Thesis Project Portfolio

HEDGE: Hypersonic ReEntry Deployable Glider Experiment

(Technical Report)

Souvenirs from the Stars: Examining International Political Impacts of Space Mining

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring, 2022

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Sociotechnical Synthesis

Introduction

Since the conclusion of the Space Race in the 20th century, possibilities and capabilities revolving around spaceflight have grown substantially. Among novel 21st century concepts of space travel, development and utilization of both small-scale, affordable satellite – or "CubeSat" - and extraterrestrial resource collection – or "space mining" - technology are highly promising concepts. This portfolio will offer an examination of both concepts, including firstly a technical report and proposal to several government agencies for a CubeSat based hypersonic flight experiment and secondly a science, technology, and society (STS) based examination of the impacts of space mining systems. In a broad sense, these technological concepts are obviously related in that they will be utilized in the environment of outer space. However, CubeSats and space mining technologies are more deeply related than just their environment of application. Specifically, both technologies are in their relative infancy of development and real-world application. In regards to space mining technology, no materials have been brought back to earth as of today other than small samples for research purposes. While CubeSats have been utilized in outer space missions before, they are presently in the process of being used with higher frequency in both research and commercial avenues. In general, the relative newness of both technologies offers a unique opportunity for the development of informed opinions and research on their future applications. Furthermore, CubeSats and space mining technology also have the potential to intertwine in their applications. Although a space mining system would need to be magnitudes larger than a single CubeSat, the small spacecraft have the potential to aid in space mining missions through applications such as prospecting for resources on celestial bodies before any mining takes place.

Technical Report Summary

The technical portion of this portfolio includes a proposal intended for the National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD) regarding usage of a three-unit (3U) CubeSat for hypersonic flight testing in the upper atmosphere. This CubeSat payload will be deployed from a third-party rocket launch (likely Northrop Grumman's *Antares* rocket) within the next several years and enter an extremely low earth orbit (ELEO), secondarily deploying an aerodynamically-shaped hypersonic glider experiment. This low orbit will decay over the course of approximately one week, at which time the glider will enter the atmosphere traveling at hypersonic speed, or five times the speed of sound, and transmit data such as position, temperature, and pressure values before burning up completely. Overall, the motivation for this project is to demonstrate the capability of both university students and CubeSat technology to produce a successful hypersonic experiment. Presently, hypersonic flight conditions are difficult to replicate in wind tunnels and expensive to achieve on rockets and aircrafts. By using a CubeSat, university students may be able to conduct hypersonic experiments at a much lower cost, and with greater accessibility.

STS Research Summary

The STS portion of this portfolio examines extraterrestrial resource collection, which is the process of collecting materials from nearby celestial bodies such as the moon, asteroids, and meteors for usage on earth or in outer space. This emerging practice threatens to disrupt a number of present-day societal processes and relationships. Collecting resources from new sources, both those common to earth and unique to outer space, inevitably has the potential to impact current societal resource utilization practices. Additionally, previous international treaties have established barriers against claiming materials in outer space, likely to strain international

governmental discourse as space mining systems are implemented. The objective of this research is to investigate both the relation between space mining applications and present-day resource practices it is poised to disrupt, along with an examination of several inherent international political impacts of space mining systems. The science, technology and society frameworks of *technological fix* and *political technologies* are used to support the investigation of each aspect of this research, respectively. The results of this research provide an ethics- and practicality-based comparison between space mining and comparable practices on earth. Additionally, this research highlights international political impacts of space mining technology, along with current undertakings aimed to address these impacts. Overall, this research serves to provide both a source of background information and realistic societal perspectives of an important and impactful near-future technological system.

Conclusion and Reflections

As a whole, conducting research on both a CubeSat-based hypersonic flight mission and space mining systems simultaneously has been a valuable experience. Design and development of spacefaring systems is a complex and intricate process, with a large number of aspects to be considered technologically. The same can be said, however, in regards to ethical considerations and implications. The development of this portfolio has involved detailed research into both of these areas of space technology: ethical and technological. Researching both of these topics simultaneously has provided a deeper understanding of the logistical aspects of spaceflight as well as the societal impacts independently. Additionally, construction of this portfolio has also granted a greater understanding of how technology and ethics interact and intertwine in regards to planning and conduction of outer space missions. Whether a small 3U CubeSat or a massive

mining ship, a successful mission in outer space demands equal attention to both technology and ethics, as well as how one can potentially affect the other.