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14. ABSTRACT

A coherent body of theory for “space” has not been established, but several parallels between the space and sea domains suggest Mahan’s theories, through written 130 years ago, can offer insights for competing in space. Mahan’s framework, combined, as this paper will demonstrate, with our technological advantages in space, will enable the United States to build space power and successfully complete in the space domain. Mahan teaches that sea power is obtained by the combination of production, shipping, and colonies and markets. Translated into the space domain, the United States must establish persistent human occupied colonies and stations in the domain. To accomplish this, we must be prepared to operate and develop three types of production and shipping, the traditional Earth-based manufacture of rockets, capsules, and associated equipment for space exploration, digital products and transmissions back to Earth, and in-space manufacturing. The melding of these three ideas, production, shipping, and colonies and markets, will allow the United States to successfully compete in space, and develop, in a word, space power.

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MASTER OF MILITARY STUDIES

TITLE: Building Space Power Using the Theories of Alfred Thayer Mahan

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF MILITARY STUDIES

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Executive Summary

Title: Building Space Power Using the Theories of Alfred Thayer Mahan

Author: Major Kevin Frank Counce, United States Army Reserve

Thesis:

Mahan's theories on sea power offer key insights and a useful framework for thinking about how the US can compete with adversaries in the space domain.

Discussion:

A coherent body of theory for "space" has not been established, but several parallels between the space and sea domains suggest Mahan's theories, through written 130 years ago, can offer insights for competing in space. Mahan's framework, combined, as this paper will demonstrate, with our technological advantages in space, will enable the United States to build space power and successfully complete in the space domain. Mahan teaches that sea power is obtained by the combination of production, shipping, and colonies and markets. Translated into the space domain, the United States must establish persistent human occupied colonies and stations in the domain. To accomplish this, we must be prepared to operate and develop three types of production and shipping, the traditional Earth-based manufacture of rockets, capsules, and associated equipment for space exploration, digital products and transmissions back to Earth, and in-space manufacturing. The melding of these three ideas, production, shipping, and colonies and markets, will allow the United States to successfully compete in space, and develop, in a word, space power.

Conclusion:

Short of direct military confrontation, the United States possess no effective tool to dislodge the Chinese from the South China Sea (SCS). The Chinese are in de facto control of the region and will not acquiesce to international diplomatic or legal challenges on their territorial claims. To prevent a similar Chinese advantage in the critical space arena, this paper demonstrates that the theories that Alfred Thayer Mahan wrote for controlling the sea and establishing sea power are powerful frameworks that can guide the United States to advantage in the space domain. China may hold small islands in the SCS, but the United States will hold the high ground in space.

DISCLAIMER

Figures

Figure 1. Power of Nations Using Beckley Units…………………………………...……….7
Figure 2. Trade Exports in United States Dollars……………………………………………..17
Figure 3. Budget of Space Programs…………………………………………………………….22

Table of Contents

MMS Cover Page……………………………………………………………………………..i

Executive Summary………………………………………………………………………….ii

Disclaimer………………………………………………………………………...…….iii

Figures…………………………………………………………………...………………….iv

Table of Contents…………………………………………………………………………..…v

Preface…………………………………………………………………………...……vii

Introduction…………………………………………………………………………...……1

The Existing Literature: Mahan in Space……………………………………………...……..5

Links in the Chain of Sea Power……………………………………..…………6

General Conditions Affecting Sea Power………………………………………….....9

I. Geographical Position………………………………………………...…9

II. Physical Conformation………………………………………………………..11

III. Extent of Territory……………………………………………………...13

IV. Number of Population…………………………………………………….14

V. National Character…………………………………………………………16

VI. Character of the Government…………………………………………..18

An Interim Conclusion on the Mahanian Conception of Space…………………………23

Technology Review: The State of the Art……………………………………………..…24

The Great Parties in Space…………………………………………………………….25

Crewed Space Vehicles………………………………………………………………..…26

Russian Crewed Space Vehicles…………………………………………………26

United States Crewed Space Vehicles……………………………………...…28

Chinese Crewed Space Vehicles…………………………………………………32

Super Heavy Lift Rockets…………………………………………………………..…33

Russian Super Heavy Lift Rocket………………………………………..…33

United States Super Heavy Lift Rockets……………………………………...34

Chinese Super Heavy Lift Rocket…………………………………………..…35

An Interim Conclusion on The State of the Art ……………………………………………36
Bringing it All Together: Space Power……………………………………………………..37

Preface

Writing this paper reignited the passion I felt as a nine-year-old boy in Florida: in December 1992, my family waited for hours in the chilly morning to watch the Space Shuttle Discovery launch into orbit; the countless trips to Kennedy Space Center as a Boy Scout staring with awe at the historic equipment that carried humans into space; having the honor to meet Astronauts Neil Armstrong, Jim Lovell, and Gene Cernan during their visit to Iraq in 2010; finally, sharing that same passion for space travel with my son, as together we watched (myself with tears) as the SpaceX Falcon9 and Crew Dragon Capsule successfully launched into orbit carrying two American Astronauts. That last event represented the first time since the retirement of the Space Shuttle program that American Astronauts had returned to space on American technology. Part of me will always be that young boy, staring at the sky hoping I would get my chance. This paper is my attempt to be part of the next great step in human exploration.

"The Dream is Alive." – Astronaut John Young, upon touchdown of the Space Shuttle Columbia after its first orbital flight. April 14, 1982

Introduction

China's strategy of reclaiming land in the South China Sea and building military bases on disputed islands and rocks has paid off for Beijing. China has de facto control over the region even though the claims are not recognized by any other nation and falls within the definition of international waters. The United States and other partner efforts to counter China have so far fallen short. China will not cede the territory it physically controls; China effectively owns the South China Sea. The success of its maritime operations in the region has inspired Beijing to replicate the success in the Himalayan mountains. China has undertaken programs to build and populate militarized villages in contested areas boarding India, Nepal, and Bhutan. Once constructed, the villages are populated and overseen by citizens loyal to the Chinese Communist Party.[1] Just as in the South China Sea, China can establish de facto control over the area, play a long game, and wait for international acceptance of the new reality.

The response by the United States to these violations of international law in the South China Sea has been to publicly reject the territorial claims,[2] and to conduct frequent freedom of navigation operations in the region.[3] The United States government is stuck in a cycle of reaction to Chinese provocation and has lost the initiative. A diplomatic option is always a possibility, though less likely for every day that passes with China in control of the area. The fact remains that China is in de facto control of the South China Sea and the economic and strategic benefits that come with it.

How can the United States prevent a similar outcome in another, even greater sphere of competition—space? This paper argues that Washington should get ahead of our near-peer adversaries and conduct our own flavor of anti-access area denial operations (A2/AD) in the space domain. Space, without sounding too cliché, is the final frontier of human exploitation and exploitation. The space domain offers commercial and resource exploitation potentials that could exceed those of the South China Sea by orders of magnitude. Currently commercial opportunities in space have been limited to communications, digital products, and a limited amount of tourism. The first nation to successfully develop space power will be the most advantageously positioned to exploit the domain. But, how does the United States create space power?

The United States has no unifying theory that provides a framework to establish space power. This does not mean the US lacks policies regarding space. The United States and other nations have had longstanding policies on space. Soviet space doctrine in 1984 was militaristic, and its space operations were conducted to support and maintain military superiority.[4] Comparatively, American space doctrine at the time sought to maintain "US Space Leadership" and "Obtain Economic/ Scientific benefits through exploitation of space."[5] Both policies are light on specifics. The National Space Council, a cabinet-level council designed to guide American civil and military space policy, was established in 1989 under President H.W. Bush was disbanded from 1993 – 2017. President Trump reactivated the council in 2017. President Trump and Vice President Pence were enthusiastic about the space domain and, from 2017 to 2021 the council issued seven Space Policy Directives (SPD) with a wide range of topics:[6]

SPD-1 Reinvigorating America's Human Space Exploration Program (2017)

SPD-2 Streamlining Regulations on Commercial Use of Space (2018)

SPD-3 National Space Traffic Management Policy (2018)

SPD-4 Establishment of the United States Space Force (2019)

SPD-5 Cybersecurity Principles for Space Systems (2020)

SPD-6 National Strategy for Space Nuclear Power and Propulsion (2020)

SPD-7 U.S. Space-Based Positioning, Navigation, and Timing Policy (2021)[7]

It is yet to be seen how enthusiastic President Biden and Vice President Harris will be regarding space policy. The Interim National Security Strategic Guidance issued in March 2021 by the Biden Administration is sparse on space. Only two sentences mention the domain, and both are vague: "We will explore and use outer space to the benefit of humanity, and ensure the safety, stability, and security of outer space activities," and "We will lead in promoting shared norms and forge new agreements on emerging technologies, space, cyber space, health and biological threats, climate and the environment, and human rights."[8] Interested in space and space policy has waxed and waned depending on the administration in power.

Compounding the issue of a lack of a policy to establish space power is just how new the domain is. Humans have only been capable of spaceflight since Yuri Gagarin's famous spaceflight in 1961. There is not a wealth of knowledge on how to achieve space power; no long history of success or failure to draw conclusions from. Conversely, human experience with the land and sea domains has a history that stretches back thousands of years, even before the invention of the written language. Theorists such as Clausewitz and Jomini are revered as the prophets of land-based warfare. Similarly, Mahan and Corbett are the scholarly masters of the sea.[9] Utilizing a theory or set of theories that could be reapplied to the space domain would place the United States in a more advantageous position to exploit space against our near peer adversaries.

The space and sea domains are more similar in nature to each other than the sea and land, or space and land. The land domain has been partitioned up, claimed, and occupied by nation-states while the sea and space domains are common or international territory. Both the sea and space domains are treated similarly by international laws. The sea by The United Nations Convention on the Law of the Sea. Space by the Outer Space Treaty, and the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Moon Treaty). Both the sea and space domains require specialized technology, vehicles, and knowledge to enter, the sea with ships and space with rockets, capsules, shuttles, orbital inclinations, etc. When traveling in the sea or space domains ships and spacecraft move from point to point, harbor to port, launch pad to orbit. Refuge is not to be found in the dangerous open waters, under the sea, or in deep space. In terms of warfare, the sea and space domains are even more similar. In both domains a ship or spacecraft has no option to "dig-on" and remain on the defensive. Both domains leave combatants vulnerable to first strike, favoring the side which can bring effective fires to bear first. Vessels can be armored to survive longer just as spacecraft are armored against micrometeorites. Once that armor is defeated then both are susceptible to destruction. There has been no armed conflict in space yet, but modern crewed spacecraft and space stations have been "holed" by space junk and micrometeorites. Finally, and humorously, humans cannot breathe or scream in space or under the sea. The analogy between the sea and space domains may be viewed as flawed by some scholars, this paper acknowledges that comparison is not perfect, however, the sea and space domains exhibit more similarity between each other than the sea and land domains, or the space and land domains.

The United States does not need to reinvent the wheel when looking for a theory on space power. The United States already has a venerated scholar and citizen who literally wrote the book on how to establish sea power, a man who served as a commissioned officer in the United

States Navy for over 37 years and who Secretary of State Henry Stimson referred to as a prophet. The United States can use the theories that Alfred Thayer Mahan wrote for controlling the sea and establishing sea power and reapply those same theories to compete in the space domain and establish space power. A coherent body of theory for "space" has not been established, but several parallels between the space and oceanic arenas suggest Mahan's theories, through written 130 years ago, can offer insights for competing in space. This framework combined with our technological advantage in space will allow the United States to successfully complete in the space domain and build space power.

The Existing Literature: Mahan in Space

This paper's argument expands on and integrates the works of previous thinkers who have also recognized the similarities between the space and maritime arenas, and, specifically, how Mahan's theories might apply to space. Several authors have raised various aspects of the topic, whereas this paper seeks to place these individual treatments into an overall framework. This section will review the links in the chain of sea power and the six general conditions Mahan posits as affecting sea power. Then, this section will move to a review of what various authors have written concerning that specific facet of Mahanian sea power and how it relates to space power.

Links in the Chain of Sea Power

Mahan describes sea power as consisting of three critical factors, production, shipping, and colonies and markets**, "production** with the necessity of exchanging products, **shipping**, whereby the exchange is carried on, and **colonies**, which facilitate and enlarge the operations of shipping and tend to protect it by multiplying points of safety—is to be found the key to much of the history, as well as of the policy, of nations bordering upon the sea. [emphasis added] " [10] Expressed more succinctly as "(1) Production; (2) Shipping; (3) Colonies and Markets, —in a word, sea power."[11]

Production and the ability to trade was for Mahan, the most important aspect of sea power.[12] Mahan notes that not all nations who have an economic inclination will gravitate towards sea power. In the case of France, a populous nation with an industrious people, was never able to grow and maintain a strong maritime legacy.[13] Traveling the sea has historically been fraught with dangers, both natural and human man. The solution to merchant shipping when it ventured far from the shores of the mother country was a strong navy, and a series of colonies[14]. Colonies provided commercial and military benefits. In times of peace colonies acted to project the economic power of the nation allowed for trade. In war the colonies provided defense and the ability to project military might. As Mahan notes colonies were generally chosen for either their strategic or commercial important, though sometimes both in the specific case of New York.[15]

Martin E.B. France makes several connections regarding how space is analogous to the sea. That large portions of global production are transported by the sea, just as "raw and processed data" is transported digitally by satellites.[16] The shipping lanes of the sea can be compared to the orbital pathways of satellites.[17] Further, that if satellites are producing and shipping data that the satellite itself could be considered a seaport.[18]

For Parker, production is analogous to gross domestic product (GDP). Writing in 2003 he breaks out the GDPs of the United States, Germany, France, Russia, China, and Japan. Parker also provides the populations of each nation as well. He notes that the United States is the most economically powerful nation in the world; only the country of Luxembourg has a high per capita GDP[19]. Therefore, his assessment is that the United States has the best capacity for production as defined by Mahan. Beckley, writing in 2018 developed a new metric to measure the power of a nation using GDP and GDP per capita. Beckley first faces a problem in defining power. He uses a quote from Joseph Nye explaining the difficulty in defining power; power is like love, "easier to experience than to define or measure."[20] Beckley states that most scholars measure power in terms of resources, specifically wealth and military assets[21]. Beckley's calculation for power is to multiply GDP by GDP per capita[22]. Therefore, we can estimate the power of various nations using Beckley's methodology. As illustrated in figure 1, the United States is positioned well above our near peer competitors (China and Russia).

Figure 1

Country	GDP (US, Billions)	GDP Per Capita (US, Thousands)	Power (Beckley Units)
United States	20,807.27	63.05	131.19
European Union	15,592.79	35.62	55.54
Japan	4,910.58	39.05	19.18

China	14,860.78	10.58	15.72
Canada	1,600.26	42.08	6.73
Russia	1,464.08	9.97	1.46

All values courtesy of the International Monetary Fund

The crux of Mahan's argument is the establishment of sea power, the combination of production, shipping, and colonies and markets. Several authors connected how the sea and space domains are analogous, how production and shipping could potentially work in the space domain, but none made the great leap that markets and colonies in space are required for space power. Translated from Mahanian speech, space stations and colonies or habitats located on celestial bodies such as the moon. Production and shipping in space will require humankind to rethink what these concepts traditionally entail. As for colonies and markets, the United States and other near peer competitors already have plans for the establishment of new space stations in lunar orbit and a base on the moon. A key difference between Mahanian sea power and space power is that these colonies and markets cannot be militarized. Weapons of mass destruction are forbidden in space, the moon, and all other celestial bodies. Moreover, space is deemed the domain of all humankind to be used for peaceful purposes.[23] What is not explicitly stated in any literature is the need for these colonies and markets to be crewed. Without persistent human habitation a near peer competitor will never recognize an unspoken territorial claim over a station or colony. Not many people remember that the Soviet Union beat the United States to the moon with multiple probes and landers in the 1950s and 1960s. The world *does* remember that America was the first to send people to the moon. In the future, unmanned probes and landers might be the first to plant a flag on far flung planets, and even perform most of the dangerous work there, but humans on the spot will be the determining factor in asserting ownership.

General Conditions Affecting Sea Power

Mahan names six conditions that affect sea power I. Geographical Position. II. Physical Conformation, including, as connected therewith, natural productions and climate. III. Extent of Territory. IV. Number of Population. V. Character of the People. VI. Character of the Government[24]. This paper will review each condition separately, offering insights on how each condition may apply to the space domain.

I. Geographical Position

[A] nation be so situated that it is neither forced to defend itself by land nor induced to seek extension of its territory by way of the land, it has, by the very unity of its aim directed upon the sea, an advantage as compared with a people one of whose boundaries is continental.[25]

Mahan pointed to England an example of a nation with an advantage of geographical position. As an island nation it does not need to fear invasion by land, nor can it extend its territory on land. Additional England holds an advantage by having access to the Atlantic as well as the Mediterranean (Gibraltar), and the ability to concentrate its naval forces quickly to either location. France is mentioned as a nation with geographical disadvantage affecting its potential sea power. Threatened with invasion by land and the desire to extend its continental territories. France cannot concentrate its naval forces from the Atlantic to the Mediterranean or vice versa as the British control Gibraltar[26]. Additionally, a strategic geographic position in the world allows a nation to rapidly concentrate forces against an adversary. Mahan closes out this section by advising that the US will need to establish stations (colonies) in the Caribbean in order to project power to the canal[27].

Martin France glosses over Mahan's first condition by simply stating that "the first three of Mahan's conditions still play an extremely important role in defining a nation's space power."[28] Parker agrees with Mahan that the United States is situated in a strategically advantageous position, having unfettered access to both the Atlantic and Pacific oceans. He also identifies the various overseas territories, possessions, and military bases around the world that allow for power projection[29]. Perhaps an extension of the colonies that Mahan asserted would be required.

The geographical position of the United States gives it a strategic advantage in the quest for space power. First, the United States has had no reason to seriously fear invasion of the continental homeland since the Mexican-American war in 1848. The United States does not need to spend resources to secure the homeland like our near peer competitors Russia and China. Secondly, the United States has access to the Atlantic and Pacific Oceans. These are vital assets when launching and retrieving spacecraft, as oceans and other large bodies of water reduce the possibility of civilian casualties or property damage. The low latitudes Central Florida and Southern California allow launch vehicles to place objects more efficiently into low inclination orbits, while a launch complex in Alaska allows for effective high latitude (polar) and Molniya orbits.

II. Physical Conformation

The seaboard of a country is one of its frontiers; and the easier the access offered by the frontier to the region beyond, in this case the sea, the greater will be the tendency of a people toward intercourse with the rest of the world by it. If a country be imagined having a long seaboard, but entirely without a harbor, such a country can have no sea trade of its own, no shipping, no navy.[30]

In Mahan's judgement, a country must not only have access to the sea via long coastline, but also have harbors for sea-based trade. Have coastline with no ability to bring goods to port would not extend an advantage. Thus, was the case of Belgium, the port of Antwerp was closed as a condition of peace in 1648; the wealth of trade that previously flowed through the city switched to Holland[31]. This change put an end to the sea power of the Spanish Netherlands.[32]

In addition to the coastline some physical conformations of a land lead people to or from the sea. Mahan uses two examples to illustrate his point. First France, its coastline and harbors in both the Atlantic and Mediterranean combines with its safe ports should make it strong sea power. But the French people did not flock to the sea like the English and the Dutch. Mahan asserts France's pleasant land, delightful climate, and the ability to produce more than its people needed worked against sea power.[33] "England, on the other hand, received from Nature but little, and, until her manufactures were developed, had little to export. Their many wants, combined with their restless activity and other conditions that favored maritime enterprise, led her people abroad; and they there found lands more pleasant and richer than their own."[34] Mahan ends the discussion of this condition with a warning for the United States, "internal resources are boundless as compared with present needs; we can live off ourselves indefinitely in "our little corner."[35] That the United States should take heed the example of the French, to not turn inward and ignore the sea.

Turning to space, Martin France writes, “Since all current boosters are staged vehicles that drop expended stages downrange from launch, physical conformation and extent of territory argues in favor of spacefaring nations able to place their spaceports either on the seacoast, where an uninhabited corridor exists into which debris may fall.”[36] He notes the powerful position of the United States by having access to spaceports boarding both the Atlantic and Pacific oceans, as well as smaller space ports in Alaska and Hawaii.

Parker succinctly summarizes Mahan’s writings on physical conformation as “how the physical geography of the country either enhanced or deterred its ability to interact with regions beyond its borders, concentrating of course on the sea.”[37] Parker, like France, notes that the United States has multiple launch sites that enhance our ability for space exploration[38]. Parker notes that the United States is blessed a favorable climate, an abundance of natural resources, and a thriving economy. Any resources not available internally in mass can be obtained through the international marketplace.[39]

As noted by both Parker and France, the United States has multiple launch sites across the United States and her territories. Since Parker’s thesis, written in 2003, the United States has established several new major spaceports, Pacific Spaceport Complex (Alaska), Spaceport America (New Mexico), and the Mid-Atlantic Regional Spaceport (Virginia). This does not take into account the numerous military launch sites that exist at White Sands Missile Range (New Mexico), Barking Sands (Hawaii), and Kwajalein Atoll (Republic of the Marshall Islands).

Mahan, writing in 1890, was worried that our physical conformation similarities to the French would lead us to be an isolationist nation. One could argue that he was correct up until

World War II. Our abundant natural resources and ability to internally produce most manufactured goods and agricultural meant that we had no need to venture outside of our Western Hemisphere bubble. The situation is different today. Our natural resources, position straddling two oceans, numerous overseas possessions, territories, and states, and thriving economy place us in the strongest position to exploit space power.

Geographical Position and Physical Conformation within the space domain is a blind spot that no authors on Mahanian theory have addressed. The establishment of a colony or space station in the domain would, in Mahanian terms, provide unity of the nation's aim towards further exploration compared to a nation which has no possessions in space. The first nation to successfully establish a persistent colony or station in lunar or deep space will establish an advantageous physical conformation over other nations which seek space power. Colonies and stations effectively extend what Mahan would call, the seaboard of a nation, an outlook allowing for power projection and an extension of frontiers.

III. Extent of Territory

As regards the development of sea power, it is not the total number of square miles which a country contains, but the length of its coast-line and the character of its harbors that are to be considered. As to these it is to be said that the geographical and physical conditions being the same, extent of sea-coast is a source of strength or weakness according as the population is large or small.[40]

France and Parker both connect Mahan's quality of harbors to the United States' numerous space ports active on both the Atlantic and Pacific Coasts.[41] We have already discussed the strength of the space ports used by the United States. Space power will require colonies and stations beyond low Earth orbit. Extent of territory will apply to those possessions as well. No author in the review made the connection between extent of territory and space stations or colonies. Some authors were writing before long term space stations were established and the omission can be forgiven. Currently though, no nation has an advantage in this area. The only active space station is the International Space Station, which as the name suggests, is an international cooperative effort between 15 different nations: United States, Russia, Canada, Japan, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.[42]

To build space power and complete in the domain the United States will need to build and crew quality colonies and stations that allow for persistent human habitation. The Soviet Union built and crewed ten low earth orbit stations from 1971 until 2001, culminating in *Mir*. They failed to establish space power with their stations because they did not allow for persistent human habitation. Of course, this argument does not take into account the fact that experimentation was needed to even establish the mechanisms we have to keep humans alive in space for extended periods of time. With the lessons learned from Soviet, American, and Chinese experiences in space, the future of space power will require a persistent human presence on and in quality Mahanian "harbors."

IV. Number of Population

After the consideration of the natural conditions of a country should follow an examination of the characteristics of its population as affecting the development of sea power; and first among these will be taken, because of its relations to the extent of the territory, which has just been discussed, the number of the people who live in it. It has been said that in respect of *dimensions it is not merely the number of square miles, but the extent and character of the sea-coast that is to be considered with reference to sea power; and so, in point of population, it is not only the grand total, but the number following the sea, or at least readily available for employment on ship-board and for the creation of naval material, that must be counted.*[43]

It would be a simplistic argument to just assume that Mahan only meant the number of people in the nation. As shown in the quote above for Mahan it was also the number of people able for employment on ships as well as the craftsmen requirements to build and maintain those ships. Mahan use the term reserve force to describe his concept. Mahan illustrates his point with a historical example regarding French sea power following the revolution. France had a much larger population than England and was initially able to commission and man more ships of the line than England. However, several years later the French had used up all of her reserve of naval manpower and could not man more than 71 ships of the line while England could man 120. The French had exhausted their naval reserve force while the English had not. [44]

Martin France shrugs off the implication of population as “probably not a limiting factor for space power as it might have been at one time for sea power.”[45] However, this is a grave mistake. We just concluded that Mahan did not mean simply the number of people living in a country, but rather population as a reserve force. Parker grasps the intent of Mahan and states that number of people willing to work in space-related industries bode well for space power in the United States and globally.[46]

The United States could be considered by some to be the leader in space related activities. We maintain a robust reserve force of citizens who can either travel to space or work to develop, build, and maintain space power systems. Three of the most successful international private launch providers are based in the United States and received NASA contracts (SpaceX, Blue

Origin, United Launch Alliance). Part of our shared heritage as citizens of the United States is knowing that we are the only nation on Earth to send humans to another celestial body.

V. National Character

If sea power be really based upon a peaceful and extensive commerce, aptitude for commercial pursuits must be a distinguishing feature of the nations that have at one time or another been great upon the sea. History almost without exception affirms that this is true. Save the Romans, there is no marked instance to the contrary. All men seek gain and, more or less, love money; but the way in which gain is sought will have a marked effect upon the commercial fortunes and the history of the people inhabiting a country.[47]

In simple terms, sea power will be gained by those nations and people who seek economic gain. Mahan notes that the "tendency to trade, involving of necessity the production of something to trade with, is the national characteristic most important to the development of sea power."[48] Both France and Parker give an advantage to the United States simply by stating that the United States has the most powerful economy in the world without providing much in the way of backup or support. As shown in figure 1, the United States maintains the most powerful economy in the world in terms of GDP. The European Union would come in second if considered a single nation with China in a close third. In terms of total exports (figure 2) the European Union would dwarf the combined exports of both China and the United States, if considered a single state. Ignoring the European Union for a moment we can see that the exportable trade difference between the United States and China is only $12B.

Figure 2

Country	Exports in $USD (Trillions)
European Union	7.73
China	2.64
United States	2.53
Japan	0.90
Canada	0.55
Russia	0.48

All values courtesy of The World Bank

As France points out, in the near-term future space trade will consist heavily of raw and processed data[49]. Given our current technology, it is prohibitively expensive to launch production goods for trade into orbit and back down again. The Department of Defense has flirted with the idea of rocket cargo used to resupply far flung troops on the battlefield[50]. The future of space trade appears to be harvesting resources from space (heavy and precious metals) and bringing those raw goods back down the gravity well to Earth.

A large portion of Mahan's book is written as a case study on the British Empire and how it was able to cultivate, build, and maintain sea power throughout the centuries. For national character Mahan puts forth that the British an aptitude towards commercial pursuits and trade as a strength for sea power. What is unsaid is that the United States is effectively a child of the British. Our modern mixed market economy stems from our shared British economic history. Our near peer space competitors, China and Russia have a much different past. Their current mixed and transitional economies were born from a communist centrally planned economy. The simple fact is that the United States has been operating as a trade based society longer than our competitors, since even before our birth as a nation in 1776. Economic pursuits and the tendency to trade is in effect, part of our birthright.

VI. Character of the Government

Nevertheless, it must be noted that particular forms of government with their accompanying institutions, and the character of rulers at one time or another, have exercised a very marked influence upon the development of sea power. The various traits of a country and its people which have so far been considered constitute the natural characteristics with which a nation, like a man, begins its career; the conduct of the government in turn corresponds to the exercise of the intelligent willpower, which, according as it is wise, energetic and persevering, or the reverse, causes success or failure in a man's life or a nation's history.[51]

It would be simplistic to argue that, in terms of sea power, a free democratic system of government will perform better than a despotic one. It is especially popular in today's time to make assumptions that only free democratic people can achieve greatness. Mahan notes that free governments have failed to achieve sea power while despotic governments have succeeded. Both systems of government can build great sea power. Just as both systems of government can lose sea power after their leader or government coalition leaves power. As Mahan directly puts it, "most brilliant successes have followed where there has been intelligent direction by a government fully imbued with the spirit of the people and conscious of its true general bent."[52]

Mahan states that the government can influence the sea career of the people in two ways. The first is during peace time, it can favor the natural will of the people to gain by way of the sea, or the government can develop industries when they do not naturally exist[53]. Conversely the government can “check and fetter” the progress that the free people would have taken without intervention. The government will either boost or hinder the people’s desire to work the sea[54].

One historical example used by Mahan is that of the French under the leadership of Jean-Baptiste Colbert, French First Minister of State (1661-1683). Colbert revitalized the French Navy and Merchantman fleet. In this he linked all three of the chains of sea power: production, shipping, and colonies[55]. The speed and efficiency that the French gained sea power astonished even the English. Yet, French Sea power did not last as Colbert was not the king of France. War with the United Providences broke out in 1672, and Louis XIV placed an emphasis on land war; Colbert’s reforms relating to sea power were put on the back burner. French Naval power would continue to be reduced. "Lack of system in the government," says a French writer, "brought about indifference, and opened the door to disorder and lack of discipline.”[56]

Sandvigen, writing in 1984 provides a historical case study regarding the character of government in relation to space power. In 1984 the Soviet space doctrine stated:

> The Soviet Armed Forces shall be provided with all the resources necessary to attain and maintain military superiority in outer space sufficient both to deny the use of outer space to other states and assure maximum space-based military support for the Soviet offensive and defensive combat operations on land* at sea, in air. and in outer space.”[57]

In contrast, US national objectives in space at the time were:

1. Strengthen the security of the United States.
2. Maintain US Space leadership.
3. Obtain Economic/ Scientific benefits through exploitation of space.
4. Expand US private sector investment and involvement in civil space/space related activities.

5. Promote international cooperative activities which are in the national interest.

6. Cooperate with other nations in maintaining the freedom of space for activities which enhance the security and welfare of mankind.[58]

The Soviet Union's purpose for space exploration was aligned with the goals of the military. Military superiority in outer space. Sandvigen notes that our goals are technological and economic in nature. Meanwhile the Soviet Union has one militaristic goal. In 1984 90% of all Soviet Satellite launches were military in nature leaving only 10% with civilian or scientific purpose[59]. Sandvigen ends this prediction regarding the Soviets in space, "As can be seen the Soviets have very far reaching and well-planned objectives for reaching their goals in space. Within the next ten to fifteen years there will probably be many more surprises as this effort moves forward."[60] A cautionary tale for any potential space power, exclude the economic benefits of space power at your own peril.

By attempting to militarize space the Soviet Union failed to build lasting space power. Failing to recognize the economic and commercial aspects of the space domain was a major blunder that Mahan would have warned against.[61] The Soviet space shuttle, *Buran* represents an excellent case for comparing the rationales that drove the Soviet space program. *Buran* was designed explicitly to counter the perceived military threat that the American shuttle represented. The Soviets believed that the American shuttle program was primarily militaristic in nature. The civilian missions being just "good cover" for military missions from Vandenburg Air Force Base.[62] Buran flew only once, a successful unmanned operation in November 1988. After that the Buran was never used again. Deemed too costly to operate for civilian missions or space station support. The Soviets failed to follow the guidance of Mahan. They focused their efforts on controlling space militarily and set up several space stations. But with no eye to the economic vitality of their program, namely the production and shipping, it ultimately failed.

Martin France would agree; he argues that prior to collapse, the Soviets could be considered the preeminent space power in the world. That the Soviets built their space program almost entirely for national security purposes with little commercial aspects. Therefore, the Russian space program collapsed when their economy was in ruin[63]. Interestingly, it was the Russian's that pioneered the selling of seats to wealthy individuals. Strapped for cash, ROSCOMOS, launched anyone into orbit who could pay to ride on their aged Soyuz capsules. After the cancellation of the Space Shuttle Program in July 2011, the only way to reach the International Space Station was to ride a Soyuz capsule. It is ironic that the nation who developed its space program for militaristic needs, ended up using its launch systems in the most capitalistic ways.

Parker does not delve deep into analyzing the government of the United States in terms of space power, only saying "The United States government implements policies that support economic growth and military strength. In the future, these policies will ensure the United States status as a world leader in space and its related industries."[64]

As stated previously, Mahan says that a peacetime government can favor the natural will of the people to gain by way of the sea. Is it the will of the citizens of the United States to explore and compete in the space domain? The indication of numerous private and public companies in the United States devoted to space exploration and exploitation should provide that answer. As to the question, is the United States adequately supporting space, that answer would appear to be yes. The United States outspends China by nearly 7 to 1 (figure 3). These two factors would indicate strongly that the citizens and the government of the United States both support the continued space exploration and therefore, space power.

A weakness for the American effort in space is our democracy and cycle of elections. The desire for space exploration ebbs and flows with the coming of each new administration. An additional concern is public disillusionment of space spending over domestic concerns. Most Americans at the time did not support the Apollo program. A poll in 1979 showed that only 47% of the population thought Apollo was a good idea. Whereas in 1989 that number was raised to 77%. The opinion of the moon landing increased the further away we come from it.[65] The United States government must learn to properly sell exploration and exploitation of the space domain to the public.

Figure 3 – Budget of Space Programs

Country	$USD Billions
United States	$41.00
China	$5.80
Russia	$4.20
Japan	$3.10
European Union*	$2.10

*European Space Agency only. Nations such as France and Germany maintain their own private space programs in addition to European Space Agency funding.

An Interim Conclusion on the Mahanian Conception of Space

Several authors have made the connection between Mahan's theory for sea power and space power. Most of the authors agreed that Mahan's theories suggest the United States is in an advantageous position to compete in the space domain with our near peer competitors. All the authors connect space power directly to some form of military power as well. No author researched studied the concept of space power in purely economic or non-military terms.

Mahan also argues that to achieve sea power a nation must possess a strong navy. The same logic can be applied to the space domain. To achieve space power a nation must possess the capability to sending crewed space vehicles into space using their own indigenous technology. Nations like Japan, India, Germany, or the United Kingdom might be able to enjoy some fruits of space by piggybacking off of great power human space flight technologies. But they will not become effective space powers unless they develop their own (or via pooled resources ala a "Euro" or "Indo-Pacific" consortium) technology to send humans to space using their own devices. For its part, the US as a great power cannot afford to relying on the generosity of other nations to send its citizens into space to compete with rival great powers like China.

Technology Review: The State of the Art

Theory must be translated into practice in the real world. This translation, in turn, hinges on the technical capabilities that great powers can bring to bear in space. In the following section, we will explore the state of the art. The focus for the review will be on the crewed space flight and the ability of a country to reach lunar orbit, also called trans lunar injection. This milestone of sending humans into lunar orbit requires two pieces of technology; a crewed spacecraft and a superheavy lift rocket. Both of these must be capable of operating and launching beyond low earth orbit.

The reason that crewed spaceflight represents the measuring stick for great power competition in space is threefold. First, Mahanian colonies and markets, or space stations and colonies, require a persistent human presence. A parrell can be seen in China's build up of bases in the South China Sea. China made the correct decision of establishing a persistent Chinese presence on the islands to make territorial claims; placing a series of sensors and mechanical equipment would not have the same effect. Second, the area on and around the Moon represents the next frontier of space-based competition. The United States and our near peer competitors have been experimenting with satellite, anti-satellite, and low earth orbit space stations since the 1950s. The space around the Earth is littered with the debris of our exploration. The Moon is the next step. Finally, humans emotionally connect with crewed spaceflight. The desire for human exploration is an ancient impulse that cannot be satiated with machines alone. Citing "emotional" factors may sound overly poetic, but the human commitment to exploration will be a key factor in governments' ability and willingness to fund expensive space technologies. In sum, the future of space exploration and exploitation is and remains crewed spaceflight.

The Great Parties in Space

The space capabilities of only three countries will be evaluated: The United States, Russia, and China. An explanation as to why other countries or space programs were omitted is required. The United States, Russia, and China are the only nations which possess the capability of human space flight using indigenous technology. As this paper has argued, nations wishing to complete in the space domain and establish space power must be capable of establishing colonies and space stations in the domain. As explored in the previous section, the establishment of colonies and ports to project naval power was a fundamental tenant of Mahanian thinking. A nation which relies on another to send it's citizens into space cannot truly establish and maintain a *sovereign* colony or station within the space domain.

The European Space Agency (ESA) technically has the capability for human spaceflight but relies on Russian technology to do so. Currently, the ESA operates three families of space launch vehicles (SLVs). The Ariane and Vega SLVs are indigenous to the ESA and are currently operational. The ESA also purchases Soyuz-2 SLVs from Russia for use at their launch facility in French Guiana. This arrangement benefits both the ESA and Russia. The ESA gains access to a third family of SLVs allowing them to conduct more launches. Russia gains access to the French Guiana spaceport which is located much closer to the equator allowing for a substantial increase in payload capability compared to the Russian's main spaceports at Baikonur or Plesetsk. Neither the Ariane nor Vega SLVS are human rated. While the Soyuz-2 is rated for human space flight the spaceport in French Guiana is not currently configured for human spaceflight.

An additional reason to discount the ESA at this point is their lengthy and strong participation with NASA in space exploration missions. Eleven of the 15 contributors to the international space station are member nations within the ESA (Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom).[66] The upcoming Artemis Program, which aims return humans to the moon by 2024, will include a permanent Lunar Gateway station. The ESA and NASA have already signed an agreement to work cooperatively on the Gateway. The ESA providing funding, material, and technology in return for access to the Gateway by ESA astronauts.[67] The ESA is an international partner with NASA, contributing to the space power of the United States.

Crewed Space Vehicles

The crewed space vehicles of each nation will now be examined. The focus will be on operational vehicles and those in development. The honor of first reviewed will go to Russia as the first nation to send a human into space.

Russian Crewed Space Vehicles

Russia has maintained its status as a major player in human spaceflight.[68] Roscosmos's only current SLV for human space flight is the venerable Soyuz rocket and Soyuz crew capsule. Originally developed in 1967, the Soyuz capsule has remained in service for 53 years and has made over 140 successful flights. The capsule, originally designed for two Soviet Cosmonauts, can now snugly accommodate three people. The Russians, in order to keep their space program alive during the tumultuous years after Soviet breakup, began to sell seats on the Soyuz to international partners and high paying business clients. Russia has the honor of allowing the first space tourist, American Dennis Tito who purchased a ride on a Soyuz capsule in 2001. For eight years after the retirement of the Space Shuttle, and before the successful launch of the SpaceX Crew Dragon spacecraft, the Soyuz capsule and SLV was the only method to deliver and retrieve people from the International Space Station.[69] During this time NASA and other space agencies paid the Russians a fee to be allowed onboard the Soyuz. The Russians have adopted an evolutionary approach to space capsule design instead of revolutionary. They have continued to upgrade the Soyuz since its first appearance; the current Soyuz MS capsule is the 10th iteration its long history.[70] Russia is currently searching for a replacement for Soyuz. The Orel spacecraft, originally named Federation, has been in development since 2009 with plans for a first unmanned testy flight as early as 2024 or 2025. One should expect that this timeline will be pushed back further as it has since 2009. The Orel, unlike the Soyuz will be reusable for future missions and will accommodate up to 6 humans. [71] The Soyuz space capsule represents the backbone of Russian manned space capability for now and into the near future. Internationally known as a reliable and cost-effective platform due to the many years of operation.[72] The Russians should be proud.

The Soyuz capsule has a crew capacity of three people. It has been solely launched various versions of the Soyuz SLV, the most current model is the Soyuz-2. Total cost for a Soyuz capsule launch is difficult to find, NASA was paying up to $86 million for a single seat on a Russian Soyuz prior to the launch of the Crew Dragon.[73] Many tech experts assume that this cost is inflated. The Soyuz capsule is not reusable; a new capsule must be produced for each mission. The Soyuz capsule has a habitable pressurized volume of 8.5 m^3 or roughly 300 ft^3. This volume includes both the orbital module and the decent module. Cosmonauts right the

Soyuz capsule into space in the decent module. Once in orbit they have access to the orbital module containing most of the living and habitation space. Once the mission is complete the orbital module detaches from the decent module and is left in space. This configuration is similar to the Chinese Shenzhou space capsule. However, current and future American capsules in have ditched this design; the entirety of the pressurized spacecraft is designed for atmospheric reentry. The Soyuz capsule has a design life of 30 days operating independently and up to 180 days when docked with the International Space Station.[74] The Soyuz capsule was originally designed for operation within low earth orbit but is capable of lunar orbit as well.

United States Crewed Space Vehicles

On 30 May 2020 the United States returned to manned spaceflight using indigenous equipment with the successful launch of the SpaceX Crew Dragon capsule. Since 2011 the United States was forced to pay for seats on Russian Soyuz crew capsules and space on Russian Progress cargo capsules. The Crew Dragon capsule launched on Falcon9 rockets represent the only method available to the NASA for human space exploration and rides to the International Space Station. The Crew Dragon is a relative a bargain for NASA at $55 per seat vs the Soyuz's $86 million.[75] [76] As another comparison is cost roughly $1.75 billion for each space shuttle launch compared to $400 million for a Crew Dragon.[77] The Crew Dragon was born out of NASA's Commercial Crew Program (CCP) and is the first commercially designed manned space vehicle to become operational. The CCP, started in 2011, saw contacts handed to both Boeing and SpaceX for the development of new low-cost crewed space vehicles. The initial investment was $6.8 billion in 2011, $4.3 billion for Boeing and $2.5 billion for SpaceX.[78] In addition to the two CCP capsules, NASA is developing the Orion capsule for operation outside of low earth orbit for use in the Artemis program.

Space X Crew Dragon

The SpaceX Crew Dragon capsule can accommodate up to seven people for private commercial purposes or up to four astronauts when on NASA missions. The Crew Dragon capsule was designed to be launched from the Falcon9 SLV, both the standard and the heavy variants. In a technological first, both the Crew Dragon capsule and Falcon9 SLVs are completely reusable. SpaceX charges NASA roughly $55 per astronaut or about $209 million per launch. These figures were calculated by NASA's Office of the Inspector General based on the contract awarded to SpaceX in 2014 for the Crew Dragon as part of the CCP. After development costs are subtracted the cost for the first six launches comes out to approximately $209 million per launch.[79] Costs should continue to decrease as SpaceX continues to cut costs increase efficiency. The Crew Dragon has a pressurized volume of 10 m^3 or roughly 353 ft^3.[80] The capsule is capable of operating for 10 days in free flight or up to 210 days when docked with the International Space Station. As part of the CCP, the capsule was designed primarily for operation in low Earth orbit. As previously stated, the Crew Dragon is fully operational following the successful flight and retrieval of the Crew Dragon capsule *Endeavour* in August 2020.[81]

Boeing CST-100 Starliner

The CST-100 Starliner (Starliner) is Boeing's contribution to the CCP. Like the Crew Dragon the reusable Starliner will be able to accommodate up to seven passengers for commercial purposes or four astronauts when on NASA missions. Like the Crew Dragon it was designed to work in low earth orbit.[82] Unlike the Crew Dragon the Starliner was designed to land on the ground; it is the first American space capsule designed for ground landings.[83] The Starliner was designed to work with the Atlas V, Falcon9 and Delta IV, and Vulcan families of SLVs, however at this time only the Atlas V has been used.[84] The Starliner costs roughly $90 million per astronaut and $345 million per launch. These figures were calculated by NASA's Office of the Inspector General based on the contract awarded to Boeing in 2014 for the Starliner as part of the CCP. After development costs are subtracted the cost for the first six launches comes out to approximately $345 million per launch.[85] Costs should continue to decrease as Boeing continues to cut costs increase efficiency. The Starliner has a pressurized volume of 11 m^3 or roughly 390 ft^3, the largest of any spacecraft either in operation or in development.[86] For comparison the retired Space Shuttle had a pressurized volume of 73 m^3 or 2625 ft^3. The Starliner was designed to operate for up to 10 days in orbit, or 210 days when docked with the International Space Station. The Starliner is not operational and is currently undergoing un-crewed tests. The most recent being Orbital Test Flight on 20 December 2019. The test ended in a technical failure as a computer error caused the craft to suffer an orbital insertion issue.[87] The test did prove the viability of the ground landing system. According to Boeing all faults with the mission have been corrected and the next un-crewed test is set for September 2021.[88] The first crewed launch of the Starliner is planned for no earlier than December 2021.[89]

Orion Multi-Purpose Crew Vehicle

The final major American crewed space vehicle under development is NASA's Orion Multi-Purpose Crew Vehicle (Orion). Unlike the Crew Dragon and the Starliner, the Orion is being developed for NASA jointly by Lockheed Martin and Airbus. Orion is a key component of the NASA's Artemis program, which aims to return humans to the moon, build a permanent space station in orbit around the moon, establish a presence on the moon, and prepare for a human mission to Mars. With such lofty goals the development of Orion has taken longer and cost more than the CCP. With a crew of four to six astronauts, Orion was designed from the beginning to operate beyond low earth orbit unlike the Crew Dragon and Starliner spacecrafts.[90,91] Orion was designed to be launched on the Space Launch System which is currently under development. The most recent un-crewed test of the Orion spacecraft was launched from a Delta IV Heavy Rocket. The Orion has a pressurized volume of 8.95 cubic meters or 316 cubic feet.[92] Orion, being designed for operation beyond earth orbit, was designed to operate for up to 21.1 days with no additional modules or compartments required.[93] The cost per launch or seat of the Orion is difficult to calculate. The Orion is being developed as a governmental cost-plus program unlike the CCP which is a fixed cost program. So far development of the Orion spacecraft has cost NASA nearly $12.2 billion.[94] The first six Orion's to be delivered to NASA will come with a price tag of $900 each, this does not include to cost to launch them into space.[95] At this time no crewed flights of Orion have occurred. An un-crewed test flight abord a Delta IV heavy rocket was success in 2014 and proved the capsules ability to insert into orbit and land via splashdown.[96] The first crewed flight is the Artemis II mission scheduled for launch sometime in 2023.[97]

Chinese Crewed Space Vehicles

China is the most recent nation to develop indigenous technology which allows for manned spaceflight. China's only operational space capsule is the Shenzhou, meaning Divine Craft in Mandarin. The Shenzhou is heavily based on the Russian Soyuz capsule though considerably larger. Whereas the Soyuz capsule has a habitable pressurized volume of 8.5 m^3, the Shenzhou has 14 m^3, or over 494 ft^3.[98] This volume is larger than any current or planned American crewed space capsule. Like the Soyuz the Shenzhou is split into two habitable sections, a spherical orbital module containing living space, and a middle module for ascent and decent. When returning to Earth the orbital module is left in orbit. No section of the Shenzhou is reusable. The Shenzhou has seats for three people and launches on the Long March 2F SLV. Cost per launch is difficult to determine. China rarely releases the cost of their space programs and when they do the cost is deceptively low.[99] The Shenzhou, like the Soyuz was designed for operation in low earth orbit. When used in free flight the Shenzhou can operate for up to 20 days. The Shenzhou is currently operational. The first crewed spaceflight was in 2003 and the most recent flight was in 2016.[100]

China is currently developing a successor to the Shenzhou capsule. Unofficially known as the Next-generation crewed spacecraft, the capsule is being designed from the ground up by Chinese National Space Administration. Little is known about the successor to the Shenzhou, it will carry a crew of three to six depending on mission requirements, is thought to be at least partially reusable. Habitable space will be approximately 13 m^3 or 459 ft^3. Unlike the Shenzhou or Soyuz, the Next generation crewed spacecraft will consist of only one habitable section in which the crew lives, conducts experiments, and returns to Earth. The capsule is though to be at least partially reusable. Clearly designed for operation in deep space, the Next-generation crewed spacecraft is expected to have a design life comparable the Russian Orel or American Orion capsules. The spacecraft is not yet operational. China successfully conducted an uncrewed test in May 2020 using the Long March 5F SLV to prove the spacecraft's ability to enter orbit and descend safely. The Next-generation crewed spacecraft is integral to China's future space station program, crewed tests are expected within the next several years. Exact dates are difficult to ascertain.

Super Heavy Lift Rockets

The super heavy lift rockets of each nation will now be evaluated. NASA defines a super heavy lift vehicle (SHLV) as one that can lift at least 50 tons of payload into low earth orbit.[101] A further distinction can be made by assessing the capacity of the rocket to conduct a trans-lunar injection of the payload. A nation wishing to built colonies and space stations in both low earth orbit as well as on the moon and in deep space will require a reliable SHLV or risk being confined to low earth orbit.

Russian Super Heavy Lift Rocket

Russia has no operational SHLV. Since becoming a space faring nation, The Soviet Union/Russia has twice attempted to develop a SHLV with middling success. The first attempt was the disastrous N1 rocket. Originally designed to beat the United States to the moon during the space race, all four test flights ended in complete failure. The program was cancelled in the

1970s. The lack of statis test firing of the complex system of engines was blamed for all failures. The Soviet Union's next attempt at a SHLV was the Energia. Developed for the Buran spaceplane, the Energia was rated to carry at least 98 tons into low earth orbit. It only flew twice and failed to reach orbit due to a technical malfunction on the first attempt. Russia's third attempt at developing a SHLV is named the Yenisei. Details, in English, are difficult to find. Those that are available read like bad propaganda from the Soviet era. The Yenisei, not slated for a test flight until 2028, will apparently be more efficient, reliable, and cheaper than the American SLS. The rocket is projected to be able to lift 103 tons of payload into low earth orbit.[102] At this time, the trans lunar insertion payload capacity of the Yenisei is not known.

United States Super Heavy Lift Rockets

Unlike its competitors, the United States has at least one operational SHLV and another in development. The Falcon Heavy is the world's most powerful operational rocket and the only operational SHLV. This distinction comes with a caveat. The Falcon Heavy is only a SHLV when used in its expendable mode. The Falcon Heavy is capable of operating in a partially recoverable mode where the two side boosters can be reused for future flight. In order to lift the maximum payload of 64 tons into low earth orbit all three rocket cores must be expended.[103] Fully expendable the Falcon Heavy is expected to have a trans-lunar injection payload capacity of 18-22 tons.[104]

The other United States SHLV in development is NASA's Space Launch System, it along with the Orion capsule are the centerpieces of the Artemis program. The SLS has been in development since 2011. The SLS program has fallen behind its original projected timeline to be fully operational by 2017 with a manned lunar mission by 2021.[105] The first unmanned test flight is scheduled for November 2021 with a manned flight to follow in 2023 for Artemis 2.[106] The SLS is being designed to operate in two different versions, block 1 and block 2. The version used on mission will be determined by payload requirements. The higher rated version of the SLS is the block 2. The SLS block 2 has a protected payload capacity to low earth orbit of 131 tons and 45 tons to trans-lunar orbit.[107] A tangential note or fun fact, the solid rocket boosters which will be used on the SLS are nearly the same as was used on the Space Transportation System. The boosters are the only solid rocket motors in the world to be rated safe for human flight.[108]

Chinese Super Heavy Lift Rocket

China is currently developing a SHLV, the Long March 9. Details are slim as the project was only officially approved and announced via state TV in February 2021. The Long March 9 is being developed to have a low earth orbit payload capacity of 140 tons and more than 50 tons of capacity to trans-lunar insertion. The Chinese would like to eventually make the booster sections reusable. [109] Like the Russians, the Chinese expect their SHLV to be more powerful, more efficient, and more reliable than the American SLS. Though not until 2030.

An Interim Conclusion on The State of the Art

By 2023 the United States has the potential to possess three independent options for sending humans into space. The SpaceX Crew Dragon and Boeing Starliner capsules and their associated family of SLVs can provide low-cost access to low earth orbit. Just as important each CCP capsule comes with its own family of SLVs. A failure of one CCP system can be compensated by the other providing redundancy; an important element in the space domain considering past failures. The Space Shuttle program was twice grounded due to catastrophic failures. After Space Shuttle Columbia disaster in 2003, the United States was forced to rely on a foreign nation to resupply the International Space Station. With multiple indigenous options available to NASA the risk of relying on Russia to ferry personnel and supplies to and from the International Space Station is reduced.

The success of the CCP allows NASA to focus on missions which push the limits of crewed spaceflight to the Moon and beyond. Missions which offer commercial entities little reason to undertake. Companies like SpaceX and Boeing, who are space powers within their own right, would have little incentive to develop, plan, and launch deep space probes or crewed missions entirely devoted to scientific curiosity. The future of NASA human spaceflight is the Artemis program, with such loft goals as building a Lunar Gateway station in Lunar orbit, as well as a Lunar basecamp, will require a sizeable amount of resources and funding. The success of the program will allow for Lunar exploration and exploration as well as the future missions to Mars. Exploration of the Moon by NASA will figuratively pave the way for future commercial missions and exploitation.

In comparison, Russia and China have only one system low earth orbit system each to lean on. Both built around the aging, yet reliable Soyuz capsule. Both nations are years away from a modern space capsule designed to operate outside of low earth orbit and even further from developing SHLV capacity. The United States and our space domain allies have opened a technology gap over Russia and China. Now the question is, what will we do with it?

Bringing it All Together: Space Power

For Mahan, production, shipping, and colonies and markets were intertwined. A nation cannot have just one or two factors. Only when combining all three factors can a nation truly establish sea power.[110] Establishing and maintaining space power will require the same three factors. Not fully committing to all three will cause a failure of the system.

Mahan's treatment of production and shipping—the process of producing a physical good in the home country and transporting the good via the sea to market—made sense during his time period, but the traditional concept must be modified for the space domain. Transporting physical goods from one point of the Earth to another via space is costly. Currently no nation or company operates orbital shipping. The Army has flirted with an idea for a quick resupply of troops by orbital resupply.[111] The potential is there for future use, but the cost of launches must come down before orbital shipping could be considered commercially viable. In order to successfully compete in the space domain, the United States must establish permanent colonies and stations in the domain, to accomplish this America must be prepared to operate and develop three types of production and shipping, the traditional Earth-based manufacture of rockets, capsules, and associated equipment for space exploration, digital products and transmission back to Earth, in-space manufacturing.

Building space power as China has built sea power in the South China Sea will require a significant and persistent human presence. Compounding importance of human habitation within the space domain is the news that both are our near pear competitors, China and Russia, have recently signed a pact to collaborate with a future lunar gateway, although this likely remains aspirational more than practical, for now.[112] Meanwhile, America's own Lunar Gateway is planned for an initial launch in no earlier than 2024. Contracts for the first stages of the permanent space station have been awarded to SpaceX.[113] When American Astronauts return to the Lunar surface in 2024 on the Artemis III mission, one of their many missions will be scouting a location for a future lunar base, named the Artemis Base Camp. One space station and a lunar base camp will not be enough. Colonies and stations are the ends to the way. The means are the various methods of production and shipping that will be required to build, equipment, and sustain the future outposts of human habitation in space.

As shown in the State of the Art section, the United States is currently in an advantageous position concerning the traditional manufacture of both SLVs and crewed space capsules. By 2023, America will have three different options to send humans into space. The CCP placed the United States into marked advantage over our near peer adversaries. CCP funding allowed both Boeing and SpaceX to build and bring to market an entirely new family of SLV and crewed space capsules. The companies retain ownership of the products which can be used for contracted NASA flights or for commercial civilian flights. Additionally, the United States is the only country to have an operational SHLV with an additional system slated for operation by 2023. Our near-pear competitors have at least another decade before obtaining an operational

SHLV. While America may be currently in the lead, complacency cannot be allowed to overtake the hard-won successes. The United States must continue to be the world leader in the traditional Earth-based manufacture of space technology including SLVs, crewed space capsules, satellites, etc. Establishing colonies and stations on the Moon and deep space will require an advanced Earth-based manufacture capability.

Digital products and transmissions blur the line of what Mahan viewed as production and shipping, but are no less important. Digital production and shipping requires a robust traditional manufacture method as described above. Satellites must be produced and launched into orbit. Satellites provide communications, internet, radio, global positioning, etc. and transmit those signals back to earth. Mahanian production and shipping in the digital world. One example of a single company combing both the traditional manufacture method and the digital is SpaceX with its Starlink satellite internet constellation. SpaceX produces the Falcon9 reusable SLV as well as the Starlink satellites. Once in orbit, the Starlink satellites provide broadband internet signals to Earth. The Starlink satellite, once the product, is now become the method of shipping. A strong digital infrastructure will be required to communicate with future missions not only in low earth orbit, but also on the Moon and deep space.

The final piece of the production and shipping puzzle is In-Space Manufacturing (ISM). Succinctly put by NASA, ISM represents a "paradigm shift in the design and manufacturing of space architectures." Currently limited to plastic 3D printing on the International Space Station, ISM will need to grow significantly if America is to complete in space.[114] The confirmation that ice exists in significant quantities on the Lunar surface represents a significant potential advantage of ISM over Earth-based manufacture for specific applications.[115] Water can be used to drink, to grow plants hydroponically, and to separate the hydrogen from the oxygen and used as rocket propellent. The latter is the most exciting, as it would allow for the refueling of rockets in Lunar orbit. Refueling rockets in lunar orbit will open Mars, the Asteroid Belt, deep space to human exploration and exploitation. ISM could also be applied to the construction of Lunar and Martian colony bases. Establishing colonies on another celestial body will require a significant quantity of building materials. Unlocking the ability to produce concrete or a building block like substance from Lunar or Martian regolith will drastically speed up construction times while also reducing the amount of payload that must be launched from Earth. While ISM is the least developed of the production and shipping methods, it has the potential to set off to largest phase of human expansion since the re-discovery of the New World. The important of ISM cannot be downplayed if the United States has any ambitions of space power.

Short of direct military confrontation, the United States possess no effective tool to dislodge the Chinese from the South China Sea. The Chinese are in de facto control of the region and will not acquiesce to international diplomatic or legal challenges on their territorial claims. The United States can learn from the Chinese by conducting the same actions in the emerging space domain. However, the United States lacks a framework or theory to apply to the space domain to effectively compete. As the space and sea domains and similar in many ways, the United States can use the theories that Alfred Thayer Mahan wrote for controlling the sea and establishing sea power, and reapply those same theories to the space domain. Mahan's theories, through written 130 years ago are still applicable to the modern world. Mahan teaches that sea power is obtained by the combination of production, shipping, and colonies and markets. Translated into the space domain, the United States must establish persistent human occupied colonies and stations in the domain. To accomplish this we must be prepared to operate and develop three types of production and shipping, the traditional Earth-based manufacture of rockets, capsules, and associated equipment for space exploration, digital products and transmissions back to Earth, and in-space manufacturing. The melding of these three ideas, production, shipping, and colonies and markets, will allow the United States to successfully compete in space, and develop, in a word, space power.

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