

Modular Battery Management System
(Technical Paper)

The Social Construction of Space Technology and Society
(STS Paper)

A Thesis Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

Nikilesh Subramaniam

Technical Project Team Members

Dipesh Manandhar

Nripesh Manandhar

Phillip Phan

William Zhang

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

Signature _____ Date _____

Approved _____ Date _____ ,
Department of Electrical and Computer Engineering

Approved _____ Date _____ ,
Department of Engineering and Society

Introduction

On May 30 2020, a private spaceflight company named SpaceX launched two NASA astronauts towards the International Space Station in Earth's orbit (Potter, 2020). A commercial spacecraft heading to a worldwide cooperative space project would have been unimaginable when NASA was created at the start of the Space Race in 1958 ("The Space Race", 2010). The social imagination of space and space technology has drastically changed from 1958. Space has been a focus of the US ever since the extremely competitive Space Race to the Moon against the USSR that started in 1957 (Jha, 2017). Since the competitive era of the Space Race, the US has increased space cooperation with other nations to set up the International Space Station ("History and Timeline of the ISS", n.d). Additionally, other agents such as China and private space companies have come to prominence. China has been developing their space program (Jones, 2020) and private space companies such as SpaceX and Blue Origin have been working on their goal of space tourism and colonization (Carson, 2018). Space technology will have a large impact on the world as there are so many actors involved. Understanding how the social imagination of space has changed over time will help us understand how it can change in the future.

I am interested in exploring how the interactions between the US government, other national governments, and private space companies affected space technology and society and how that has changed since 1958. Space technology benefits from an STS investigation because determining how space society is constructed is a wicked problem with multiple stakeholders. There are large competing governments, like the U.S. and China, who may look to dominate space for military purposes (Whitford, 2019). There are also governments with smaller space programs who rely on space cooperation and favor the Outer Space Treaty which sets space as a

multilateral environment (Mallick and Rajagopalan, 2020). Additionally, there are private companies who are interested in space tourism, colonization, space mining, or using resources obtained from space mining (Urrutia, 2018). The interactions between stakeholders have also changed over time, as the U.S and Russia are more cooperative in space compared to the 1950s.

There is no one solution to constructing a space society that can please all of the stakeholders in this problem. Space is not a neutral zone for scientists to conduct research, but instead it is an area full of different opposing interests. History has shown that space is an area with international competition, commercial interests, and government regulation. Smaller countries promoting cooperation in space may not align with the goals of large government space programs. In the International Space Station, smaller programs from Japan and Europe want equal authority in the ISS while the U.S wants to be a leader (Broniatowski et. al, 2006). The goals of government space programs can affect regulations placed on private space companies. Environmentalists may directly oppose stripping space of its resources, which is the business plan for companies such as Moon Express (“Moon Express”, n.d). This problem is connected to other wicked problems such as the environment, regulations of private industry, and relationships between countries.

Research Question

This research topic can be broken down into a set of questions. First, how has the imagination of space and space technology changed from the 1950s to the present? Second, how has the change in the imagination of space affected the practice and purpose of space technology? My hypothesis is that space was initially viewed as a battleground during the Space Race, but this view has gradually changed to see space more for its scientific and commercial

value. I believe that this change in the imagination of space has led to more international cooperation and the rise of private space companies. The analysis of how the imagination of space has changed over time can help to predict how the future of space will change.

Another part of my research topic is to analyze the rise of private space companies in the United States. First, what has been the role of private companies in space exploration throughout American history from the 1950s to the present and how have they affected the social construction of space? Second, what can the U.S. government do to protect public interests, such as national security and environmental concerns, during the rise of private space companies? By analyzing the rise of private companies and how they interacted with the U.S government, I may be able to recommend how to handle the future of private space companies.

Literature Review

Previous academic works have discussed how the United States and the Soviet Union viewed space during the Space Race. Previous articles have also analyzed current problems with space exploration and their potential policy solutions. While there has been STS analysis for space technology at different time periods, few papers have analyzed the change in space technology over time with a social framework.

In the Journal of American History's review of "Eisenhower's Sputnik Moment: The Race for Space and World Prestige" (2014), they mention that Yanek Mieczkowski, the author, shows that the Space Race was really a race for worldwide prestige. Mieczkowski uses correspondence with members of the media and Congress to point out that there was an association between U.S space exploration and national prestige. This source puts a lot of focus on Eisenhower and his pursuit of prestige, but doesn't emphasize other actors or future presidents enough. First (2017) gives an overview of the book "Soviet Space Mythologies: Public Images,

Private Memories and the Making of a Cultural Identity” by Slava Gerovitich. In the book, Gerovitich explains the tension between Soviet engineers and cosmonauts and how that led to failures. Instead of autonomous rockets being products of Soviet totalitarian system, Gerovitich claims that they are products of the tension between engineers and cosmonauts and lack of clarity in their roles caused mission failures. This point of view may be attributing too much power to individuals in a Soviet system.

De Zewart and Stephens (2019) explore the relationship between space innovation and the military. They claim that military technology is embedded in space technology. For example, the launching of Sputnik was a military threat to the United States because of the power of the rocket used. De Zewart and Stephens also examine how the military has reacted to the change in space technology over the years. As more commercial space ventures have grown, the military has bought commercial products as well as started its own agencies such as the Space Force and the Space Development Agency.

Devezas et al. (2012) explores the magnitude of space activity over time by analyzing the number of satellites launched, budgets of space agencies, and other statistics. They claim that that space activity peaked during the Space Race, then declined, and is now increasing with China being a major player. This paper fails to credit this pattern to the decreased competition after the Space Race as a factor. Another work also analyzes the current space environment, calling it a new space race with multiple countries and private companies (Weeks & Faiyetole, 2014). They claim in order to follow the Outer Space Treaty, that promotes equality in space, that cooperation and space education needs to increase.

More academics such as Iliopoulos and Esteban (2020) focus on the emerging commercialization of space. They claim that policy must ensure a focus on environmental and

financial sustainability for all space ventures. They also counter the Outer Space Treaty by stating that space treaties should allow for private property in space. Viadurri et al. (2020) agrees with the focus on sustainability by claiming that government policy needs to be proactive for planetary protection and ethics in space. The researchers disagree with Iliopoulos and Esteban by stating that imperialism should be avoided in space since colonial competition was the premise of the Outer Space Treaty. Brehm (2015) agrees with Iliopoulos and Esteban that private space property should be given because banning private property will hinder the development of space technology.

Lal (2016) has a different perspective on the government's relationship with private space companies. They propose that the government adapt to become a catalyst for the private space industry. One way to accomplish this is for the U.S government to partner and fund private ventures in order to attract the best space talent. Christensen et al. (2019) agrees that the U.S government needs to position itself to grow the space industry. They also claim that any regulations should be incremental and reactive since challenges in space exploration are not fully understood.

These academic works make interesting points about the interaction between space technology, the government, and society at different periods of time. The literature confirms that space is not a neutral cooperative playground, but full of national, social, and economic interests. My research will provide a systematic approach to understand the evolution of all of these interests through the SCOT framework. This is important to understand the meaning of space and its impact on technological and societal development.

STS Framework and Method

In order to understand the change in the imagination of space over time this study will

use the social construction of technology (SCOT) framework. This framework recognizes different social groups who are involved with constructing a technological artifact. Each group interprets this technology differently and has different problems with it. There is then negotiation between groups which evolves technology until closure is reached. The SCOT framework applies to my research topic because there are so many social groups involved in space, such as the United States, USSR, the UN and private space companies. All of these groups negotiate to have a social construction of space society and technology. Additionally, my research topic looks at how this network of social groups changes over time, which is a part of the SCOT framework. Closure is not permanent and new social groups bring new problems and power dynamics into the SCOT network which advances space technology. For my study, I will perform a SCOT analysis on different periods of space exploration and compare and contrast the social groups, interpretational flexibility, and technological artifacts.

In order to examine the change in social imagination of space over time I will analyze United States government policy documents and space news sources from 1957 to the present. Document analysis is the research method that suits my project the best because my topic analyzes history. Government documents from NASA's archive such as the Outer Space Treaty of 1967 and President Trump's directive to allow for space commercialization will provide insight to how the government's attitude toward space exploration, international cooperation and space commercialization has changed. These documents will be biased to highlight U.S accomplishments while hiding U.S failures in space. To combat this bias I will also be analyzing historical space news. Space media from the ProQuest Historical Newspaper database will provide sources to show the American public's view of space and the rise of private space industry. By analyzing articles from multiple newspapers I will get multiple perspectives of

space exploration and reduce bias.

Timeline

This research study will be conducted over three months from February 1st 2021 to May 6th 2021. In the first month of the study I will be gathering documents from my sources and analyzing them. These documents will give me information and point me to more documents that I will analyze in the second month. At the end of the third month of the study I will finish synthesizing my data to write a paper about how the imagination of space has changed over time, in terms of the SCOT framework.

Conclusion

This research study will analyze how the imagination of space has changed from the competitive Space Race between the United States and the USSR to the current space environment with international cooperation and the commercialization of space. Analyzing the shift in the imagination of space is important as it may hint at how space can change in the future and future benefits and problems. Document analysis of NASA's space policy archive and ProQuest's Historical Newspapers was chosen because this topic is historical. The outcome of this research study will connect the Space Race to the current space environment by providing insight to how space society changed.

Bibliography

- BREHM, A. R. (2015, September 1). PRIVATE PROPERTY IN OUTER SPACE: ESTABLISHING A FOUNDATION FOR FUTURE EXPLORATION. *Wisconsin International Law Journal*, 33(2), 353 - 379.
- Broniatowski, D. A., Faith, G. R., & Sabathier, V. G. (2006). The Case for Managed International Cooperation in Space Exploration. *The Case for Managed International Cooperation in Space Exploration*. Retrieved October 7, 2020, from https://web.mit.edu/adamross/www/BRONIATOWSKI_ISU07.pdf.
- Carson, E. (2018, March 11). For Elon Musk, space is the place to preserve humanity. <https://www.cnet.com/news/elon-musk-wants-to-preserve-humanity-in-space/>.
- CHRISTENSEN, I., LANGE, I., SOWERS, G., ABBUD-MADRID, A., & BAZILIAN, M. D. (2019, January 1). NEW POLICIES NEEDED TO ADVANCE SPACE MINING. *Issues In Science & Technology*, 35(2), 26 - 30.
- Cylindrical Batteries More Suitable For Electric Vehicles. (2019, March 11). <https://www.dnkpowers.com/cylindrical-batteries-suitable-electric-vehicles/>.
- DE ZWART, M., & STEPHENS, D. (2019, July 1). THE SPACE (INNOVATION) RACE: THE INEVITABLE RELATIONSHIP BETWEEN MILITARY TECHNOLOGY AND INNOVATION. *Melbourne Journal of International Law*, 20(1), 1 - 28.
- Devezas, T., De Melo, F. C. L., Gregori, M. L., Salgado, M. C., Ribeiro, J. R., & Devezas, C. B.C. (2012, June 1). The struggle for space: Past and future of the space race. *Technological Forecasting & Social Change*, 79(5), 963 - 985.
- (2014, March 1). Eisenhower's Sputnik Moment: The Race for Space and World Prestige. *Journal of American History*, 100(4), 1263.

- FIRST, J. (2017, April 1). Soviet Space Mythologies: Public Images, Private Memories and the Making of a Cultural Identity. *Technology & Culture*, 58(2), 600 - 602.
- History and Timeline of the ISS. (n.d.). Retrieved from <https://www.issnationallab.org/about/iss-timeline/>
- Iliopoulos, N., & Esteban, M. (2020, February 1). Sustainable space exploration and its relevance to the privatization of space ventures. *Acta Astronautica*, 167, 85 - 92.
- Introduction to battery-management systems. <https://www.coursera.org/learn/battery-management-systems>.
- Jha, M. (2017, July 27). This is How the Space Race Changed the Great Power Rivalry Forever. Retrieved from <https://nationalinterest.org/feature/how-the-space-race-changed-the-great-power-rivalry-forever-21690>
- Jones, A. (2020, May 28). China outlines intense space station launch schedule, new astronaut selection. Retrieved from <https://spacenews.com/china-outlines-intense-space-station-launch-schedule-new-astronaut-selection/>
- LAL, B. (2016, June 1). Reshaping Space Policies to Meet Global Trends. *Issues In Science & Technology*, 32(4), 63 - 74.
- M, B., H, G., M, W., Lorentz, V. R. H., Giegerich, M., G, F., ... W, P. (2012). Batteries and battery management systems for electric vehicles. 2012 Design, Automation & Test in Europe Conference & Exhibition. <https://doi.org/10.1109/DATE.2012.6176637>
- Mallick, S., & Rajagopalan, R. P. (2020, October 9). If space is 'the province of mankind', who owns its resources?

<https://www.orfonline.org/research/if-space-is-the-province-of-mankind-who-owns-its-resources-47561/>.

Moon Express. Moon Express Inc. <https://moonexpress.com/>.

NASA. Key Documents in the History of Space Policy. NASA.

<https://history.nasa.gov/spdocs.html>.

Orion Li-Ion Battery Management System: Affordable & Reliable EV Li-Ion BMS.

<http://www.orionbms.com/>.

Pappalardo, J. (2018, June 06). SpaceX Can't Hire International Rocket Scientists Even If It Wants To. Retrieved from

<https://www.popularmechanics.com/space/rockets/a23080/spacex-elon-musk-itar/>

Potter, S. (2020, May 30). NASA Astronauts Launch from America in Test of SpaceX Crew Dragon.

<https://www.nasa.gov/press-release/nasa-astronauts-launch-from-america-in-historic-test-flight-of-spacex-crew-dragon>.

Saleem, R. (2020, February 14). Space Mining - the Quest for the World's First Trillionaire Amid Earth's Growing Resource Scarcity.

<https://wccftech.com/space-mining-the-quest-for-the-worlds-first-trillionaire-amid-earths-growing-resource-scarcity/>.

The Space Race. (2010, February 22). Retrieved from

<https://www.history.com/topics/cold-war/space-race>

Urrutia, D. E. (2018, October 12). How Will Private Space Travel Transform NASA's Next 60 Years? Retrieved from

<https://www.space.com/42113-nasa-future-private-spaceflight.html>

- Vidaurri, M., Wofford, A., Brande, J., Black-Planas, G., Domagal-Goldman, S., & Haqq-Misra, J. (2020, February 1). Absolute Prioritization of Planetary Protection, Safety, and Avoiding Imperialism in All Future Science Missions: A Policy Perspective. *Space Policy*, 51.
- Weeks, E. E., & Faiyetole, A. A. (2014, February 1). Science, technology and imaginable social and behavioral impacts as outer space develops. *Acta Astronautica*, 95, 166 - 173.
- Whitford, G. (2019, October 29). Trouble in the Stars: The Importance of US-China Bilateral Cooperation in Space. Retrieved from <https://hir.harvard.edu/trouble-in-the-stars-the-importance-of-us-china-bilateral-cooperati-on-in-space/>
- Xiao, X., Liu, X., Qiao, L., & Li, S. (2012). A Li-ion Battery Management System Based on MCU and OZ8920. *Procedia Engineering*, 29, 738–743.
<https://doi.org/10.1016/j.proeng.2012.01.033>
- Xu, J., & Cao, B. (2015). Battery Management System for Electric Drive Vehicles – Modeling, State Estimation and Balancing. *New Applications of Electric Drives*.
<https://doi.org/10.5772/61609>