Hoo-Rizon 1: Subscale Sounding Rocket

Global Collaboration in Space Technology

A Thesis Prospectus
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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

High powered rocket development has become a crucial piece of the present day aerospace industry. Access to the technology is more widespread than ever, as private industry, public agencies such as NASA, and even amateurs are creating and launching rockets of various sizes and purposes. While rocket technology, and more broadly space technology, is a field that continues to grow in the United States, it is of utmost importance for the nation to remain on the cutting edge. The Office of the Under Secretary of Defense for Research and Engineering has identified space technology as a critical technology area that will require continuing commercial viability to maintain national security (Under Secretary of Defense Research and Engineering, 2022). A problem the nation is faced with is how to incorporate the next generation of engineers into this sector while doing so in a way that is feasible and cost effective.

A solution to this problem is the further use of sounding rocket technology at universities through implementation in coursework and student organizations . Rocketry is often seen solely as a means to get people and things into space, but it has become a crucial part of the scientific process. Scientific data is the lifeblood of the scientific method, and experiments which yield no usable data are better off never being performed. As technology advances, more and more methods for collecting data emerge. The sounding rocket is a great example of this. Since the 1950's, sounding rockets have been used to support meteorological and lower atmosphere research through data collection. Rockets are launched into lower orbits for short missions of around 13 minutes to collect or 'sound' various types of data that can be applied to a variety of disciplines. Missions are typically low cost and allow the payload to be prepared and launched on a much shorter timeline (European Space Agency, 2014). Based on its affordability and direct scientific impact, sounding rocket technology has the potential to be explored and implemented across the nation’s many engineering universities. This technical project focuses on developing a subscale sounding rocket mission to collect critical atmospheric data and will consist of research, design, fabrication, and a culminating launch. The end goal is for this project to act as a framework for future sounding rocket missions at the University of Virginia and beyond so that undergraduate engineers can begin contributing to the growth of space technology in a meaningful and affordable way.

Designing a Subscale Sounding Rocket

The primary objective of the technical portion of the capstone is to design and launch a sounding rocket to a height of around 3000 feet to collect atmospheric data such as altitude, temperature, pressure, and ultraviolet levels. Sounding rockets typically travel into the atmosphere at a parabolic trajectory at lower speeds than typical long duration missions. The technology can be used to reach parts of the atmosphere that satellites cannot. Additionally, they do not need the typical expensive boosters or tracking technology of long range rockets and can share resources between missions (NASA, 2023b). With this in mind, an important goal for this particular project is to make sure that low cost and recovery are accomplished. Staying within the $2800 student budget while also designing the rocket to be recoverable via a parachute will be paramount to the success of the project.

This particular project will be carried out in a similar manner to typical sounding rocket missions. Design decisions will be made regarding the aerobody (the physical rocket design itself), avionics (the electronics and sensors), and propulsion (engine) systems before fabrication and launch. Considerations will need to be made regarding stability as the rocket approaches apogee (maximum height) and how to manage mass for the eventual parachute deployment.

OpenRocket software will be used throughout the design process for visualization of the rocket itself (see Figure 1).

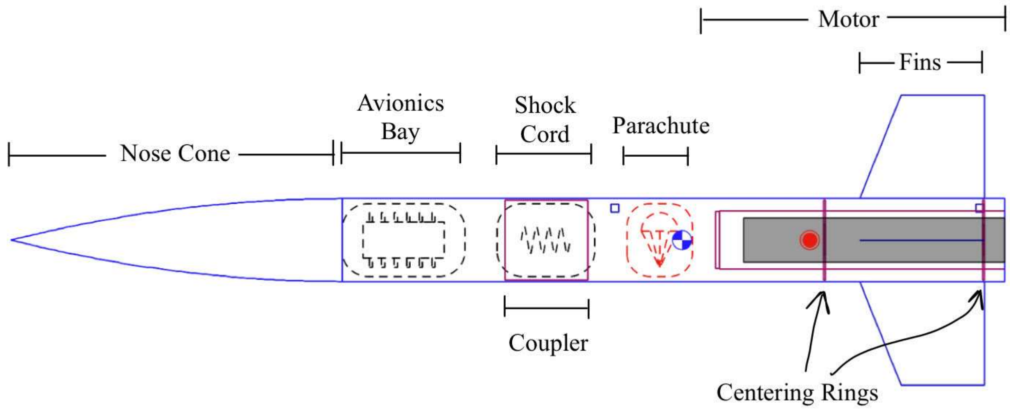

Figure 1. OpenRocket model of Hoo-Rizon 1.

One key difference between this project and many commercial ones is the emphasis on 3-D printed components. Components such as the fins and nose cone, which control the dynamics of the flight, and the avionics bay, which houses all necessary sensors for sounding, will be designed and fabricated using 3-D printing technology. This will help keep the team on budget while also creating a more sustainable design that allows for design flexibility. Additionally, an off-the-shelf motor will be purchased to maximize the opportunity to complete the launch. This was done since student-designed motors often do not end up feasible at launch due to their complicated and somewhat dangerous nature.

Some of the design constraints come from the Tripoli Central Virginia Flight Requirements, as the final launch is expected to take place here. Strict guidelines are in place, but they exist to keep all participants and the public safe (Tripoli Central Virginia, 2023). One important consideration being made is the use of redundant systems. These are essentially duplicate systems that allow for successful rocket functionality even if a particular subsystem fails (NASA JPL, 2009). This rocket will feature multiple redundant systems, including the utilization of a second altimeter to collect altitude and velocity data should the primary one fail. This will further contribute to a successful launch by creating more certainty that key data will be collected.

STS Research Topic: Global Collaboration in Space Technology

Missions that utilize space technology are often affected by international affairs and geopolitics. Specifically, the relationships between the United States, Russia, and more recently China have become the key dynamics in the global space technology sphere. For nearly 50 years following the end of World War II, the United States and Russia fought for military, political, and technological supremacy. This led to the inception of rocket technology in both countries as a means of creating military missiles. Eventually, the primary goal of the technology evolved from defense to space exploration, and the space race was born (National Air and Space Museum, 2023). While China was not a key party in this initial space race that culminated in the 1960's, China would become a key player later on. In 2003, China joined the U.S. and Russia as the 3 three countries to send manned rockets into space, and the country has seen more milestones over the past two decades, including multiple lunar orbiters and an unmanned probe to mars. (Reuters, 2020). Competition in space exploration between these three nations has significant implications for international relations, national security, and the advancement of technology. Space is becoming a new frontier for geopolitical rivalry (Zanidis, 2023).

While these nations are often associated with having tumultuous relationships with each other when it comes to space and space technology, meaningful collaboration still exists. The most prominent example of this evolution is the International Space Station, or ISS. Beginning construction in 1998, the ISS has served to advance science and global collaboration through the carrying out of scientific research and experimentation in space. The U.S., Russia, and China continue to collaborate on the space station to this day (NASA*,* 2023a). Global collaboration on the ISS can lead to enhanced research outcomes, faster experimental completion times, and shared research, (Hasbrook et al., 2017). It can also serve as a form of international diplomacy between China, Russia, and the U.S. where the scientific collaboration is very strong despite geopolitical tensions (Mauduit, 2017).

In order to analyze this dynamic, I will be using the Social Construction of Technology framework from Bijker and Pinch. The essence of this whole framework is that technology is not just a product of scientific knowledge, but rather it is the manifestation of both science and the interactions between different people groups. The particular success of a technology is determined by how it fits and functions within a social context, not by the inherent value possessed by a technology (Pinch & Bijker, 1987). This framework is appropriate for analyzing how international affairs has affected and will continue to affect space technology missions since it will allow for the study of various social groups, such as the citizens and governments of involved nations.

Additionally, Lee Humphreys' work on social groups and closure will also contribute to the STS analysis. Humphreys points out how social groups contribute to social closure, which is an idea that individual technologies can reach a point where their general structure and outcomes are normalized and socially accepted (Humphreys, 2005). This will be critical for the case of international mission collaboration, as space technology has not reached closure on this front. It is constantly evolving, changing, and bringing in new social actors, and this is important to study further.

Research Question and Methodology

While international collaboration is so important to the success of many present day space technology endeavors, there is not a clear framework in the United States to engage in international collaboration. The NASA Office of Inspector General highlights international collaboration as essential for the Artemis lunar program, but cites that NASA currently lacks a comprehensive strategy to manage international partnerships (NASA Office of Inspector General, 2023). On an international level, this problem also exists. Audrey Schaffer in *Acta Astronautica* highlights the lack of formalized international collaboration mechanisms for space exploration and argues that the informal collaborations since the 2006-2007 Global Exploration Strategy (GES) should be formalized (Schaffer, 2008).

Further research into this area is to be performed to find an answer to the following question: Can an international collaboration framework be established, and how? Case study analysis will be used to accomplish this by focusing on the International Space Station as an example of international collaboration, particularly in the post-GES era since 2006. I will look into how working groups at organizations such as the United Nations and European Union have approached how to handle ISS international relations and examine various policy briefs or publications that have come out of these efforts. I will also look into various ISS missions reports and observe how international collaboration played a role in their success. In both of these, I will look for successful mechanisms that can contribute to the formation of a framework. In addition to the ISS case study, I will reference the Schaffer work from above to inspire more research into the GES and similar efforts to see what elements can be taken from these and applied to a present-day framework.

Conclusion

As space technology continues to grow globally, it is important for the United States to remain a global leader on this front. This capstone project will serve as a way to advance this goal in two distinct ways. The first of these is through the carrying out of the technical project, the subscale sounding rocket. Through designing and launching this rocket, a framework will be introduced that can be used nationwide to prepare the next generation of innovators to interact meaningfully with space technology. The second way is through the STS research project, where through case study analysis I will seek to find out how an international collaboration framework can be created to make sure efforts such as the ISS can continue to grow and succeed in their societal contexts regardless of the geopolitical state they exist in.

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