n.d.). Some of the next goals in space innovation are the colonization of the moon and mars. These goals are viewed as wasteful by some, with no benefit to life on earth. The STS research section will explore how space colonization is not a reason to abandon earth, but in fact a proving ground for technologies that will aid the wellbeing of people and the environment on earth. The lack of available information regarding hypersonic travel for modeling, and the implications of increased space travel on future colonization are the topics that will be discussed.

Capstone

In 2019, the spacecraft design course at the University of Virginia sent a CubeSat, Libertas, to orbit on a rideshare with an Antares rocket provided by Northrop-Grumman. Contact was successfully made with the satellite until a firmware fault in the radio component of the craft made further communication impossible (Goyne, 2022). Despite this, the mission was considered a partial success and served as the first step to develop research using CubeSats. The next mission currently being considered is the HEDGE: Hypersonic Re-Entry Deployable Glider Experiment which is a concept for low-cost hypersonic flight research using the CubeSat form factor.

The primary goal of the mission is to collect data about hypersonic re-entry conditions before burning up in the atmosphere (Angeliotti et al.). After natural orbit decay, HEDGE will re-enter the atmosphere at hypersonic velocity and send telemetry to the ground. A Structures and Integration (S&I) team plans the assembly of a spacecraft, ensuring that construction is feasible and that the final design will be able to integrate with the launch vehicle (Caldwell, 2021a and Caldwell 2021b). The S&I team will also focus on the structural design of the craft for aerodynamic stability and material selection, addressing the balance between having the craft survive long enough to collect meaningful data and being able to burn up in the atmosphere for safety.

The team has developed a series of methods to ensure that the structure meets the design goals. An important approach that we are taking is to delegate specific members for inter-team communication. Our team must work with the power, thermal and environment team to select materials that will allow our vehicle to endure re-entry while preserving the viability of the hardware onboard. It is also critical that our team communicates with the Attitude Determination and Control System (ADACS) team to ensure the vehicle is oriented in the proper direction on re-entry; if the craft fails to enter nose-first, the re-entry structure will no longer be optimal for hypersonic flight, and our project would not be a success. Our team will also need to be in contact with the communications and avionics team to determine the arrangement of hardware on the vehicle, as shown in figure 1. It is important that all necessary hardware be on the vehicle, despite the 10cm x 10cm x 10cm size restriction for CubeSats (Loff, 2015). To accomplish this goal, team members will be assigned to be designated liaisons to the other subsystem teams. Another approach that our team has taken on is to use finite element analysis (FEA) software and computational fluid dynamics (CFD) software to verify the structure proposed by the previous year's team, as shown in figure 2, which is critical for reducing risk during spacecraft development (Blandino et al. 2018). We will also be using Ansys Granta software to determine which materials are best for our design, taking into consideration cost, strength, temperature resistance, machinability, and commercial availability.

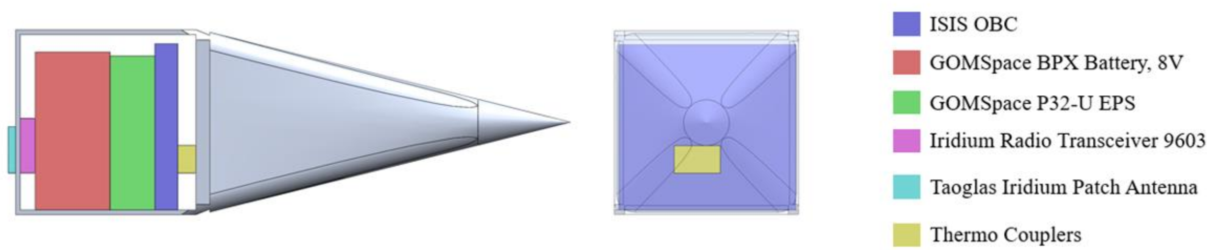

Figure 1: Approximate volume distribution of HEDGE components (Angeliotti et al., 2022)

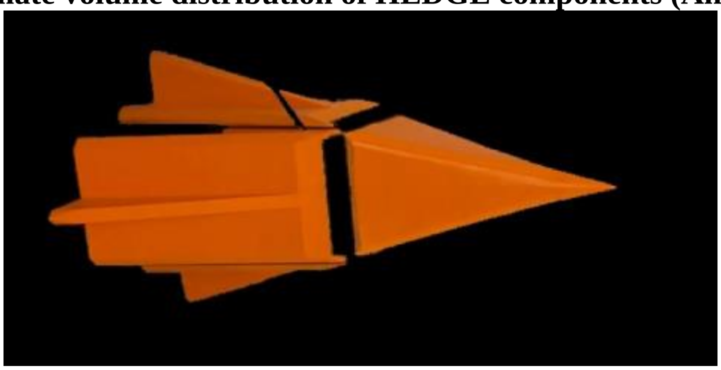

Figure 2: Mockup of HEDGE fins deployed in re-entry configuration (Goyne, 2022)

In the design and construction of the HEDGE spacecraft, the group will have access to the UVA Engineering Rapid Prototyping Lab and Mechanical Engineering Machine Shop, which will allow for quick and inexpensive fitment testing and design reviews. We will also have access to UVA Engineering Faculty, including our technical advisor Prof. Chris Goyne, among other subject matter experts (SME) who have experience in mission planning, structural analysis, and materials design.

The deliverable for the Fall semester will be a preliminary design review. This will be followed by a critical design review and a proposal to industry for the funding to build and launch the spacecraft in the spring semester.

STS Topic

As technological innovation continues, the reality of colonizing other celestial bodies within the solar system draws closer to reality. SpaceX's starship, is designed as a reusable craft capable of transporting large amounts of people and cargo to the moon and mars (*SpaceX*, n.d.). There are many facets to the current space industry, from short term satellite launches to long term plans of colonizing the moon and mars. Focusing on space colonization, there is a public perception that colonizing other planets is a short-term cop out in order to avoid the problems on Earth. The topic of the research paper will focus on colonization of other planets, and how it is not necessarily a way to avoid problems on earth, and how the technology produced through the crucible of colonizing another celestial body can bring new technology and improvements to the people on Earth (King, 2017). The space race provided many parts of modern technology (NASA, 2016), which serves as a historical precedent that further space exploration can lead to greater technological advancements. The research question is: "How can humans colonize other celestial bodies while leading to improvements in the conditions on Earth?" With the intention of the exploring the public perception of space colonization, and whether or not another expansion into space may aid in life on earth.

The research question will be examined using the Wicked Problem Framework (WPF). The WPF was created by Horst Rittel and Melvlin M. Webber in 1973, and is being used since it is suited to analyze large problems without a clear solution that is not universally agreeable (**cite**). This framework is suited for the research question since it involves analyzing the problem of quality of life on earth and the potential avenues of space colonization; both of which have no clear nor direct solutions. However, it is worth noting that some critiques of WPF state that "The wicked problems idea is flawed because it is poorly conceived and disconnected from its historical context, and thus stretched beyond conceptual coherence." (Turnbull & Hoppe, 2019). Therefore, the authors claim, using this framework is misguided and any policy research that is based upon WPF is "ill-equipped to support [the policy]" (Turnbull & Hoppe, 2019). The authors argue to reject WPF and transition back to a general framework for any problem, rather than one that implies the issue is unsolvable. With these critiques in consideration, the WPF is still the best method to analyze the research question when taking into consideration that just because the problem cannot be "solved," does not mean it is futile to work towards.

Methodologies

Research Question: How can humans colonize other celestial bodies while leading to improvements in the conditions on Earth?

To answer the research question, I will be using documentary research methods, case studies, and discourse analysis. Beginning with background, I will give the context of the past space programs and the technologies that were developed because of them, as well as opinion pieces to show the public perception of space colonization. To analyze the impact of past developments case studies looking at the influence of those technologies will be collected for evidence. These documents will be gathered using keywords focused on "Martian/lunar colonization," "technology," and "public opinion." These keywords have been chosen since they will focus on the technology involved in space colonization and to discover the current public opinion on it. Documentary research methods, case studies, and discourse analysis have been chosen to support the research question since they will provide the necessary background and scholarly discussions pieces in order to fully analyze the topic.

Conclusion

This paper covers an investigation of hypersonic test platforms and analysis as well as the global impact of advancing technologies centered on space colonization. The Structures and Integration team will work to develop a finalized design of HEDGE to be presented at the critical design review for HEDGE by the end of the spring semester, along with the proposal to industry to have it be funded for construction and testing. If HEDGE is accepted, then the testing will work to develop experimental results in hypersonic flight that can then be used in further design. With the expanding technologies, this paper will explore the global impacts of space colonization, and whether or not it will produce beneficial technologies that will aid in the quality of life on Earth. By researching the impact of space colonization, it can then be determined if the pursuit is one that is avoiding the problems on earth, or a method to help solve the issues faced today.

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