Student Researched and Developed High Power Rocket

Sustainability in a Commercial Space Race

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

One of the most fascinating and technically difficult achievements in human history is the conquest of space. Since commercialization, this field was once the province of government agencies but has recently seen a surge of private organizations seeking to reach the highest levels of success. The space sector has welcomed various commercial actors that have driven a more business oriented approach (Iacomino, 2019) This change has sparked a renewed interest in space exploration among humans and brought with it several difficult socio-technical issues, such as environmental sustainability as space traffic increases. The aspect of this dynamic is exhibited by the Capstone project I'm currently working on, which involves the design and construction of a rocket.

Concurrently, my STS work addresses the complex problem of sustainability in the face of space commerce. The central question of this investigation is how can we maintain/promote sustainability amid increased exploration due to privatization/commercialization. The increasing frequency of private launches has implications not only for the sky above but also for the terrestrial ecosystems below. Launches of rockets leave carbon imprints, produce substances that deplete the ozone layer and may leave debris in space and our atmosphere (Wishwakarma, 2023). The importance of these issues increases with the number and scope of private space initiatives, requiring a discussion on sustainable methods. The dual nature of progress and responsibility in aerospace engineering is reflected in the interconnectedness of the technical and socio-technical aspects. The rocket project presents an opportunity to assess and apply sustainable practices as a microcosm of the broader commercial space industry. Using this perspective, the project can support a responsible exploration model in which every launch serves as a case study for reducing environmental effects while maximizing scientific and technological output.

One of the core ideas of my capstone project and STS research is sustainable exploration, or, at the very least, the efficient use of resources. This convergence point emphasizes the need for technological advancements toward space to be in accordance with ideas regarding ecological awareness on Earth. As future scientists and engineers, it is our responsibility to design not just for functionality but also for the preservation of the environment on Earth. By pursuing these two goals simultaneously, the growing space industry can be steered toward a time when sustainability and exploration are not mutually exclusive but have become ingrained in spacefaring societies' culture. This STS research proposes a framework within which such endeavors can be pursued responsibly, even as my capstone project aims to exercise the technical prowess required to reach the high frontier. The overlap of these subjects is representative of the larger problem of sustainable innovation that aerospace engineering faces. To make sure that our mission to discover new worlds does not come at the expense of the one we already live in, we must recognize and confront this dual imperative.

Technical Topic Section

The central focus of our Spacecraft Design capstone project is the design and construction of a rocket. The rocket we are constructing will be approximately 6-9 feet tall, with an intended apogee of around 4000 feet. There will also be a payload housed within the rocket near the nose. The rocket is meticulously designed and constructed to satisfy various parameters and requirements. The engine of the vehicle is its propulsion system. An efficient propulsion system is light and compact while having the necessary force output to meet the intended target (Rai, 2006). The rocket's body, or airframe, is going to be constructed with the use of material that bolsters adequate strength-to-weight ratio for inner atmospheric flight. This design enables our rocket to endure the demanding pressures directly from the propulsion system, as well as the

pressures imposed by aerodynamic forces during flight. The optimization of both the propulsion system and the aerodynamic structure is an obvious design objective to increase the efficiency of resource usage. Our project's control systems are vital for functionality, an aspect of the endeavor headed by our mechatronics team. Adjusting for factors like wind and air pressure, this network of systems and onboard computers ensures that the rocket stays on its intended course and that the intended breakup of the body is properly executed. A nod to sustainability, the recovery system is equally important. It aims to safely bring the rocket back to Earth's surface for analysis and reuse. This will be executed by the deployment of a series of chutes for the different sections of the rocket.

The group will face several technical obstacles during the project. We must precisely determine the rocket's center of mass and center of pressure in order to guarantee stability during flight. We must create an effective and dependable engine to get the rocket to its intended apogee. All of this has to be done within the bounds of safety, legal compliance, and financial constraints. We are learning how to do so while keeping economic and environmental factors in mind. To maintain sustainability, it is imperative to create a technology-driven approach while navigating challenges with effective usage always in mind (Wishwakarma, 2023).

The commercialization of space, an emerging industry with enormous potential for both discovery and disruption, provides a backdrop for this technical undertaking. There has been increased opportunity for commercial actors to play a more pivotal role, and the overall space sector has become more business-oriented in certain respects (Iacomino, 2019). The consequences for the planet's environment grow in importance as more private businesses join the space race. There are environmental effects from rocket launches, the chemicals they release, and the debris they leave behind that need to be considered. Within this larger context, our

capstone project acts as a microcosm where we can investigate the dynamic between environmental consciousness and technological advancement. Our goal in comprehending and addressing these intricate relationships is to provide a working rocket and a valuable understanding of the responsible advancement of the rocketry field.

STS Topic Section

As we prepare for a new era of space exploration largely funded by the private sector, an important socio-technical question emerges: How can we maintain and advance sustainability in the face of the increased space exploration brought on by privatization and commercialization? The implications of increased private launches for the environment emphasize how crucial this issue is. The turn toward space commerce, as demonstrated by organizations like SpaceX, Blue Origin, and others, signifies a dramatic change in the environment surrounding space exploration (Genta, 2014). This change brings with it several environmental issues in addition to speeding up innovation and cutting costs. Nevertheless, there still exists a connection with the government and political facets of space exploration that must also be addressed. Endeavors in space exploration are heavily facilitated not only when it's relevant to societal needs but also when the potential benefits are worth the cost (Vedda, 2008). The growing issue of space debris, the possibility of ozone layer depletion, and the carbon footprint of rocket launches are all signs of a rapidly expanding industry surpassing the systems intended to sustain it.

A multimodal approach involving scientific journals, literature reviews, and environmental impact data analysis will be used to analyze this topic. The study will look at past data to track the development of commercial space activities and their effects on the environment, as well as present laws and industry norms. It will also investigate new developments in technology and legislation that are meant to allay these worries. Evidence will

be gathered from a variety of sources, such as business reports, academic journals, environmental impact assessments, and international space policy documents. The research aims to create a thorough picture of the current sustainability status in commercial space exploration by gathering and combining data from various sources.

The concept of Actor-Network Theory (ANT), will also be used in this study to better understand the intricate relationships between the many parties involved in the commercial space sector, such as corporations, governments, international organizations, environmental groups, and the technology itself. The goal of this research's output is to support sustainable practices that guarantee space will be a resource for future generations and to add to the critical conversation about space stewardship. The interpretations derived from the gathered data aim to offer practical insights that may influence public awareness campaigns, industry standards, and policy choices. This STS research aims to shed light on the current issues and suggest strategies for a more sustainable interaction with the final frontier.

Conclusion

The central topic is the commercialization of space. More specifically, it explores how society can preserve sustainability in an environment of increased space endeavors due to the privatization and commercialization of the space sector. The prevalence of private launches and exploration presents substantial environmental implications. We must maintain and continue to promote a sustainable approach when navigating a field that requires large-scale resource usage for various endeavors. The quantity and scope of private space initiatives raise the significance of these issues, necessitating a discussion of sustainable solutions. This research paper aims to produce relevant data and analysis to further the understanding of a new age in space exploration and its interconnectedness with society, with an emphasis on environmental implications.

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