Applying Mahan's Theory of Sea Power to Future Space Development

A Monograph

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Space has the potential to provide abundant commercial profits and scientific discoveries. However, the US currently faces a problem in space with how best to protect commercial and national interests against adversarial threats. Previous studies have failed to show how to practically apply a method of space development that ensures the security of both national and commercial interests. This study solves this issue by using the theories of Mahan, historical examples of sea development, and scientific studies on space exploration to create a fictitious future scenario where space is developed. As a result of this fictitious look at the future, a renewed interest in the US becoming a space-faring people, establishing a manned lunar base, and infrastructure to secure space lines of communication can reasonably be assessed as the best option for securing future US interests in space. Finally, this study can be used to show the importance and feasibility of securely developing the region of space that encompasses the orbits of both the Earth and the Moon.

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Abstract

Applying Mahan's Theory of Sea Power to Future Space Development, by MAJ Craig A. Maybee, 47 pages.

Space has the potential to provide abundant commercial profits and scientific discoveries. However, the United States currently faces a problem in space with how best to protect commercial and national interests against adversarial threats. Previous studies have failed to show how to practically apply a method of space development that ensures the security of both national and commercial interests. This study solves this issue by using the theories of Mahan, historical examples of sea development, and scientific studies on space exploration to create a fictitious future scenario where space is developed. As a result of this fictitious look at the future, a renewed interest in the United States becoming a space-faring people, establishing a manned lunar base and infrastructure to secure space lines of communication can reasonably be assessed as the best option for securing future US interests in space. Finally, this study can be used to show the importance and feasibility of securely developing the region of space that encompasses the orbits of both the Earth and the Moon.

Contents

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Figures

Introduction

Background of the Study

It is the year 2040. Throughout the region of space between the Earth and the Moon, commercial space vessels transport passengers and valuable supplies. Satellites are recovered, refueled, and repaired in orbit. Researchers make exponential gains in science using microgravity orbital laboratories. Various mining locations on the Moon provide resources to a resource exhausted, densely populated Earth. There is even talk of vessels readying to bring the first colonizers to Mars. Patrol ships glide along transit routes between the Earth and the Moon, ensuring the safety of vessels throughout the region. All of these operations are coordinated through Lunar Base Armstrong. In full operation, the base is supported by an extensive communication network that connects to Earth, and hosts numerous commercial and military patrol ships in its terminals. While defensive in nature, Armstrong can rapidly deploy in response to any threat or emergency significantly faster than ships from Earth. Lunar Base Armstrong is pivotal to securing lines of communication in space, bringing peace, stability, and economic prosperity to the global space commons.

However, there was a time when establishing Lunar Base Armstrong was merely a concept. Decades had passed since the last Apollo missions put mankind on the Moon. In the early 2020s, China and Russia continuously threatened the US and allied satellites that much of the developed world relied on. The near-term threat to its satellites forced the United States to shift priorities away from lunar exploration to focus on threats much closer to Earth. However, in what was to be known as the Second Space Race, the Chinese Lunar Exploration Program began to explore the Moon as a viable option for resource exploitation and military basing. With plans for establishing bases on the far side of the Moon, the People's Republic of China sought complete control of the entire region of space between the Earth and Moon. Faced with the threat

of an adversarial nation securing the ultimate high ground in space, the United States was forced to restart dormant space development programs; officially entering the Second Space Race.

Fortunately, the United States and its allies did not remain idle to the threat against their interests in space. Leveraging an emerging commercial space industry, the National Aeronautics and Space Agency (NASA) established the Artemis Program to send a manned mission back to the Moon. They planned to set up a lunar base, establish a foundation for a commercial lunar economy, and eventually send humans to Mars.[1] While NASA's plans were ambitious, the Artemis Program did not consider the need for security that emerging threats posed in contested space. An answer to the security gap came when, in 2019, the US Space Force was established to provide a single command responsible for protecting US interests in space.[2] Once established, the Space Force refined their doctrine based on the principles set forth by Alfred Mahan's theories of sea power. Mahan's principles of sea power helped the Space Force define their role as a military force whose presence in space would support space commerce, and protect space lines of communication. Once that role was defined, the US Space Force and NASA were able to coordinate their resources to develop space in a manner that US interests could be secured for generations. Finally, to protect cislunar lines of communication, to create a safe port for commercial and military space vessels, and protect the interests of a space-faring nation, the United States launched an audacious plan to connect the Earth to the Moon by building the first manned base on the Moon; US Lunar Base Armstrong.[3]

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[1] "NASA: Artemis Accords," *NASA*, accessed September 15, 2020, https://www.nasa.gov/specials/artemis-accords/index.html.

[2] United States Space Force, "About Space Force Mission," accessed September 16, 2020, https://www.spaceforce.mil/About-Us/About-Space-Force/Mission/.

[3] "These are elements of Mahan's theories". A. T. Mahan, *The Influence of Sea Power Upon History: 1660-1783*, 12th ed. (Boston: Little, Brown, and Company, 1918).

Statement of the Problem

Space has the potential to provide abundant commercial profits and scientific discoveries. Previous studies have failed to show how to practically apply a method of future space development that ensures the security of both national and commercial interests. Given the importance of space for many aspects of life and the increased commercial development of space, how could the United States develop space to best project power, secure national interests, and protect the emerging commercial space environment? In 2020, the United States was a technologically advanced nation, with an estimated $1.6 trillion of US annual business depending on satellites and space-based systems for communication, geolocation, imagery, and weather.[4] Space systems were a critical component of the nation's infrastructure; and always under threat. The Russians had deployed "inspector satellites" that could change course to shadow and potentially disable US satellites.[5] The Chinese had demonstrated anti-satellite missiles, brazenly showcased their willingness to steal space-based intellectual property, and announced an ambitious plan to colonize the Moon by 2030.[6]

China's manned lunar base was considered part of a larger effort to control the space lines of communication. On Earth, the US Navy's ability to secure sea lines of communication in the South China Sea was seen as a threat to Chinese interests. If China could establish a manned presence on the Moon first, they would potentially own the cislunar space lines of communication, have the freedom to establish a new silk road, and gain leverage over the US

[4] Stephen M McCall, "Challenges to the United States in Space," *Congressional Research Service* (January 27, 2020): 2.

[5] Joseph Trevithick, "A Russian 'Inspector' Spacecraft Now Appears to Be Shadowing an American Spy Satellite," *The Drive*, last modified January 30, 2020, accessed September 18, 2020, https://www.thedrive.com/the-war-zone/32031/a-russian-inspector-spacecraft-now-appears-to-be-shadowing-an-american-spy-satellite.

[6] Joseph Trevithick and Tyler Rogoway, "China's Secret Spacecraft Looks to Have Landed at This Remote Base with a Massive Runway," *The Drive*, last modified September 8, 2020, accessed September 18, 2020, https://www.thedrive.com/the-war-zone/36270/this-remote-base-with-a-massive-runway-looks-to-be-where-chinas-secretive-spacecraft-landed.

economy.[7] China's announcement of their lunar program and prior success with manned space missions like Shenzhou-11, showed they were capable of establishing a manned lunar base and wrestling supremacy away from the United States.[8] Whether the United States was ready or not, a new space race was on, and the stakes were incredibly high.

The purpose of this study was to close the research gap between scientific exploration, security in space, and commercial space interests by using science fiction to create a thought-provoking future where space development has been guided by Mahan's theory of sea power.[9] This study provided an outline for developing a permanent manned presence in space as a necessary condition for protecting future US interests in space. Specifically, the study used a futures approach that combines qualitative research methods, history, theory, and science fiction. This fictitious futures analysis of space development can serve as an outline for decision-makers responsible for protecting the interests of the United States and its partners in space while ensuring space is a peaceful place for all. Additionally, this study provided a conceptual framework for the alignment of political, military, commercial, and scientific interests in the future development of space.

The significance of this study was that it not only highlighted the salient issues surrounding a rapidly emerging threat to US interests in space, but also provided a unique framework for considering the application of potential solutions grounded in established theory. The results of this study may be useful in highlighting the magnitude of the current problem, and in doing so provide a platform for examining enduring solutions that ensure the development and protection of US national interests in space for years to come.

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[7] Namrata Goswami, "Explaining China's Space Ambitions and Goals through the Lens of Strategic Culture," *The Space Review*, last modified May 18, 2020, accessed September 18, 2020, https://www.thespacereview.com/article/3944/1.

[8] James Griffiths, "Shenzhou-11 Astronauts Return Home After China's Longest-Ever Space Mission," *CNN*, accessed September 26, 2020, https://www.cnn.com/2016/11/18/asia/china-space-shenzhou-11/index.html.

[9] Mahan, *The Influence of Sea Power Upon History: 1660-1783*.

In 1957, the Soviet Union launched Sputnik, the first satellite into space, beginning what would eventually be known as the Space Race. Since Sputnik, the environment in which nations began to exercise power projection grew to include space. The introduction of commercial space launch capabilities like SpaceX has opened space exploration by commercial enterprises, and significantly reduced the cost of exploring space outside of Low Earth Orbit. China recognized the potential of space development in the future and launched an ambitious effort to establish control over space lines of communication. In 2020, the role of the space domain was vast, the stakes were high, and the United States was in yet another space race. The United States had to address these threats soon and develop an enduring space presence to protect its national interests.

Definition of Terms

This section provides definitions for the major concepts discussed throughout this paper. Due to the unique nature of this study, the definitions of these terms come from various scientific and theoretical sources rather than military doctrine alone.

Cislunar Space

Cislunar space is the region of space lying between the Earth and the Moon's orbital path.[10] Cislunar space is a common term used by most space agencies and encompasses area of interest necessary for the establishment of the Earth-Moon lines of communication.

Lagrange Points

Lagrange points are positions in space where objects tend to stay put because the gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them.[11] Lagrange points are essential for space exploration and space basing

[10] Merriam-Webster.com, "Definition of Cislunar," Dictionary, *Merriam-Webster.Com*, accessed September 18, 2020, https://www.merriam-webster.com/dictionary/cislunar.

[11] Neil J. Cornish, "What Is a Lagrange Point?," *NASA Solar System Exploration*, last modified March 17, 2018, accessed September 14, 2020, https://solarsystem.nasa.gov/resources/754/what-is-a-lagrange-point.

because satellites and space stations can be parked at these points and maintain stable orbits with a minimal expenditure of fuel.[12] There are five Lagrange points in cislunar space.

Space Line of Communication

The term space line of communication will be one of the most used terms in this study. Space lines of communication are common routes in cislunar space. These routes are the physical and electronic pathways connecting commercial and military bases of operations, along which supplies, equipment, and information move. In space, as on the sea, there are well-worn paths of travel from the Earth to the Moon and other desired locations. For example, both the Apollo missions and Artemis mission utilized the Kennedy Space Station Launch (Earth to space) and Pacific Ocean recovery (space to Earth) lines of communication to get to the Moon and back. Because of the dual-use of lines of communication in this paper, the definition in this paper is a merger of the military-centric US Department of Defense's definition, and Mahan's definition of lines of communication that includes both commercial and military use of lines of communication.[13]

Low Earth Orbit

Low Earth orbit (LEO) is an orbit that is generally at an altitude of between 160 and 1000 km above.[14] LEO is the closest orbit to Earth and contains the majority of all satellites and the

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[12] NASA Langley Research Center, *Voyages: Charting the Course for Sustainable Human Space Exploration* (National Aeronautics and Space Agency, June 2011), 11, accessed September 22, 2020, https://www.lpi.usra.edu/lunar/strategies/Voyages_NASA_NP-2011-06-305-LaRC.pdf.

[13] A route, either land, water, and/or air, that connects an operating military force with a base of operations and along which supplies and military forces move." US Department of Defense, "DOD Dictionary of Military and Associated Terms" (Joint Chiefs of Staff, June 2020), 131, accessed September 18, 2020, https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/dictionary.pdf.; "A wide common, over which men may pass in all directions, but on which some well-worn paths show that controlling reasons have led them to choose certain lines of travel rather than others." A. T. Mahan, *The Influence of Sea Power Upon History: 1660-1783*, 12th ed. (Boston: Little, Brown, and Company, 1918), 25.

[14] Linn Boldt-Christmas, "Low Earth Orbit," *European Space Agency*, last modified February 2, 2020, accessed September 17, 2020, https://www.esa.int/ESA_Multimedia/Images/2020/03/Low_Earth_orbit.

international Space Station (ISS). Due to their proximity to Earth, LEO satellites orbit quickly around the Earth (usually around 90 minutes).[15]

Medium Earth Orbit

Medium Earth Orbit (MEO) is an orbit that is between 2,000km and 35,000km in altitude. MEO orbit contains the majority of the US Global Positioning Satellites (GPS).[16]

Geosynchronous Orbit

A geosynchronous orbit is a high Earth orbit that allows satellites to match Earth's rotation. Located 35,786 kilometers above Earth's equator, this position is a valuable spot for monitoring weather, communication, and surveillance.[17]

Theoretical Framework

This is a qualitative research project using a history – theory – science fact – science fiction approach. It is written about a fictitious future in which a manned lunar base has already been constructed. By combining the historical development of Alfred Thayer Mahan's theory of naval power with a science fictional narrative, analysis of space history, and publicly available scientific documentation, the proposed research questions will be examined.

The United States currently faces a problem with how best to develop cislunar space and protect the emerging commercial environment that is space. Based on the theories of Mahan, historical examples of development, and scientific studies on space exploration, a fictitious scenario can be used to show the importance and feasibility of US development in cislunar space. As a result of this fictitious look at the future, a renewed interest in the United States becoming a space-faring people and establishing a manned lunar base and infrastructure to secure space lines

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[15] Charles D Lutes, *Toward a Theory of Spacepower: Selected Essays* (Washington, DC: National Defense Univ. Press, 2011), 243, https://ndupress.ndu.edu/Portals/68/Documents/Books/spacepower.pdf.

[16] Kai-Uwe Schrogl et al., eds., *Handbook of Space Security* (New York ; Heidelberg ; Dordrecht ; London: Springer Reference, 2015), 758.

[17] Elizabeth Howell, "What Is a Geosynchronous Orbit?," *Space.Com*, last modified April 24, accessed September 17, 2020, https://www.space.com/29222-geosynchronous-orbit.html.

of communication in cislunar space can reasonably be assessed as the best option for securing future US interests in space.

Research Questions

One primary and four secondary research questions guided this study. First, how might the sea power theory of Alfred Thayer Mahan inform the future development of space? Second, how does the United States establish space lines of communication? Third, why does the United States need a manned mission to further space development? Fourth, how does the United States build a lunar base to support lines of communication? Finally, how does the United States build and train the personnel willing/needed to protect cislunar lines of communication?

The study had one significant limitation; the prediction of technological maturation. As a result of this limitation, this study primarily focused on technology currently in existence or being developed that could feasibly be integrated into future technological systems.

This study utilized an approach that allowed the researcher to develop a utopian future that blends both military and commercial environments. By building a fictitious future where the lunar surface and cislunar lines of communication have already been secured by the United States, the study was free to focus research on how that development in space came to be. As a result of this delimitation, this study was able to look at successful space development informed by Mahan and work backwards. The goal of establishing these delimitations is to allow commanders, planners, and stakeholders to engage in intellectually creative dialog and discussions about the study's concepts. A secondary goal of these delimitations is to provide readers a scenario for envisioning operational plans in a world where cislunar space has already been developed.

This study relied on two assumptions. First, the political environments of both the friendly and adversarial governments continue to pursue future space development. Second, the economic, social, or technological advantages and disadvantages between the United States and

adversarial nations do not drastically change in the next ten years. Such a paradigm shift would likely result in shifts to implementation timelines, and potentially alter the course of who controls cislunar space.

This study is organized into five sections. Section one included the background of the study, statement of the problem, purpose of the study, definition of terms, theoretical framework, research questions, limitations, delimitations, and the assumptions of the study. Section two presents a review of the existing literature, focusing on relevant theoretical works, closely related scholarly articles, current US plans for space development, and the scientific research used in this study. Section three describes the methodology used for this research study. It includes a conceptual implementation timeline of development, the application of space-based technology against theoretical tenets, potential application scenarios, and procedures for analyzing successful completion of developmental milestones. Section four presents the final analysis of the study, addresses the hypotheses, and answers the research questions. Finally, section five provides a summary of the entire study, discussion of the findings, and recommendation for further research.

Review of the Literature

Introduction

This section examines prior literature and presented the rationale for researching the future development of space guided by Alfred Mahan's sea power theory. Although much has been written about space development, space security, and the application of Mahan's sea power to space theory, there are still many gaps left unexplored. Security considerations were missing in the majority of past literature on space development. This absence is likely the result of the technical nature of space exploration and the historical lack of adversarial threats in space. This study focused on a new era of space development-- where space is no longer simply explored to bring nations prestige through scientific exhibitions. Space is now a competitive and commercialized place that must be secured. With the exception of emerging US Space Force doctrine, past space security literature rarely addressed threats beyond geosynchronous orbit.[18] To address space security, many authors have begun to look to naval theorists like Alfred Mahan to better understand space development and space power. Current literature comparing Mahan's sea power to space does well to address space power as a theory, but the application of Mahan's theories to future space development remains limited.[19]

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[18] Gary Oleson, Bob Silsby, and Darin Skelly, "NASA Is Essential for National Security," *The Space Review*, last modified December 31, 2012, accessed September 30, 2020, https://www.thespacereview.com/article/2210/1; Beth Duff-Brown, "The Final Frontier Has Become Congested and Contested," *Center for International Security and Cooperation*, last modified March 4, 2015, accessed September 14, 2020, https://cisac.fsi.stanford.edu/news/security-space-0; Tara Murphy, "Security Challenges in the 21st Century Global Commons," *Yale Journal of International Affairs* 5, no. Spring/Summer 2010 (n.d.): 28–41; National Aeronautics and Space Agency, "Memorandum of Understanding between NASA and USSF" (National Aeronautics and Space Agency, September 21, 2020), accessed October 2, 2020, https://www.nasa.gov/sites/default/files/atoms/files/nasa_ussf_mou_21_sep_20.pdf.

[19] Scott Swilley, "Space Power: A Theory for Sustaining US Security Through the Information Age" (School of Advanced Military Studies, May 2011), accessed August 22, 2020, http://cgsc.contentdm.oclc.org/cdm/ref/collection/p4013coll3/id/2785; Martin E. France, *Mahan's Elements of Sea Power Applied to the Development of Space Power* (Fort Belvoir, VA: Defense Technical Information Center, January 1, 2000), accessed September 2, 2020, http://www.dtic.mil/docs/citations/ADA432784; Martin E. B. France, "*Back to the Future: Space Power Theory and A. T. Mahan*" (August 4, 2000): 9, accessed September 2, 2020, https://www.airuniversity.af.edu/Portals/10/ASPJ/journals/Chronicles/france1.pdf; Michelle Shevin-Coetzee and Jerry Hendrix, "From Blue to Black: Applying the Concepts of Sea Power to the Ocean of

Space Development

With the successful landing of Apollo 11 on the Moon in 1969, the dream of establishing a permanent manned lunar presence seemed like a real possibility. Several studies published by NASA and the scientific community outlined different concepts of how such a colony could be created. At the time of their publication, these studies were considered some of the foremost literature on space development, comprising the most scientifically feasible plans for establishing a permanent manned lunar presence.

One of NASA's first, post-Apollo 11 publications on establishing a permanent manned lunar presence was the 1977 publication *Space Settlements: A Design Study*.[20] The design study's primary goal was to outline a space settlement that maintained itself and exploit the environment of space to grow a harmonious community. In the study, NASA highlighted the requirements for life support systems and habitation spaces necessary for a society in space. Coincidentally, the study included a chapter called "tour of the colony" that was written in a fictitious future. NASA only briefly mentioned security, stating that "… external security initially falls to the Earth-based sponsoring organizations."[21] On the subject of lunar commercial space, NASA admitted that the only feasible option they could come up with was solar power plant manufacturing.[22] Finally, instead of a lunar settlement, the Moon is used only as a "mining base;" NASA focused the bulk of the study on building a settlement on a space station at the fifth Earth-Moon Lagrange Point.[23]

Erik Seedhouse's 2009 *Lunar Outpost: Challenges of Establishing a Human Settlement on the Moon* provided an updated look at the technical difficulties of building a permanent

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Space," *Center for a New American Society*, last modified November 18, 2016, accessed September 2, 2020, https://www.cnas.org/publications/reports/from-blue-to-black.

[20] National Aeronautics and Space Agency, "Space Settlements: A Design Study" (Scientific and Technical Information Office, 1977), 9, accessed September 26, 2020, http://large.stanford.edu/courses/2016/ph240/martelaro2/docs/nasa-sp-413.pdf.

[21] Ibid., 30.

[22] Ibid., 51.

[23] Ibid., 95.

manned lunar settlement.[24] Seedhouse's stated purpose was to provide a detailed narrative of the technological architecture required for NASA to successfully return astronauts to the Moon.[25] Having worked in both the public and private space sectors, Seedhouse offered a unique perspective on space development. *Lunar Outpost* outlined challenges inherent to modern spaceflight and the building of a lunar outpost by considering the emerging technology across the international space community.[26] The paper also highlighted a new era of space exploration and competition, specifically pointing to Russia and China's lunar aspirations as serious attempts to seize the economic and political advantages offered on the Moon.[27] Finally, due to the technological and engineering focus of this paper, Seedhouse focused primarily on natural threats, like radiation, not adversarial threats to missions in cislunar space.[28]

Lunar Settlements was a collection of essays on space development, edited in 2010 by Haym Benaroya.[29] Created for the Rutgers Symposium on Lunar Settlements, these essays were a comprehensive scientific body of work that discussed feasible scientific approaches to establishing a lunar settlement. One of the most illuminating discussions presented in this document was an excerpt from Harrison H. Schmitt, Apollo 17 astronaut, on the economic and energy potential of mining Helium-3 (He-3). According to Schmitt, He-3 is a substance that will be used in the near future for fusion nuclear power. While extremely costly to acquire on Earth, mining He-3 on the Moon is considerably easier and has the potential for commercialization.[30] *Lunar Settlements* presented an excellent array of scientifically sound and economically feasible options for returning to the Moon and inhabiting cislunar space. The scope of *Lunar Settlements*

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[24] Erik Seedhouse, *Lunar Outpost: The Challenges of Establishing a Human Settlement on the Moon*, Springer Praxis Books (Springer New York, 2009), https://books.google.com/books?id=ZJm_i3GS4r4C.

[25] Ibid., xiii.

[26] Ibid., 41.

[27] Ibid., 39.

[28] Ibid., 196.

[29] Haym Benaroya, *Lunar Settlements* (Boca Raton: CRC Press Taylor & Francis, 2010), accessed October 7, 2020, https://www.taylorfrancis.com/books/9781420083330.

[30] Ibid., 699.

was limited to the science of establishing and exploiting resources on the Moon and therefore did not address any security requirements.

NASA's 2020 report titled *Artemis Plan: NASA's Lunar Exploration Program Overview* provided the most realistic overview of future space development.[31] The report outlined NASA's Artemis mission milestones and discuss improvements to NASA's Moon mission that planned to send the first woman and next man to the Moon. The *Artemis Plan* outlined the establishment of a permanent lunar base camp and an orbital station called the Habitation and Logistics Outpost (HALO).[32] In compliance with the 1967 Outer Space Treaty, NASA's *Artemis Plan* highlighted a space program that focused on exploration of space for peaceful purposes.[33] *Artemis Plan* also provided details on a new precedent that enabled private sector companies to extract lunar resources for commercial purposes.[34] As such, security concerns center around protecting against the harsh environment of space, not from adversarial threats.

Space Security

Security is a valuable aspect of protecting national investments and interests when considering the future of development in cislunar space. Most literature on space development focused on the scientific aspects of "how" to develop space. With no adversarial threat in space, the Apollo program focused its resources on overcoming the massive technological challenges inherent in safely exploring space. However, a different approach must be taken to develop space in the 21st century. As competition to invest and profit beyond geostationary orbit grows, so does the need to secure those investments.

[31] National Aeronautics and Space Agency, "Artemis Plan: NASA's Lunar Exploration Program Overview" (National Aeronautics and Space Agency, September 2020), accessed September 22, 2020, https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf.

[32] Ibid., 10.

[33] Ibid., 71.

[34] Ibid., 29.

The 2012 essay by Gary Olson, Bob Silsby, and Darin Skelly "NASA is Essential for National Security*"* was published on the website The Space Review.[35] The article provided a review of the relationship between NASA and national security, arguing that NASA is essential for national security, not by its inclusion as an apparatus of national security, but its purposeful absence.[36] The article discussed NASA's unique position to facilitate international collaboration in ways the military could not.[37] Essentially, NASA's peaceful presence in space led to advances in national defense because NASA informs US Department of Defense (DOD) space programs of the scientific threats and challenges faced by exploring space. The article points out that NASA's scientific breakthroughs are shared with DOD, reducing the research and development costs for national security programs. In sum, NASA's relationship of collaborative resource and knowledge sharing has improved the efficiency of DOD space programs, enabling them to better address specific adversarial threats in space.

Beth Duff-Brown's 2009 article "The final frontier is congested and contested*"* discussed purposeful adversarial threats against US interests in space.[38] Specifically, Duff-Brown stated that space debris and adversaries' counter-space capabilities were significant threats to future space development.[39] Similarly, Tara Murphy's article "Security Challenges in the 21st Century Global Commons" provided countermeasures for space threats by discussing space as a global commons that the military must secure to enable the passage of goods and communication.[40] Murphy pointed out that the United States led the way in securing the global commons since World War Two, and created a global system of development that fostered stability.[41] Murphy also referenced Alfred Mahan's *The Influence of Sea Power Upon History: 1660-1783* to draw

[35] Gary Oleson, Bob Silsby, and Darin Skelly, "NASA Is Essential for National Security."
[36] Ibid.
[37] Ibid.
[38] Beth Duff-Brown, "The Final Frontier Has Become Congested and Contested."
[39] Ibid.
[40] Murphy, "Security Challenges in the 21st Century Global Commons."
[41] Ibid., 33.

attention to the economic benefits gained from creating secure trade routes through a global commons.[42]

The Memorandum of Understanding between NASA and the US Space Force in September 2020 provided an opportunity to view space security outside of Low Earth Orbit.[43] The memo described an agreed-upon understanding regarding security between NASA and the US Space Force that emphasized collaboration to further space exploration. In the memo, the US Space Force described their sphere of interest as extending 272,000 miles and beyond to encompass all of cislunar space.[44] Additionally, the memo highlighted challenges facing the US Space Force, stating that the legacy space security mission of securing geostationary orbital ranges has limited their current capabilities and architecture.[45] The 2020 memo was one of the first written documents that outlined a protection mechanism for future NASA missions. Finally, the memo specifically mentioned NASA's lunar program, Artemis, but did not detail how security could be established beyond geostationary orbital ranges.[46]

Applying Mahan's Theories to Space

Alfred Mahan's theories of sea power have informed the decisions of navies throughout the years.[47] Mahan's theories of sea power once again find value with mankind's expansion into the global commons of space. Much of the literature reviewed utilized Mahan's theories of sea power as a means to establish a space power theory.[48] This monograph is unique in that it does

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[42] Murphy, "Security Challenges in the 21st Century Global Commons., 31.

[43] National Aeronautics and Space Agency, "Memorandum of Understanding between NASA and USSF."

[44] Ibid., 2.

[45] National Aeronautics and Space Agency, "Memorandum of Understanding between NASA and USSF."

[46] Ibid., 1.

[47] Jonathan R. Dull, "Mahan, Sea Power, and the War for American Independence," *The International History Review* 10, no. 1 (1988): 60, accessed October 5, 2020, http://www.jstor.org.lumen.cgsccarl.com/stable/40107089.

[48] Michelle Shevin-Coetzee and Jerry Hendrix, "From Blue to Black: Applying the Concepts of Sea Power to the Ocean of Space," 3; Swilley, "Space Power," 4; "France, "*Mahan's Elements of Sea Power Applied to the Development of Space Power.*", 1.

not try to establish a space power theory based on the writings of Mahan, but rather develop a future in space informed by his principles.

Scott F. Swilley's 2011 School of Advanced Military Studies monograph *Space Power: A Theory for Sustaining US Security Through the Information Age* utilized Mahan's sea power theory to highlight the importance of freedom of action in space to national economic prosperity and consequently, national interests.[49] Unlike this study, Swilley focused on the theoretical aspects of Mahan's theories when applied to space, rather than providing a method for the practical implementation of Mahan's theories to space development. Swilley identified space exploration, commercial endeavors, and space enablers as three space activities that were critical to US national security.[50] Swilley also pointed out the parallel in Mahan's reference to national character and space exploration. Specifically, the national character present in a nation that can successfully explore the sea is the same national character that would find success exploring space.[51] However, discussion on how a nation might use policy to shape space development or otherwise harness its national character appears to be outside the scope of Swilley's study.

Martin E.B. France's monograph, *Mahan's Elements of Sea Power Applied to the Development of Space Power* was written in 2000, and dissected Mahan's works to use as a foundation for a theory of space power.[52] France discussed how the development of space could fit into a space power theory in keeping with the spirit of Mahan's central theoretical tenets. Unlike this monograph, France drew on Mahan's theories and used practical examples to explain the conditions faced by space-faring nations in 2000.

Written in 2016, *From Blue to Black: Applying the Concepts of Sea Power to the Ocean of Space* by Jerry Hendrix and Michelle Shevin-Coetzee, examined the sea power theories of both Julian Corbitt and Alfred Mahan to guide the understanding of strategic, commercial, and military

[49] Swilley, "Space Power."
[50] Ibid.
[51] Ibid., 9.
[52] France, *Mahan's Elements of Sea Power Applied to the Development of Space Power*.

aspects of space.[53] This article looked at each of the tenets of a nation's sea power for Mahan and applied them to the broader science of space. This look at Mahan's tenets provided a well-rounded interpretation of space power via Mahan's theories that reflected technology in 2016 and attempted to project the future of national space ambitions. For example, one of Mahan's tenets of sea power is geographical positions. *From Black to Blue* applied this tenet of sea power to space by identifying the Moon as a potential single point of strategic importance, from which a military base would naturally provide a position to conduct resupply, repairs, and space operations.[54] However, unlike this study, *From Black to Blue* did not elaborate on the development of space past providing examples to drive home the potential relationship between Mahan's sea power theory and a theory of space power.

The literature from NASA and the academic community still maintained the mindset of the 1970s where space development was reserved only for the wealthiest of nations. While providing a comprehensive outline of national space agency level plans, the literature remained limited in its incorporation of commercial industry in space exploration. Much of the literature failed to account for security in space to protect against adversarial threats. The literature on NASA, civilian policy analysts, and the US Space Force primarily focused efforts on threats up to geosynchronous orbit. Additionally, while the 2020 US Space Force mission was adjusted to include security functions throughout cislunar space, their development has been stunted strategically and operationally due to current resource constraints. The literature on Mahan's sea power application to space focused on the current threat environment, where the preponderance of risk resided in Low Earth Orbit. Finally, *From Blue to Black* briefly pointed to a future where Mahan's principles could lead to establishing a lunar base as high ground but only as an example

[53] Michelle Shevin-Coetzee and Jerry Hendrix, "From Blue to Black: Applying the Concepts of Sea Power to the Ocean of Space.

[54] Ibid., 10.

of how sea power and space power could be conceptually related. The next section presents the methodology used to conduct this study.

Methodology

Introduction

This study utilized a qualitative approach to research that blends history, theory, science fact, and science fiction to build a future where space has already been developed, guided by Alfred Mahan's theory of sea power. By combining Mahan's theory of naval power with a science fiction narrative, analysis of space history, and scientific documentation publicly available, the proposed research questions will be answered. This section consists of four parts: introduction, study design, data collection, and analysis.

Study Design

This is an exploratory study that presents a fictitious future based on a guiding theory and scientific fact. This study is unique in that it used a futures writing and planning technique called backcasting.[55] As opposed to forecasting, backcasting is a method of research or planning that starts with creating a proposed future, and works to identify how that future is connected to the present. The benefit of backcasting is that it discourages restrictive thinking about the future by using the future as the starting point for an analysis of the present. In the case of this study, backcasting permitted a starting point to be established in a future where space is already developed, allowing the research to focus on the events that must have occurred based on the present circumstances.

Data Collection

The collection of data used in this study consisted of both primary and secondary writing sources. There were two types of documents used for collecting data during this study. The first type was historical case studies. This study draws on history to provide the necessary context for projecting a realistic future. The historical case studies ranged widely but primarily focused on

[55] Oliver M. Brandes and David B. Brooks, "The Soft Path for Water in a Nutshell" (Friends of the Earth Canada, August 2007), accessed October 21, 2020, https://poliswaterproject.org/files/2007/09/The-Soft-Path-for-Water-in-a-Nutshell.pdf.

space exploration, great power competitions, and naval theory. The second type of data collected for this study is scientific documentation. Utilizing scientific research from NASA and other publicly available scientific proposals of lunar base plans, a feasible method for the development of a manned Moon base and associated infrastructure was developed that does not require the maturation of current technology. The majority of the scientific research examined for this study was directly related to commercial or government space programs in the United States. Comparatively, little detailed scientific documentation was found on adversarial commercial or government-run space programs. However, enough adversarial documentation was available to inform this study effectively.

Analysis

This study used one primary and four secondary research questions to guide the analysis of the proposed hypothesis. The primary research question was how the sea power theory of Alfred Thayer Mahan might inform the future development of space? This research question served as the foundation for this paper by using Mahan's theories to establish a theoretical framework to analyze future space development. This research question also shed light on the importance of establishing the United States as a space-faring people, securing space ports of call on the Moon, and establishing the infrastructure in space to secure cislunar communication. Finally, this research question also provided an end state to guide the purposeful development of space.

The first secondary research question was why the United States needs to have a manned mission to further develop space? In answering this question, analysis was done on the importance of manned missions in space compared to remote missions. This research question primarily highlighted the potential benefits of manned missions on the future of space development.

The last three secondary research questions all focus on "how" space should be developed according Mahan. These questions provided insights into how and where to establish secure communication lines and manned ports of call in cislunar space. The analysis of these questions highlights the parallel between space and the sea power theories regarding the need for secure sea lines of communication. When answered, these research questions shed light on the importance of secure space lines of communication for commercial and national interests in space. By answering the secondary research questions, a better understanding can be made as to how the United States could develop the personal and capabilities necessary for a space-faring people to develop space. Analysis of these questions highlighted the importance of cooperation between commercial space partners, NASA, and the US Space Force in establishing the personnel and capabilities necessary to become a space-faring nation. The next section, Section IV, serves as the analysis section and details future space development informed by the theories of Mahan from 2020 to the new present time of 2040.

Building a Future

Introduction

Today in 2040, the US presence in cislunar space ensured economic prosperity by enabling the peaceful exploration of space for resource exploitation, space commerce, and scientific research. Additionally, the collective effort of the NASA, private space companies, and the US Space Force promotes the national interests of the United States and its allies; setting conditions for the peaceful future exploration of cislunar space and beyond. This study looks back at the developmental history of space since 2020 to provide readers with the rationale for the development of space ports, a large body of trained space faring people, and secure space lines of communication.

In 2020, the United States stood at a crossroad. NASA, the agency that initially sent mankind to the Moon, was in the process of reigniting its lunar program. Private space companies in the United States were becoming increasingly more cost effective, fueling commercial desire to seek profits outside of geosynchronous orbit. However, scientific and commercial interests in space were no longer uncontested. Adversarial nations like China were rapidly developing ambitious space programs capable of controlling and exploiting the vast resources of space. The US Space Force was formed to counter these emerging threats to US national interests in space. Facing the challenge of developing space, the United States chose to turn to the theories of Alfred Mahan. By utilizing Mahan's theory of sea power, the United States was able to unify the efforts of NASA, private space companies, and the US Space Force to project power in space, secure its national interests, and protect the commercial space environment. This paper tells the story of the extraordinary space development undertaken by the United States that began in 2020.

Aiming for the Stars by Shooting for the Moon:

> The universe is an ocean, the Moon is the Diaoyu Islands, Mars is Huangyan Island. If we don't go there now, even though we're capable of doing so, then we will be blamed by our descendants. If others go there, then they will take over, and you won't be able to go even if you want to. This is reason enough.
>
> — Ye Peijian, *2018 Annual Chinese Communist Party Plenary Session*

Early in 2020, representatives from NASA, the private space sector, and US Space Force began open discussions surrounding the question of how to develop secure lines of communication in space to protect future US investments. Two years earlier the head of the Chinese Lunar Exploration Program compared the program to their contentious land grab in the South China Sea. Seeing the threat from China's Lunar program coupled with disruptive Chinese anti-satellite missile launches, the United States was anxious to develop a strategy to protect its interests in space. NASA was four years away from launching its first lunar missions as part its Artemis Plan.[56] While NASA's charter sought the exploration of space for peaceful purposes, the threat its space program could not be ignored.[57] Additionally, one of the most integral parts of the US space capabilities, the private space industry, had space missions in development with the aim of exploring space for commercial purposes. To fuse these disparate interests together and develop space securely, the US government decided to look to Mahan's theory of sea power.

Alfred Mahan, a naval theorist at the turn of the 19th century, published *The Influence of Sea Power Upon History: 1660-1783.* His theory outlined several characteristics of sea power that he deemed important to ensure the security of commerce during times of peace, and control during times of war.[58] In particular, Mahan emphasized the importance of lines of communication. Mahan described lines of communication as useful harbors, commonly traveled

[56] National Aeronautics and Space Agency, "Artemis Plan: NASA's Lunar Exploration Program Overview," 15.

[57] Sandra Erwin, "Pentagon Report: China Amassing Arsenal of Anti-Satellite Weapons," *SpaceNews*, last modified January 1, 2020, accessed February 1, 2021, https://spacenews.com/pentagon-report-china-amassing-arsenal-of-anti-satellite-weapons/.

[58] Mahan, 1.

routes, and the conditions for enabling communication between them. Finally, he believed that the navy was the force responsible for protecting lines of communication.[59] In space, as in the sea, there are lines of communication. For example, all of the Apollo missions launched and traveled the same common route to and from the Moon (Figure 1).

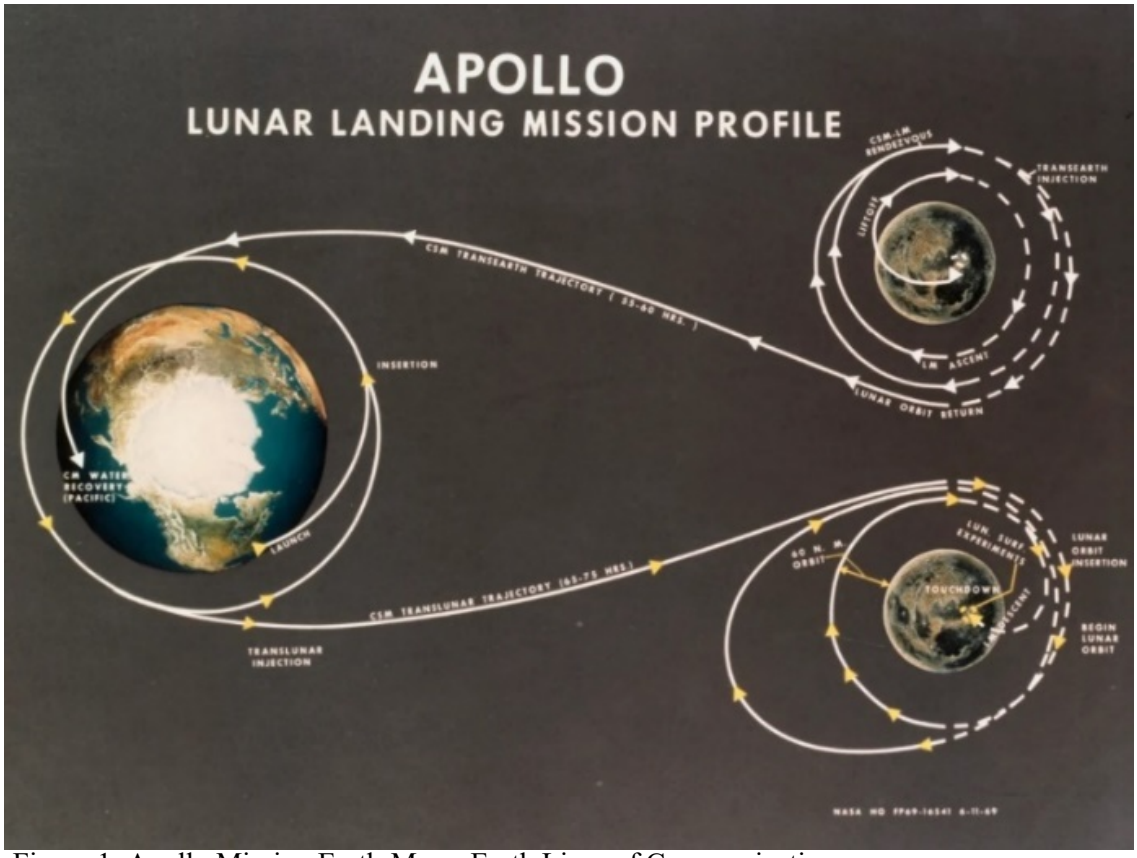

Figure 1: Apollo Mission Earth-Moon-Earth Lines of Communication.
Source: Dave Roos, "*Apollo 11 Timeline: From Liftoff to Splashdown*," HISTORY, accessed September 20, 2020, https://www.history.com/news/apollo-11-Moon-landing-timeline.

In 2020, the US Space Force's priority was to organize, train, and equip forces that enabled the protection of US national and civilian interests in space.[60] Similar to Mahan's Navy in the turn of the century, the US Space Force was tasked as the lead for the establishment of secure lines of communication in space. To this end, the US Space Force and NASA signed a Memorandum of Understanding formally declaring that the US Space Force was the lead for

[59] Mahan, 521.
[60] Chance Saltzman, "Craig Maybee's Questions to Space Force Deputy Chief of Operations" (US Space Force, November 12, 2020).

providing the "resources necessary to protect and defend vital U.S. interests in and beyond Earth-orbit" and that "new collaborations will be key to operating safely and securely on these distant frontiers."[61] In an effort to further collaborate on the creation of secure space lines of communication, the Space Force began talks with the DOD, NASA, and private sector. The outcome of those efforts was an ambitious plan. First aspect of the plan was synchronizing the development of a secure line of communication with both NASA and private sector development programs to maximize the efficient use of resources. The second, was ensuring that the security of the project was not compromised prior to its employment.

In December 2020, the US Space Force's efforts to develop a secure line of communication in cislunar space began to bear fruit with the launch of a SpaceX's Falcon Heavy rocket carrying almost 141,000lbs of cargo.[62] The rocket, containing multiple communication and imagery satellites secured with quantum communication relay suites, propelled the satellites to cislunar Lagrange points 1, 2, 3, and 4.[63] The cislunar Lagrange points (Figure 2) were chosen precisely because they are positions in cislunar space where objects tend to stay put because the gravitational pull of two large masses (Earth and Moon) precisely equals the centripetal force required for a small object to move with them.[64] The "Lagrange Satellites", as they are referred to today, were the pivotal first step in securing lines of communication between the Earth and Moon

[61] National Aeronautics and Space Agency, "Memorandum of Understanding between NASA and USSF," 2.

[62] SpaceX, "Falcon Heavy: The World's Most Powerful Rocket," *SpaceX*, accessed February 2, 2021, http://www.spacex.com.

[63] Austrian Academy of Sciences, "How to Use Entanglement for Long-Distance or Free-Space Quantum Communication," December 16, 2019, *Phys.Org*, accessed September 17, 2020, https://phys.org/news/2019-12-entanglement-long-distance-free-space-quantum.html.

[64] Neil J. Cornish, "What Is a Lagrange Point?," NASA Solar System Exploration, last modified March 17, 2018, accessed September 14, 2020, https://solarsystem.nasa.gov/resources/754/what-is-a-lagrange-point.

by providing the secure network infrastructure and early warning threat detection required for further development.

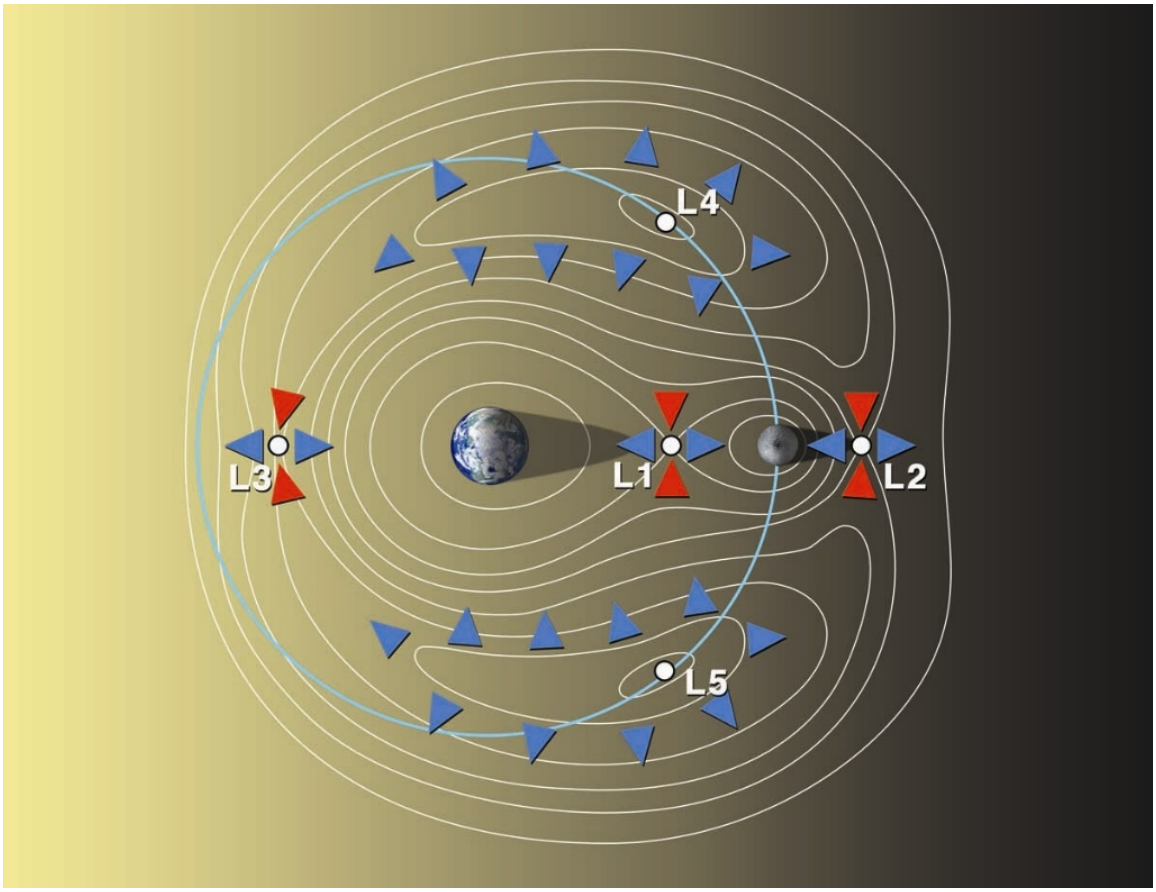

Figure 2: Cislunar Lagrange Points.
Source: David A. Kring. "*The Earth Moon Lagrange Points*." LPI-JSC Center for Lunar Science and Exploration, 2012. https://www.space.com/images/i/15157/i02/Earth-Moon-lagrange-points.jpg

Using the launching of the Lagrange Satellites as a backdrop, the President-elect of the United States announced an ambitious effort to further develop space, stating "Today, we begin our journey to the Moon. We choose to make this journey to protect those that dream and protect those that have the indomitable drive to explore the unknown. America has harnessed our current capabilities, and is developing further capabilities, to secure our place in the stars, for the next generation. The Moon will not be an isolated island in the sea, to be controlled and cut off from the world. Rather, the United States has a duty to ensure that the Moon becomes a place of

science, commerce and common ground, for all humanity to enjoy."[65] The justification provided by The White House spokesmen to the throngs of press afterward was that the President's announcement was meant to highlight the administration's support for NASA's Lunar mission, Artemis. However, unconfirmed reports began to circulate that the speech was not just about Artemis.

The speech was also a result of a yearlong effort by the heads of NASA, the US Space Force, and private space corporations, referred to as "The Counsel", to provide an answer to public concerns about how the United States planned to win the new space race against China. The space race was not just about which country would first set up a permanent manned lunar base. Instead, the new space race was about the vast amounts of untapped lunar resources. Although the 1967 Outer Space Treaty stated that a nation cannot claim sovereignty over any part of space, its ratification came at a time in which signing such a treaty meant very little to nations without the capabilities to travel to another celestial body.[66] In 2020, several nations and a few corporations, had the capabilities to travel to the Moon, putting the Outer Space Treaty under additional scrutiny. The primary issue at hand for the United States was that on top of the several loopholes in the treaty, there were fears that China would use "scientific experiments" in key locations on the Moon to deny a law-abiding nation access to the Moon. Additionally, once a permanent Chinese lunar base was established, the United States believed that the Chinese would break the treaty and begin harvesting resources for commercial purposes under the guise of science.[67] While sounding farfetched, this is exactly what the United States believed China was

[65] This speech was inspired by President Kennedy's historic "Moon Speech." Mike Wall, "JFK's 'Moon Speech' Still Resonates 50 Years Later," *Space.Com*, last modified September 12, 2012, accessed February 2, 2021, https://www.space.com/17547-jfk-Moon-speech-50years-anniversary.html.

[66] United Nations Office of Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies," *United Nations Office of Outer Space Affairs*, last modified December 4, 2020, accessed December 8, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

[67] Alvin Powell, "Eternal Light, Up for Grabs," *Harvard Gazette*, last modified July 12, 2016, accessed February 16, 2021, https://news.harvard.edu/gazette/story/2016/07/eternal-light-up-for-grabs/.

doing in 2020, with regards to international laws and controlling resources in the South China Sea.[68]

With the Lagrange Satellites settling into their respective cislunar orbits, and the full weight of the new administration behind them, The Counsel began the next step of their process to secure cislunar lines of communication. Mahan emphasized the importance of secure ports when navigating lines of communication, stating that these vital points should not be dependent upon the military for protection, but for supplies and refitting at regular intervals.[69] It was this mindset that led The Council to seek an opportunity to supplement NASA's Artemis program by adding the development of Lunar Base Armstrong. The base would serve as a secure, open port of call for all space expeditions and provide an anchor for cislunar lines of communication. In addition to Lunar Base Armstrong, The Counsel also began developing a larger more permanent orbital station called Orbital Station Shepard. The station, designed on a concept similar to that of the International Space Station, was intended to provide logistical and technological support for all operations. Additionally, the orbital station served as a support hub and relay station for bases on lunar surface, including Lunar Base Armstrong as well as any future lunar colonies or expeditions.

On July 4, 2028, the newly built SpaceX Falcon Super Heavy Rocket launched from the Kennedy Space Station in Florida, marking a historic day in space development. In the mission NASA mission controllers had dubbed "Operation New Moon," the rocket carrying around 100 tons of equipment bound for the Moon, marked the beginning of a new era in lunar history. Approximately six hours after the New Moon capsules departure from Kennedy Space Station, NASA mission controllers successfully transferred control to the NASA engineers aboard the

[68] Michael R. Pompeo, "US Position on Maritime Claims in the South China Sea," *United States Department of State*, July 13, 2020, accessed December 8, 2020, https://www.state.gov/u-s-position-on-maritime-claims-in-the-south-china-sea/.

[69] Mahan, 529.

newly constructed Artemis Gateway Module orbiting the Moon. Closer in proximity to the Moon, these engineers easily guided the capsule to a hilltop just outside the Stackleton Crater.

Named after the famous British naval explorer Ernest Shackleton, the Stackleton Crater (Figure 3), is a lunar crater located on the south pole of the Moon, and features several hills that receive sunlight nearly 90% of the year, a solar power advantage for any lunar settlement.[70] To land, the capsule used four sophisticated reverse thrusters to gently touch down on the lunar surface.

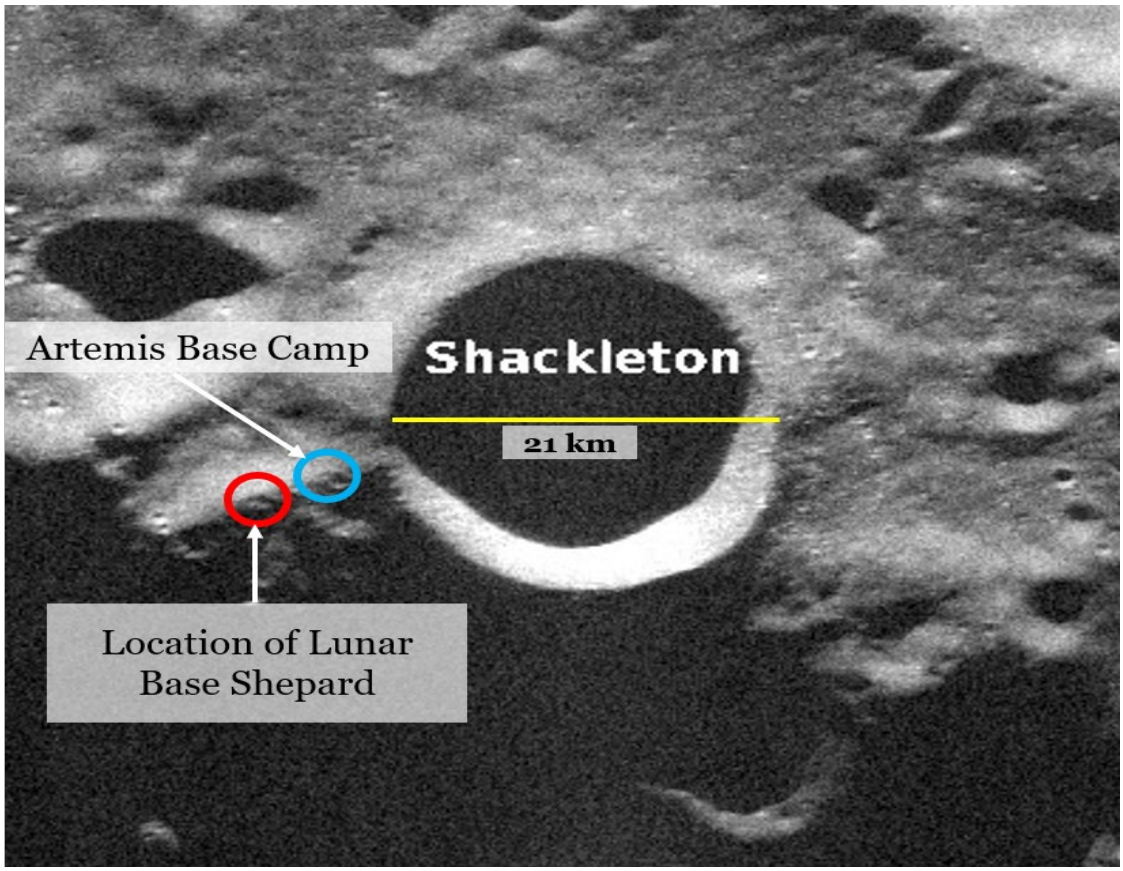

Figure 3: Shackleton Crater with Locations of Lunar Base Armstrong and Artemis Base Camp. *Photo customized from source*: Margot, Jean-Luc. "*Topography of the Lunar Poles from Radar Interferometry: A Survey of Cold Trap Locations*." Science 284, no. 5420 (June 4, 1999): 1658–1660.

[70] Kieran Mulvaney, "The Stunning Survival Story of Ernest Shackleton and His Endurance Crew," *HISTORY*, last modified October 21, 2020, accessed February 2, 2021, https://www.history.com/news/shackleton-endurance-survival.

Once on the lunar surface, the New Moon Capsule opened and deployed a series of construction rovers. Officially called WALL-Es, each rover was fitted 3D printers, specially designed for the lunar environment, that utilized microwaves to turn the powdery lunar regolith into concrete bricks.[71] For the next year, NASA extraterrestrial habitat engineers on Earth and the Artemis Gateway Module guided the WALL-Es around the clock, carefully creating one lunar habitat shell after another, and connecting each with shell tunnels.[72] These regolith brick structures served as the first line of protection for residents of Lunar Base Armstrong from solar radiation and lunar impacts. Once the WALL-Es completed the basic structures, another set of robots deployed pressurized inflatable habitats inside the structures. This created the physical framework for which the first astronauts deployed to Lunar Base Armstrong would not just survive; but thrive.

Meanwhile, back on Earth, the United States was scrambling to adjust commercial space policy to address the demands from the rapid development of space. Here they turned once again to Mahan for guidance. One of Mahan's most prominent elements of sea power is a term he called national character. According to Mahan, national character is the aptitude for commercial pursuits at sea as a distinguishing feature of a nation.[73] When applied to space, a nation must develop the infrastructure and encourage commercial pursuits to build the necessary national character. Additionally, Mahan also discussed the character of government as being the traits and characteristic of a government as seen through its policies, to exercise intelligent will power in the manifestation of sea commerce and adventure in such a way that is bound by the rule of law, and through which prosperity can be secured.[74]

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[71] Ian Steadman, "Giant Nasa Spider Robots Could 3D Print Lunar Base Using Microwaves," *Wired UK*, March 1, 2013, accessed December 9, 2020, https://www.wired.co.uk/article/giant-nasa-spider-moon-base-sinterhab.

[72] Purdue University, "Resilient ExtraTerrestrial Habitats," *RETH: Resilient ExtraTerrestrial Habitats*, last modified April 9, 2019, accessed February 2, 2021, https://www.purdue.edu/reth/.

[73] Mahan, 50.

[74] Ibid., 82.

Simultaneous to developing secure lines of communication, the United States began to work with commercial partners to incentivize private investments in space development. One goal was to strengthen both the character of government and the nation in space by providing the physical and legal protections for commerce in space. as it has done on the seas for a century. A major hurdle was providing the regulatory framework necessary to incentivize commercial companies to risk investing in the US space development program. Developing secure lines of communication helped reassure much of the commercial community that their investments would be physically secure. However, the potential legal restrictions imposed by the Outer Space Treaty presented a new challenge. One of the most debated issues surrounding the Outer Space Treaty was the legality of commercially extracting resources in space.[75] To that end, the United States was able to assure commercial partners and allied governments of the legality of resource extraction by asserting that the 2015 United States Commercial Space Launch Competitiveness Act allowed US citizens and companies to extract resources in space.[76] The Act specifies that while no asteroid or plot of lunar land can be owned, resources extracted can be both owned and sold for commercial purposes.[77] These contracts were also initially given to corporations by organizations like NASA under the Artemis Program, but were then extended to a broader commercial space market. Additionally, by allowing preferential investment by commercial entities of allies and partners into US owned corporations, contracts to harvest lunar resources were created, allowing the international commercial space community access to a robust US-led commercial space market.

[75] Jeff Foust, "Lunar Exploration Providing New Impetus for Space Resources Legal Debate," *SpaceNews*, last modified September 7, 2019, accessed February 3, 2021, https://spacenews.com/lunar-exploration-providing-new-impetus-for-space-resources-legal-debate/.

[76] Mike Wall, "New Space Mining Legislation Is 'History in the Making,'" *Space.Com*, last modified November 20, 2015, accessed December 9, 2020, https://www.space.com/31177-space-mining-commercial-spaceflight-congress.html.

[77] Ibid.

Finally, as with any emerging industry, training for both commercial and government space personnel was in high demand by the late 2020s. To fill the massive influx in demand for trained space qualified personnel, both NASA and the US Space Force partnered with universities and the commercial sector to develop the Space Cadet University System. This education system, much like any other academic or vocational school system, was intended to provide both education and qualification for any person who desired to work in space or support space operations. Though initially ad hoc in form, and without a firm direction, after several years of trial and error the Space Cadet school began to gain a reputation for its trained space worthy personnel; providing both high quality generalists and specialist from campuses across the United States and Europe. The school also provided a program to train constabulary forces, providing the genesis for a space qualified police force capable of enforcing the law on the Moon and in cislunar space.

Expeditions of Commerce

The 2030s saw a major boom in commercial space travel as a result of the progress in securing cislunar lines of communication, increasing the legal protections and government incentives for resource development in space, and the continued decrease in commercial space lift costs. In late 2030, the need for lunar in-situ resource development led to lucrative contracts for the extraction of water and other minerals on the Moon from both NASA and the US Space Force being issued out. This influx in contractual demand created what would be known as the "water rush of 2030." Like the gold rush in the United States during the late 18th century, the water rush of 2030 saw an influx of commercial space corporations flooding the market in order to come up with methods to extract resources on the Moon. The first contracts for prospecting were awarded in 2031, when ten commercial companies were cleared to search for, and if possible, extract water on the Moon. The first successful extraction, storage, and transportation of water on the lunar surface came in 2033. LunarX, a SpaceX and Google joint venture, developed a drone-enabled

ice mining concept that utilized a series of mirrors on the top of a permanently darkened lunar crater. Once in place these mirrors directed sunlight into the crater heating the water saturated regolith.[78] Drones deployed inside the crater collected water in the form of ice and through a series of filtration systems the liquid water was extracted and containerized for transportation. Once established, the modularization and transportation of water extraction set a precedent for a replicable system that could sustainably extract water from lunar craters. The commercial water extraction venture also created the inroads for an in-situ staple economy on the Moon, essential for the future of space commerce.

On June 3, 2034, after several delays and setbacks, NASA's Artemis Lunar Mission finally landed on the Moon. During this historic mission, the Artemis Base Camp, a single inflatable temporary habitat, was established on the Shackleton Crater's edge, only four miles away from the construction site of Lunar Base Armstrong. Artemis' success marked the beginning of a new era in space exploration, and rapidly sped up the process of construction of Lunar Base Armstrong. With the Artemis crew on the Moon, Lunar Base Armstrong's construction was overseen in real time by a small team of engineers only miles away; as opposed to several hundreds of thousands of miles away on Earth. Most importantly, these astronauts paved the way for future operations by physically conducting missions to the base and ensuring that all the seals on the inflatable habitats built by the drones were safe, and that the entire base was ready for full time crew occupation. Although talks were in the works to allow the original Artemis astronauts to stay for a longer period of time, the original Artemis astronauts ultimately returned to Earth after only fifteen days on the lunar surface.

One of the most significant events about the Artemis lunar landing was discovered after the crew returned to Earth. Once lunar samples from Artemis were analyzed, NASA was able to

[78] Leonard David July 13 and 2018, "Mining Moon Ice: Prospecting Plans Starting to Take Shape," *Space.Com*, accessed December 9, 2020, https://www.space.com/41164-mining-Moon-water-plans-take-shape.html.

confirm the existence of higher-than-expected levels of He-3, a substance valued at around $5 billion per ton.[79] On Earth, He-3 is acquired as a biproduct of radioactive tritium decay and as a result is extremely rare, with the entire US yearly production of He-3 falling short of a demand of around seventy tons a year.[80] He-3 has a multitude of potential uses in medicine, national security, and energy sectors.[81] Previously, it was believed that there was one million tons of He-3 on the Moon.[82] The Artemis discovery confirmed the potential existence of nearly triple that amount. The problem was always how to efficiently extract He-3 from the lunar surface. However, that all changed with a breakthrough in late 2034 by Massachusetts Institute of Technology (MIT) scientists. The scientists outlined a method of efficiently heating lunar regolith to the 600 degrees Celsius necessary to extract He-3. Needless to say, the fervor around the He-3 discovery was immense, with the CEO of SpaceX stating in an interview that "after the Artemis and MIT discoveries, space stopped being just about science! My phone has been ringing off the hook from all these private companies trying to get their equipment on to my rockets."

End Game

> As there was immense gain, as well as much risk, in these early voyages, such establishments naturally multiplied and grew.
>
> — Alfred Thayer Mahan, *Influence of Sea Power Upon History: 1660-1783*

The years 2033 to 2039 marked a period of blunders and brilliance in what some in the space industry called "controlled chaos." The potential to make fortunes on the Moon pushed many corporations and nations well past the safe limits of exploration. This period saw more catastrophic rocket failures and loss of life in space than at any other time in space history. Due to

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[79] Cecilia Jamasmie, "Mining the Moon Ready to Lift off by 2025," *MINING.COM*, March 1, 2019, accessed December 10, 2020, https://www.mining.com/mining-Moon-ready-lift-off-2025/.

[80] Department of Energy, "NP Supply and Demand of He-3| US DOE Office of Science (SC)," last modified December 28, 2010, accessed December 10, 2020, https://science.osti.gov/np/Research/IDPRA/3He-Fact-Sheet.

[81] David Grossman, "Space Force: The Truth behind the He-3 Plot Twist," *Inverse*, last modified June 3, 2020, accessed February 3, 2021, https://www.inverse.com/innovation/space-force-He-3.

[82] Cecilia Jamasmie, "Mining the Moon Ready to Lift off by 2025," *MINING.COM*, March 1, 2019, accessed December 10, 2020, https://www.mining.com/mining-Moon-ready-lift-off-2025/.

high demand, new private space companies and developing nations tried desperately to develop rockets. The scarcity of access to lunar resources even led some nations to develop plans for intercepting mining ships returning from the Moon, in hopes of stealing their He-3.

Once these malicious plans became public, the US Space Force, in an effort to ensure the protection and safety of space for all, unveiled its Space Sentinel Program. The Sentinel Program was an autonomous patrol ship program dating back to the late 2020s designed to rescue disabled ships and stranded astronauts, while providing threat warning to space agencies across the world by tracking space debris. These small maneuverable unmanned space ships eventually evolved in configuration to include a small compartment in them that could hold cargo as well as a crew of four. In an effort to ensure the safety of cislunar lines of communication, a fleet of ten Sentinel spaceships were deployed to the orbital station and cislunar Lagrange points. These Sentinels would observe and report all flights into and out of cislunar space, patrol cislunar space, and conduct rescue operations in the event that a ship became disabled or was in distress. If a ship was in distress, the Sentinels had the ability to attach onto the ship and even dock with standard ship configurations to provide support.

However, the biggest contribution to the cislunar region was the Sentinel's presence as a reporting mechanism for space commerce and policing. By 2040, lunar tensions between nations began to cool. A series of G8 meetings over lunar He-3 resulted in most nations feeling comfortable with the United States securing cislunar lines of communication so long as the distribution of He-3 would not be controlled by a single nation or corporation. The United States sent the first fully manned mission to Lunar Base Armstrong to oversee the ground work for the construction of an He-3 refueling platform, and the first ever Lunar Ship Manufacturing Plant. Things weren't perfect, but the security of cislunar space, supported by the presence of men and women at Lunar Base Armstrong, marked a new era of hope and potential that space would continue to be a safe place for all of humanity to explore.

Conclusion

The Infinite Game Continues

Space development as informed by Alfred Mahan since 2020 is not just the development of a single organization or type of technology. Successful US space development over the past twenty years can be measured by the completion of several important achievements, each the result of the collaborative efforts of multiple organizations. While each of these achievements appears to have a singular purpose when viewed individually, the true value comes from their collective purpose.

One of the most significant achievements for the United States in the last twenty years was the establishment of space lines of communication. Like the sea for which Mahan based his theories, these lines of communication were developed by identifying the common routes used for travel throughout space. In order to secure the lines of communication in cislunar space the United States was required to forge a national character capable of developing both the physical infrastructure and the space policy.

Having US astronauts in space can also provide a sense of national pride, bolstering its national character. In space the stakes are high. Time delays between signals coming from Earth to the Moon and limited communication make remotely controlling multiple autonomous systems extremely difficult, but required. When establishing the infrastructure for the cislunar lines of communication the United States relied heavily upon astronauts to ensure that they had a human in the loop. There is no better example of the importance of manned missions in the last twenty years than that of the successful construction of Lunar Base Armstrong.

Lunar Base Armstrong currently operates as the anchor point for the security of cislunar space. Mahan discussed the necessity of securing lines of communication with bases that served as ports for resupply and patrols. Building this base required a collaborative effort between NASA, the US Space Force, and the commercial industry. While the WALL-Es get the most

credit, none of their work would have been possible without the remote guidance from highly trained NASA engineers orbiting the Moon.

Space development is not sustainable without a steady supply of highly trained volunteers. Mahan's theory of harnessing the character of the people required the United States to establish a method of training volunteers. With help from the US Space Force, the Space Cadet University was established, fulfilling the demands of US space development programs.

Ultimately, it is not enough for the United States to become the current leader in space development. Rather, the United States must continue to lead the development of new space capabilities in order to ensure the security of space for future generations. If the United States wishes to continue to be a safe and prosperous space faring people, it is imperative that we continue to press forward and explore the unknown. The theories of Mahan should not be forgotten as there is no great gain without great risk. The wealth gained in space is fragile, and as such the United States must prioritize the security of all areas of space development. Competition for finite resources and technology in the commons of space will always exist. Like the dimensions of time and space, the US development of space is part of an infinite game, never complete, and always in motion.

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