Undergraduate Thesis Prospectus

Sustainable Capture of Hypersonic Flight Conditions

(technical research project in Mechanical Engineering)

Gold and Glory: 21st-Century U.S. Space Exploration

(sociotechnical research project)

by

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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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General Research Problem

How may human spaceflight capacities be expanded?

Since 1972, human spaceflight has been confined to low earth orbit. From 2011 to 2020, U.S. astronauts reached space only in Soyuz spacecraft launched from Russia. Human spaceflight is notoriously expensive. According to Tenner (2004), "the energy needed to lift a person out of Earth's gravitational well would feed him for a lifetime." To some, U.S. human space missions of the 21st century instill "not pride but embarrassment, not power but dissipation;" the U.S. has apparently been "wasting precious resources on stunts with no practical payoff" (Tenner, 2004). Louis Friedman, who cofounded The Planetary Society with Carl Sagan and Bruce Murray, has remarked that "in the 40 years since the end of the Apollo program, we have not even reached farther into space than the distance from Los Angeles to San Francisco" (Friedman 2015). Since 2011, the year of the last space shuttle mission, political support for expensive human spaceflight projects has been meagre.

John Logsdon, founder of the Space Policy Institute at George Washington University, credits human spaceflight with "delivering scientific payoffs, generating economic benefits, developing new technology, [and] motivating students to study science and engineering" (Logsdon, 2004). Friedman (2015) contends that threats "such as asteroid impact, large-scale conflict and war, pandemics, global climate change, and other types of environmental destruction" necessitate responses that may entail human spaceflight. To its advocates, human spaceflight is one of many capacities that must be developed if humanity is to manage the existential threats Friedman enumerates.

Sustainable Capture of Hypersonic Flight Conditions

How may a CubeSat be adapted to serve as a testbed for hypersonic glider evaluation?

Hypersonic flight occurs at speeds exceeding five times the speed of sound and is an expanding research field in the aerospace industry with military and civil applications. Military applications include hypersonic missiles, both offensive and defensive, and high-speed aircraft. Civil applications include access to space and commercial air travel. A CubeSat is a small satellite flown in low earth orbit that is well suited for undergraduate education. As CubeSats orbit Earth, they fly at hypersonic speeds and re-enter the atmosphere in around five to seven days if launched into Extreme Low Earth Orbit (ELEO) (Panwar and Kennewell, 1999).

This technical project will assess the capability of a CubeSat to house a hypersonic glider flight experiment. These experiments 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 these experiments at a lower cost, and with greater accessibility. The following discusses a mission proposal for a hypersonic glider CubeSat and outlines the significance, objectives, and anticipated outcomes for the mission.

Objective of the Research Work

As previously described, the aim of this research work is to perform a hypersonic experiment using a test article deployed from a CubeSat in Extreme Low Earth Orbit (ELEO). As can be seen in Table 1, this goal has been discretized into three primary objectives, which are motivated by a combination of technical and educational considerations. These have been further subdivided into supporting objectives intended to facilitate the completion of these larger goals.

Table 1. Labeled Research Objectives

O1	**Demonstrate the feasibility of CubeSats as a platform for hypersonic glider flight research.**
1.1	Design a CubeSat-based system that can survive the environment of launch and insertion into extreme low earth orbit (ELEO)
1.2	Deploy gliding hypersonic test article from the system
1.3	Maintain stable flight at hypersonic speed for maximum possible duration
1.4	Collect/transmit mission data from test article during hypersonic flight
1.5	Prevent any large fragments from reaching Earth's surface
O2	**Show that undergraduate students can conduct hypersonic glider flight experiments at lower cost and with greater accessibility.**
2.1	Minimize cost by using commercially sourced components and a student workforce
2.2	Deploy a successful experiment designed by undergraduate researchers
O3	**Provide an opportunity for undergraduates to gain hands-on experience and generate interest in the spaceflight industry.**

Anticipated Outcomes

Secured government funding and sponsors (UVA, NASA, etc.) will enable the construction of a CubeSat. By demonstrating the feasibility of CubeSats as a platform for hypersonic glider flight, this project will introduce a new method for conducting low-cost hypersonics research in conditions unachievable on the ground. The project will rely on several mission-critical events occurring: the successful deployment of the CubeSat and hypersonic glider, the stability of the glider during flight, and data being relayed during reentry. The collected flight data will be transmitted to partner organizations.

Drafting for the funding proposal, designing the CubeSat and deployable glider, and working with government organizations will result in an optimal learning environment for all undergraduate students involved. Such an environment, which requires substantial writing, design, and communication skills will lead to increased knowledge and improved abilities of participating students. Professional relationships will be established with University of Virginia faculty and government organizations for future collaboration. Additionally, through demonstrating undergraduate students' capabilities of conducting these experiments, it is hoped that prospective students take ongoing interest in future aerospace research.

Gold and Glory: 21st-Century U.S. Space Exploration

How have advocates of space exploration promoted their agendas in the 21st century U.S.?

Spaceflight in the U.S. has largely been restricted to the public sector since its inception. Human spaceflight, prior to the 21st century, has only occurred in the public domain. Today, however, private companies compete for prestige and economic profit (Censer, 2016). Among a representative sample of companies engaged in space enterprises, 30 of 36 were founded in the 2000s (Weinzierl, 2018). The commercialization of space has important implications for the future of human spaceflight (Valentine, 2012; Weinzierl, 2018).

Researchers have investigated the social factors that have influenced spaceflight. In a study of the Reagan administration's space commercialization policies, Levine (1985) found they worked to accelerate "the day when competition and deregulation will be the hallmarks of civilian operations in space." Kappel and Holmen (2019) contend that science communicators are important influences on public opinion. Weinzierl (2018) examines the growth of space

companies and the decentralizing effects of public-private partnerships called Commercial Orbital Transportation Services (COTS).

Advocates of spaceflight include idealists who invoke science, civilization, and species survival. Science communicator Neil deGrasse Tyson contends that scientific literacy is essential to "the kind of democracy you want to live in where people vote from an informed platform knowing the difference between something that is their opinion and something that is a fact" (Science Network, 2011). Science communication, Tyson argues, can then be "in the service of civilization" (StarTalk, 2017), leading to a better society for all individuals. SpaceX founder Elon Musk argues that for humanity, "there are really two fundamental paths… One path is we stay on Earth forever, and then there will be some eventual extinction event… the alternative is to become a space-bearing civilization and a multi-planetary species, which… is the right way to go" (Musk, 2017).

Through their work, academic scientists contribute to such ideals, but they are seldom driven by them. The Pew Research Center asked working Ph.D. scientists in 2014: "What were the one or two most significant experiences influencing your decision to become a scientist?" (Pew, 2016). Only 8% responded in the category, "to make a difference, contribute to society" (Pew, 2016). A plurality of the answers was in the category "an intellectual challenge, lifelong curiosity, love of science or nature" (Pew, 2016). Steele and Rickards (2021) argue that academics are "targets for and enablers of change," exemplifying "the sort of approaches and impacts they want to engender." Wilkinson (1994) adds that universities "have been forces for progress since their formation," serving "as sanctuary for cultivating the creative imagination" and as "a provocateur of new aesthetics, beliefs, and codes of conduct."

Space enterprises, advocates of human spaceflight, and their critics strive to influence national space policy, through elected officials and the National Aeronautics and Space Administration (NASA). NASA is an independent agency responsible for the civilian space program. NASA promotes U.S. aerospace enterprises and claims it seeks to "discover and expand knowledge for the benefit of humanity" (Blodgett, 2018). Elected officials sometimes respond to participants' demand for greater national spaceflight capacities. For example, Presidents Obama and Trump both favored ambitious manned space missions (Wang, 2017). According to a *Wall Street Journal Reporter*, the Trump administration favored projects that could "attract widespread voter support" and that were achievable in his initial term (Pasztor, 2017).

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