HEDGE
Hypersonic ReEntry Deployable Glider Experiment
(Technical Paper)

Impacts on U.S.-China Global Relations Due to Space Technology and Exploration
(STS Paper)

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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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Introduction

The United States and China have one of the world's most complex and important bilateral relationships. Since 1949, the countries have experienced periods of both tension and cooperation over issues including climate change, Taiwan, and trade (CFR.org Editors, 2017). Looking more closely at recent years, the United States and China have had political tensions that have been exacerbated by major events such as the trade war. The U.S.-China trade war began in July 2018, when the U.S. imposed a 25 per cent tariff on $34 billion USD of imports from China, including cars, hard disks, and aircraft parts (SCMP Reporters, 2020). China quickly retaliated to these tariffs with tariffs of their own, impacting agricultural products like soybeans, automobiles, and aquatic products. Both sides continued to impose more and more tariffs, as if it were a game of tug of war, until a phase one trade deal was signed in January 2020. As part of the trade deal, China agreed to buy an additional $200 billion USD of U.S. products over the next two years and resulted in the suspension of more planned tariffs on Chinese products (SCMP Reporters, 2020). As of 2022, these countries are currently the world's largest and second largest economies and have mutual political, economic, and security interests such as the non-proliferation of nuclear weapons (Silver, 2022).

One specific sector that these countries are interested in is the space technology and exploration power held by both countries. Both countries have been working on massive space projects that will expand their possibilities in outer space and show the prowess of their space technology. The United States will soon be launching the Artemis I space mission, which is the first in a series of increasingly complex space missions that will enable human exploration to the Moon and Mars. The Artemis II mission is the first scheduled crewed mission of the Orion spacecraft, which will be the first crewed spacecraft to travel beyond low Earth orbit since

Apollo 17 in 1972 (Foust, 2021). Finally, the Artemis III mission will land a crew at the Moon's south polar region and is planned to have two astronauts on the surface of the Moon for about one week (Chang, 2019). With the Artemis missions, NASA will land the first woman and the first person of color on the Moon, using innovative technologies to explore the lunar surface like never before (*NASA: Artemis*, n.d.). NASA is going back to the Moon for scientific benefits, economic benefits, and inspiration to maintain American leadership in space exploration and establish the first long-term presence on the Moon. Research conducted in outer space promotes scientific inquiry and can result in beneficial spinoff technologies such as advancements in medicine and technology and improvements in automobile safety testing. A study from NASA reported that their Moon to Mars exploration missions have supported more than 93,700 jobs nationwide and generated more than $20.1 billion in total economic output (Dodson, 2022).

Meanwhile, China has been constructing the Tiangong space station, which means the 'Heavenly Palace' in Mandarin and is a permanent Chinese space station that will widen China's prospects in outer space (Reuters, 2021). The Tiangong is made of three key modules that will combine to form the main structure of the space station. The first module, Tianhe or 'Harmony of the Heavens', was sent into orbit in April 2021 and contained the living quarters for crew members. The second module, Wentian or 'Quest for the Heavens', was launched in July 2022 and is utilized to carry out biological and life science research (Song & Tauschinski, 2022). The third module, Mengtian or 'Dreaming of the Heavens', is planned to be launched by the end of 2022 and will provide a pressurized environment for researchers to conduct science experiments in zero gravity. With these three modules combined, the space station will have its own power, propulsion, life support systems, and living quarters. The station is also designed to provide refueling power to China's new space telescope, called Xuntian, when it flies close to the space station in 2023 (Song & Tauschinski, 2022). The advantages of having a permanent space station include giving China its own platform for conducting research in outer space and strengthening China's "independent innovative capacity" (China Power Team, 2021). By most metrics, which include space mission accomplishments, the U.S. is still the global leader in space exploration, but this could change in coming years due to China rapidly accelerating its space agenda.

These current events are analogous to the Space Race of the Cold War between the United States and the Soviet Union during the 1950s to 1970s. Competition between the Soviet Union and the United States bred many novel scientific achievements within the space exploration field and the same thing is happening today between China and the United States. As one of the most noticeable recent developments, hypersonic systems research in China has made significant breakthroughs that have surpassed the technology of the United States, putting pressure on the United States to put more focus into hypersonic research. It is imperative that we pay attention to hypersonic research advancements of competitive countries because these advancements will impact political relations between the countries and fuel research into major areas of focus such as hypersonic research.

In my technical project, I will be demonstrating the viability of using CubeSats for inexpensive hypersonic flight tests through natural deorbit and reentry. In my STS project, I will be investigating the impacts of space technology and exploration on the global relationship between the United States and China.

Technical Topic

When people think of satellites, they often imagine these large structures that require massive rockets to launch to outer space. However, not all satellites have to be huge, and some can even be classified as miniature size. These small satellites are called CubeSats and are a class of research spacecraft called nanosatellites. CubeSats are normally built to standard dimensions of 10 cm x 10 cm x 10 cm, which is a 1U size (*CubeSats Overview*, n.d.). CubeSats are also mainly used for educational purposes as the idea started as a university education program satellite and are flown as secondary payloads on previously planned launch missions (Novak, A. et al., 2022).

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 (Urzay, 2020). Military applications include hypersonic missiles, both offensive and defensive, and high-speed aircraft. Hypersonic missiles can be split into two categories: hypersonic glide vehicles, which launch from a rocket and glide from there, or hypersonic cruise missiles, which activate a scramjet after reaching supersonic speeds (Crouse, 2022). Civil applications include access to commercial air travel and space. Hypersonic glider flight experiments are difficult to replicate in wind tunnels and are expensive to achieve on rockets and aircrafts. By using a CubeSat, university students can conduct these experiments with greater accessibility and at a lower cost (Angelotti, B. et al., 2022).

For my capstone project, called the Hypersonic ReEntry Deployable Glider Experiment (HEDGE), we are developing a flight vehicle that can be launched by NASA as a CubeSat but can reconfigure itself as a hypersonic flight vehicle for reentry. The purpose of this project is to demonstrate the feasibility of using CubeSats for low-cost, hypersonic flight experiments via natural deorbit and reentry (Goyne, 2022). The systems on HEDGE are divided into five subsystems: (a) communications, (b) software and avionics, (c) power, thermal, and environment, (d) attitude determination and control systems (ADACS) and orbits, and (e) structures and integration. As part of the power, thermal and environment sub-team on HEDGE, it is our job to ensure that all the subsystems on HEDGE are receiving their power needs, that the spacecraft remains intact, and that HEDGE remains within temperature ranges where systems can function. Through succeeding in these tasks, coupled with the success of the other functional teams, HEDGE will serve as a proof of concept for a hypersonic CubeSat and allow for the collection of temperature and pressure data in a hypersonic environment (Dick, D. et al., 2022).

With the CubeSat initiative, NASA supports bridging the strategic knowledge gaps between students and industry professionals and assists in attracting and retaining students in STEM disciplines by providing a holistic educational opportunity (Angelotti, B. et al., 2022). The design of HEDGE connects this accessibility to space for students along with aligning with the hypersonic research goals of NASA. The Department of Defense (DOD) has also shown a growing interest in pursuing the development of hypersonic systems. The DOD has more political support to research advancements in hypersonic missile production due to the high-profile advancements in defense systems by competitive nations such as China (Angelotti, B. et al., 2022). This relates to my STS research topic because hypersonic systems testing in space will impact U.S.-China global relations as both countries are trying to gain the upper hand in defensive technologies.

STS Topic

Advancements in space technologies and exploration could cause major countries that are involved in outer space to compete for national pride and gain the upper hand over the other countries. Political relations can be strained when facing strenuous circumstances such as defense weapons advancement or sending the first human to Mars. Specifically, my STS topic looks at how space technology and exploration have impacted global relations between the United States and China and whether cooperation would help these relations. The United States typically partners with other countries on major projects in outer space because it provides an opportunity for scientists all over the world to conduct research regardless of their own country's space infrastructure (*Beginnings*, n.d.). In fact, the International Space Station includes contributions from 15 different nations. The major partners of the space station are NASA (United States), Roscosmos (Russia), and the European Space Agency. These three partners contribute most of the funding for the space station and other partners include the Japanese Aerospace Exploration Agency (JAXA) and the Canadian Space Agency (CSA) (Howell, 2022). However, the United States cannot partner with China the same way as it can the other countries due to a certain piece of legislation. In 2011, the U.S. Congress passed the Wolf amendment which essentially prohibits any direct cooperation between NASA and its Chinese counterparts, leaving China out of the extensive international cooperation (Gadd, 2021). It is worth noting that the Wolf Amendment does not explicitly state that any cooperation between NASA and its Chinese counterpart is banned, but rather that NASA is banned from using government funds to cooperate with China in the absence of direct Congressional approval. A study conducted by independent consultant Rob Ronci found that the influence of the Wolf amendment has caused the U.S.-China relationship to remain mainly competitive in space exploration activities (Ronci, 2019). This inevitably will lead to the creation of two spheres of influence in the development of space-based infrastructure.

For my STS research, I will be using the social construction of technology (SCOT) theory. The key argument of SCOT is that the study of science and technology should be viewed through the lens of social constructivism (Pinch & Bijker, 1984). SCOT is broken down into mainly two stages with the first stage being interpretative flexibility. In interpretative flexibility, we look at the relevant social groups and how their interpretations of the technology lead to its eventual success. The second stage of SCOT is closure, which can be achieved in two different forms. One is rhetorical closure, defined as when social groups “see” the problem as being solved and do not require the need for alternative designs (Pinch & Bijker, 1984). The other is redefinition of the problem, which is when the technology solves another problem that is more pressing, so the previous concerns are overridden. SCOT holds the notion that those who seek to understand the reasons for acceptance or rejection of a technology should look to the social world. According to SCOT, it is not enough to explain why a certain technology succeeded by defining it as “the best” and that we must analyze how the criteria of being “the best” is defined and what groups and stakeholders participate in defining it (Pinch & Bijker, 1984). SCOT will be used in my research by setting NASA, its Chinese counterpart, and the governments of the U.S. and China as the relevant social groups. The framework will analyze how these social groups view the political effects of space exploration missions and how these social groups will achieve closure either by cooperating in space exploration or by attempting to cooperate and then stopping because it was against both countries’ interests.

Research question and methods

My research question is, how have space technology and exploration shaped global relations between the United States and China and how would cooperation in space improve or deteriorate these relations? This question is important because cooperation in outer space will bolster both countries scientific knowledge and prowess, along with reducing political tensions between these countries. However, it is also important to consider if cooperation would be non-beneficial and how the political scene would look after these countries tried to cooperate and failed. The infrastructure in outer space would remain separated between these two major space powers and tensions would rise to a higher level never seen before.

To analyze my STS topic, I will be utilizing discourse analysis and policy analysis. Discourse analysis is the close reading of texts produced by agents to understand how it functions in a social context (Ho & Limpaecher, 2021). I will be looking at government statements, news reports, scientific journals and other relevant sources that contribute to the topic. The information collected will be divided into sections, one that supports cooperation between the U.S. and China and one that is against such cooperation. Policy analysis is tracing the development, passage, and implementation of a specific policy or set of policies. I will be looking at the Wolf amendment and how it impacted the U.S.-China space relationship. To support the policy analysis, I will be looking for government documents that support the Wolf amendment and research papers that critique the Wolf amendment. By using these methods, the picture for whether these two countries should cooperate will become much clearer and easier to understand.

Conclusion

Advancements in hypersonic missile research and other space achievements from China are putting pressure onto the United States to put more focus into the research and development of hypersonic missiles and space exploration. By developing a hypersonic CubeSat, my capstone provides a way for hypersonic research to be conducted at a lower cost and exposes students to knowledge usually obtained later in industry. Through the research of how space exploration and technology has impacted the global relations between the United States and China, the understanding of the political relationship between these countries will increase. Political tensions between the two countries are at stake should they decide not to cooperate in space. The expected result of the research is that the United States and China should cooperate on major projects in outer space because it will improve their scientific knowledge and technologies, along with reducing political tensions due to the Wolf amendment.

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