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As the newest warfighting domain, U.S. interests in space must now be considered more carefully. Further, the U.S. military must be prepared to defend its national interests and maintain competitive advantage in a contested space environment. As identified in the 2018 National Defense Strategy, a resurgent Russia and a rising China add new complexity for military professionals to prepare for future conflict. Further, the reduction of the cost associated with space technologies coupled with the proliferation of space access by the commercial sector will raise the international stakes of economic competition. This paper will explore the intersection of great power competition and space as a contested environment. In particular, great power competition with China and Russia within the space domain provides a context to examine how adapting Alfred Thayer Mahan's and Sir Julian Corbett's naval warfare concepts may offer practical strategy suggestions to enable the U.S. to maintain the competitive advantage and secure vital national interests in space. For example, just as access to the seas was a method for a nation to generate wealth and enable security as expressed by Mahan, the space domain draws similar parallels to today and the foreseeable future.

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Executive Summary

Title: A "Maritime Strategy" for Space – Adapting Sea Power and Naval Warfare Concepts to the Space Domain and National Power

Author: Major Daniel Kovatch, United States Marine Corps

Thesis: By applying concepts from two prominent naval strategists, Alfred Thayer Mahan and Sir Julian Corbett, nineteenth century theories of sea power and naval warfare concepts can provide key insights to inform U.S. approaches to twenty-first century space strategy and enable the U.S. to maintain the competitive advantage over strategic pacing threats like China and Russia.

Discussion: As the newest warfighting domain, U.S. interests in space must now be considered more carefully. Further, the U.S. military must be prepared to defend its national interests and maintain competitive advantage in a contested space environment. As identified in the 2018 National Defense Strategy, a resurgent Russia and a rising China add new complexity for military professionals to prepare for future conflict. Further, the reduction of the cost associated with space technologies coupled with the proliferation of space access by the commercial sector will raise the international stakes of economic competition. This paper will explore the intersection of great power competition and space as a contested environment. In particular, great power competition with China and Russia within the space domain provides a context to examine how adapting Alfred Thayer Mahan's and Sir Julian Corbett's naval warfare concepts may offer practical strategy suggestions to enable the U.S. to maintain the competitive advantage and secure vital national interests in space. For example, just as access to the seas was a method for a nation to generate wealth and enable security as expressed by Mahan, the space domain draws similar parallels to today and the foreseeable future.

Conclusion: A modern adaptation of Alfred Thayer Mahan's and Sir Julian Corbett's sea power and naval strategies of the offensive and defense, respectively, provide a well-balance, clear-eyed approach to addressing security interests of the space domain in an emerging era of great power competition.

INTRODUCTION

The 2018 U.S. National Defense Strategy (NDS) describes a security environment highlighted by strategic competition. The NDS makes clear that, "failure to meet our defense objectives will result in decreasing U.S. global influence, eroding cohesion among allies and partners, and reduced access to markets that will contribute to a decline in our prosperity and standard of living."[1] Given the complex and ever-changing character of warfare, new technologies and warfighting domains will stress the U.S. Department of Defense in this emergent era of strategic competition. Two such responses taken by the U.S. Department of Defense in 2019 to address the growing threats posed by our adversaries are: 1) formal designation of space as the newest warfighting domain and 2) the creation of the United States Space Force, a separate service within the Department of the Air Force. Although these two responses are not aimed at provocatively suggesting the U.S. seeks or desires a conflict in the vast reaches of space, they do indicate a clear national interest for access to and use of space.

With space as a domain for the U.S. to seek and maintain the competitive advantage, this paper sets a course to explore those elements of national strategy that are best suited to attain U.S. national defense objectives, including global influence and access to economic markets, in space. In order to understand how space-based operations impact U.S. defense objectives, this paper briefly examines the current U.S. reliance on space as an instrument of competitive advantage, as well as highlight the critical capabilities and actions of other potentially adversarial strategic competitors in the space arena, such as an emergent China and a resurgent Russia. Further and more importantly, this paper explores how "old" concepts may offer a "new" way forward for addressing U.S. national interests and concerns within the domain of space. Specifically, this paper asserts that analysis of classical thinking on maritime strategy, sea power,

and naval warfare provide insights on the space domain. Absent a fully mature body of space theory, this paper argues that looking back to "old" concepts can inform the "new" domain of space. To achieve this examination, the intersection of economic power and military power will be explored through two naval theorists, Alfred Thayer Mahan and Sir Julian Corbett, in order to provide frameworks to explore how naval warfare concepts provide useful frameworks for current discussions on space and its role in securing U.S. national interests. Through these two prominent naval theorists, this paper posits that nineteenth century theories of sea power and naval warfare concepts can provide a foundation for twenty-first century space strategy and enable the U.S. to maintain the competitive advantage over strategic pacing threats like China and Russia.

BACKGROUND

Before discussing either naval theorist, this paper first establishes a baseline understanding of how space-based operations impact U.S. defense objectives, as well as highlights the critical capabilities and actions of other strategic competitors in the space arena with the potential for adversarial intentions, like an emergent China and a resurgent Russia. Additionally, it is important to highlight the benefits and risks associated with space-based operations across the international security spectrum regarding space proliferation by both state actors and the commercial sector. Further, establishing an appreciation for the historical context of the U.S. in space will aid in the subsequent discussion of Mahan's and Corbett's naval theories.

Space: Strategic Advantage

In the late 20th century, only the U.S. and the Soviet Union maintained both the means and national will to compete in space, yet by the end of the Cold War, the U.S. found itself the

sole remaining superpower with dominance in space. As part of the "Space Race" during the Cold War, the U.S. developed numerous space-based capabilities that enabled the U.S. and, by extension, its allies and partners, a unique strategic advantage. Capabilities ranging from satellite communication (SATCOM), missile warning, Intelligence, Surveillance, and Reconnaissance (ISR) imagery, environmental monitoring (weather), and Position, Navigation, and Timing (PNT), like Global Positioning System (GPS), created exceptional advantages for the U.S. military. These advantages were gained in part through space access to different types of orbits.[i] Further, the benefits of these space-based capabilities do not just include the U.S. military, but extend to the global population, making many of these space capabilities critical to everyday life for millions of people across the globe. In fact, global commerce is heavily dependent upon the services provided by space-based technologies.

The ubiquitous spread of these space services, in concert with the unique strategic advantages they provide the U.S. military, have led numerous other nations, and private industries, to invest and deploy similar space assets, to include potential adversaries. Today, a rising China is deploying vast numbers of various types of satellites and the continued commercial potential of space is just beginning to be understood. As potentially adversarial nations like China and Russia further develop their space-based capabilities and capacity, the U.S. competitive advantage in space will decrease. The increase of access to space by potential adversaries and private industry presents complex challenges and risks to U.S. national interests, to include state-based space proliferation, counterspace weapons, and commercial-based space proliferation.

[i] Although delineating different space orbits may sound like a technical issue, the topic is important to strategy in terms of understanding "key terrain". In similar fashion, key terrain in naval strategy includes an understanding of coastal seas, naval chokepoints, and sea lines of communication. Further, while key terrain plays an important role in military strategy, the seizure or control of key terrain offers benefits or advantages in other disciplines and applications as well. For an explanation of space orbits and their associated utility, refer to Appendix A.

State-based Space Proliferation

The significant growth of space-based capabilities by peer strategic competitors, like China and Russia, continue to add challenges and risks to U.S. military operations and reduce the competitive advantage space provides the Unites States.[ii] From the end of the Cold War to today, our adversaries have witnessed the remarkable military advantages gained through space systems. The first such example came in the Gulf War, in which U.S. and coalition forces used GPS to facilitate long-range maneuver and precision targeting. Additional advances in ISR capabilities, one of which includes satellite imagery, led to technological overmatch on the battlefield. This integration of space-based technology on the part of the U.S. military led to China's development of an offset strategy to counter our competitive advantages, namely through asymmetric means.[2] In fact, over the past decade China has rapidly expanded its military and commercial space sectors, successfully conducting more than 200 orbital launches and creating its own PNT constellations.[3] On a larger scale, this offset strategy is made possible by the "reduced cost of space technology and launch services [which] have supported explosive growth in the number of objects in space and enabled numerous countries to acquire advanced technologies, boosting their own space industries and countering U.S. competitive advantage."[4] This reduced cost of accessing and operating in space will only increase and encourage the use of space systems by our adversaries.

Counterspace Weapons

[ii] While the United States remains the most prevalent owner of space assets on orbit, strategic competitors like China and Russia are expanding their constellations of satellites on orbit. Appendix B is a graphic that highlights countries that own space assets on orbit as well as a breakdown of satellite function by country. The data is current as of December, 2018.

In addition to the reduced financial costs associated with accessing space, the development of counterspace technologies, like anti-satellite (ASAT) weapons, further complicates U.S. military operations in space and potentially threaten vital U.S. national interests. As the name implies, counterspace weapons are designed to deceive, disrupt, deny, degrade, or destroy by means of physical, non-kinetic physical, electronic, or cyber attack a targeted satellite or constellation of satellites.[5] Furthermore, ASATs may be ground-based or space-based weapons. A Center for Strategic & International Studies report published in 2020 on space threats describes the two different types of ASATs and briefly summarizes their characteristics, noting:

> A direct-ascent ASAT weapon attempts to strike a satellite using a trajectory that intersects the target satellite without placing the interceptor into orbit. Ballistic missiles and missile defense interceptors can be modified to act as direct-ascent ASAT weapons provided they have sufficient energy to reach the target satellite's orbit. A co-orbital ASAT weapon differs from a direct-ascent weapon because it is first placed into orbit. When commanded, the satellite then maneuvers to strike its target. Co-orbital ASATs can remain dormant in orbit for days or even years before being activated. A key technology needed to make both direct-ascent and co-orbital ASAT weapons effective is the ability to detect, track, and guide the interceptor into a target satellite. An onboard guidance system requires a relatively high level of technological sophistication and significant resources to test and deploy.[6]

Examples of counterspace weapons include: cyber effects that insert false data (deceive), use of high-powered lasers or microwaves to effect satellite receptors (disrupt), electronic spoofing of SATCOM signals (deny), electronic uplink or downlink jamming of digital signals (degrade), and co-orbital ASATs (destroy).

While counterspace weapons had first been developed and tested by both the U.S. and the Soviet Union during the "Space Race", technological improvements now include an array of weapons technology. These emergent technologies enable attack across the whole spectrum of

space-based technology.[iii] It is important to note that all space systems are organized into three segments: the space segment (e.g. satellite), the ground control or terrestrial segment, and the link segment that connects the other two segments.[7] Any of the three segments are potentially vulnerable to counterspace weapons effects. While emergent technologies certainly play a role in threats to satellites, more traditional military approaches, such as Electronic Warfare (EW), also can play a role, such as jamming the link or ground control segment.[iv] Of this wide array of counterspace weapons, however, arguably the most devasting to space systems is the ASAT.

Prior to 2007, the only nations with demonstrated direct-ascent ASAT weapons were the United States and former Soviet Union, as both nations conducted testing in the 1950s during the Cold War. As noted by author Clay Moltz, "space security evolved during the Cold War in two primary stages: the 1957 – 62 period (characterized by military-led approaches) and the 1963 – 91 period (characterized mainly by military "hedging" and negotiated approaches)."[8] Regarding direct-ascent ASAT tests, the results yielded substantial amounts of debris in space, as well as released significant amounts of radiation which had the potential to adversely impact future satellite operations. Both nations came to view the continued testing of these weapons as detrimental to future space operations. The discussion regarding ASATs dramatically changed, however, in 2007 when China successfully launched an ASAT missile targeting a Chinese weather satellite that had reached end of service life. Nearly a decade later, several thousands of pieces of debris remain in orbit, which poses a safety of flight concern for satellites currently on orbit due to risk of collision.[9] Moreover, India, in 2019, successfully conducted an ASAT missile test that was largely regarded as a response to the growing regional power of China in the

[iii] Appendix C displays an unclassified graphic of these emergent counterspace weapons technologies.
[iv] Electronic Warfare in the form of jamming can be achieved against space systems in several methods. Appendix D provides examples of how EW can act as a form of counterspace weapons technology.

region.[10] Given the potential impacts of great power competition, ASATs now pose an even larger issue in discussing future security in space.

As the development and proliferation of counterspace weapons capabilities and technologies continue, the threat to U.S. national security interests and to the future accessibility of space dramatically increase. Clearly counterspace weapons development and employment by nations like China and Russia pose significant risk in our current era of great power competition. Further, Indian ASAT development serves as a potential signpost for other nations seeking to gain international leverage. The message to nations is clear: develop counterspace weapons, with ASATs representing the ultimate symbol of national power, or risk being left on the sidelines in space.

Commercial-based Space Proliferation

The second factor that adds challenges and risks to U.S. and coalition military operations is in the rapidly growing commercial-space sector. For example, two areas in which space-based technologies have experienced that greatest growth are in the telecommunications industry and in industries that utilize commercial remote sensing, like geologists, farmers, and urban planners.[11] The rise of "The Space Barons" like Elon Musk and Jeff Bezos with their companies SpaceX and Blue Origin, respectively, represent a transformative shift in the role access to and use of space effects the commercial-space sector. As author Christian Davenport offers, "these Space Barons were behind some of the biggest brands in the world – Amazon, Microsoft, Virgin, Tesla, PayPal – that have disrupted industries ranging from retail to credit cards to air travel. And now they were betting vast swaths of their enormous fortunes that they could make space available to the masses, and push human space travel past where governments had gone."[12] By leveraging their massive fortunes to tackle the costs associated with space launch, known as "up" costs, men like

Musk and Bezos seek to build a fleet of multi-use spacecraft, like SpaceX's Falcon 9 with its reusable boosters, with the goal of offering the potential of commercial human space flight.

Moreover, space-based applications and technologies have come to dominate the world economy. From banking services to navigation, the rapidly growing commercial applications of space-based capabilities enables daily life in the civilian sector and in global markets. Furthermore, the more interconnected global financial markets become, the greater the role of commerce supported by space-based capabilities will impact and influence U.S. national interests. An increase in the U.S. economic interdependence on space and space-based capabilities will significantly increase the national interests resident in the space domain. As a result, it will be in the best national interest of the U.S. for space to remain freely accessible and free from conflict. The U.S. military will be responsible for setting and maintaining such conditions.

Further, while treaties from the "Space Race" during the Cold War, like the 1967 Outer Space Treaty and those that followed, remain in effect today and prevent the deployment of weapons of mass destruction in the space theater, they do not explicitly prohibit weapons in space. As described by a recent National Air & Space Intelligence Center report, space is becoming increasingly militarized. As more assets, private or state-based, are launched in to space, the increase in technological "dual use" capacities of satellite payloads creates challenges to security concerns. For example,

> Dual-use capabilities will challenge U.S. ability to provide advanced warning of nefarious intentions or discern between peaceful and potential hostile activity. For example, future satellite servicing and recycling capabilities incorporate a variety of technologies, such as robotic arms, to inspect, repair, or dispose of damaged satellites. However, the same technologies have inherent counterspace capabilities that could be used to inspect non-consenting satellites or to cause physical damage, steal parts, or grapple with a satellite.[13]

This paradigm increases the complexity of threat analysis by the U.S. military for space systems launched by potential adversaries and challenges deterrence in space. With technological advances continuing into the foreseeable future, coupled with reduced "up" costs, the number and variety of space systems expected to be launched will increase. Further, the "dual use" nature of many satellite payloads; the inherent difficulties in attribution, similar to issues that still persist today in the cyber domain; and the increasing commercial sector proliferation in space only add to security complexity and challenges to protecting vital U.S. national interests.

SPACE AS THE NEW "OPEN COMMONS"

Although space is clearly a potential conflict zone, there is also a historical precedent for establishing international customary law and mutually benefitting cooperation in space. For example, in the early day of sail, vessels underway were guided by the customs and attitudes of the ship's captain. The decision to provide aid to other vessels or sailors in distress was held solely by one individual with a high degree of autonomy. From those early days of sail to modern times, the development of international norms and customary law to guide and regulate acceptable behavior on the seas eventually led to codified treaties. In particular, the United Nations Convention on the Law of the Sea (UNCLOS) established the rule of law upon the international territory of the high seas. In much the same way UNCLOS provided a universal set of standards and values for seafaring nations and vessels, the 1967 Outer Space Treaty established similar restraints and constraints upon spacefaring nations, and offers a signpost for future treaty-based norms.

Security in the "Open Commons"

The United Nations Outer Space Treaty of 1967 established standards for acceptable behavior of nations in space. Chief among these standards was the establishment of space as an

area intended for peaceful purposes that would serve the common interest of all mankind. To be clear, similarly lofty rationales for international norms at sea were not always realized. Although the establishment of use of the sea by all eventually came to be common law, during European colonial expansion, for example, establishment of foreign outposts or the claiming of foreign territory was relatively unregulated and often resulted in conflict. Despite this distinction, the similarities between seafaring nations' activities in the domain of the sea and spacefaring nations' activities in the domain of space offer a useful context to frame potential accepted rules of the road governing state behavior.

Just as UNCLOS does not guarantee the "freedom of the sea" and eliminate the prospect of conflict in that domain, the United Nations Outer Space Treaty of 1967 does not preclude conflict in this modern day "universal open commons". Given the potential shared advantages that cooperation vice conflict offers, however, both peace in space and on the oceans are ideals to which nations aspire, even as states will still act unilaterally in pursuit of their national interests. As Frank Klotz notes, "whatever merits the Outer Space Treaty and other agreements may have in establishing the ground rules for national activities in space, they alone do not preclude the possibility that nations could engage in military action to interfere with access to space or the safe operation of satellites."[14] In similar fashion, the declaration of an Exclusive Economic Zone (EEZ) or the establishment of a naval blockade also disrupts accepted behaviors between nations. For example, current territorial disputes over manmade islands in the South Pacific serve as potential flashpoints for international conflict. The implications of a regional conflict in the South Pacific for the world economic system would be devasting, as vast quantities of world trade pass through this heavily trafficked sea lane on a daily basis. By comparison, conflict in

outer space also has the potential to effectively crash global markets and severely impact both spacefaring and non-spacefaring nations alike.

DRIVERS OF ECONOMIC POWER

Having explored some of the similarities of space and the sea, this paper now focuses on the first naval theorist: Alfred Thayer Mahan. First, a review of Mahan's theory offers a linkage between sea power and the economic wealth of a nation.[v] Next, adapting Mahan's maritime theory to the twenty-first century space domain translates to present day great power competition and protection of national interests by maintaining the competitive advantage in the space domain.

Mahanian Theory of Sea Power

Writing in the late nineteenth century, Mahan's seminal work *The Influence of Sea Power Upon History* laid out the key relationship between sea power and the economic well-being of a nation. As a veteran of the American Civil War, Mahan was influenced by the successful blockades of the Confederate South and saw its devastating effect on the Confederate economy. Mahan came to appreciate firsthand the impact a naval power could have upon an adversary. Further, as a student of naval history, Mahan studied how the exploits of the Royal Navy in the eighteenth century led to far-reaching economic effects across Europe and served as a guarantor of wealth to the British. These effects were even felt in the U.S. economy following the British dominance over the Dutch fleet, effectively shutting down the streets of Amsterdam.[15] Additionally, despite U.S. efforts to "discourage the British by attacking their sea-borne commerce…that had not prevented the Royal Navy from attacking wherever it wished along the US coast, burning the capital, Washington, and coming close to sealing the Mississippi River

[v] This paper will examine Mahan's thinking on naval combat – stressing offensive action by the big-gun battlefleet to win naval supremacy – below.

mouth (the major outlet for much of US agriculture) by seizing New Orleans"[16] during the War of 1812.

For Mahan, the economy of a nation was increasingly linked to other nations and access to the sea which could enable a nation to secure economic growth. To Mahan, it was therefore crucial to develop and maintain a strong naval and merchant marine capability in order to protect access to trade and support foreign policy abroad. This is the essence of control of the sea to Mahan. As the U.S. began to generate considerable wealth after the American Civil War, the U.S. Navy convened a board to conduct a review of naval strategy. At the time, Mahan was a faculty member at the Naval War College and advised the board that to prevent the U.S. from becoming a target of a European power, in the future, a large fleet capable of threatening a foreign shore was necessary to defend American economic interests. This concept "was the beginning of the long-term US shift towards strategies of forward engagement,"[17] which was founded on the underlying theme of control of the sea. As Philip Crowl points out, Mahan had written, "The stoppage of commerce compels peace…control of maritime commerce through command of the sea is the primary function of navies,"[18] prior to his advisement of the naval strategy board. Therefore, according to Mahan, the military instrument of national power - specifically the navy - enabled the economic prosperity of the nation.

Space Applications of Mahanian Theory

Much like Mahan viewed sea power as a means to generate economic and therefore national power for a nation, the space domain provides similar opportunities in the twenty-first century. Regarding U.S. national space policy in the late 1990s, then Secretary of Defense William Cohen issued a memo stating, "Space is a medium like the land, sea, and air within which military activities shall be conducted to achieve U.S. national security objectives. The

ability to access and utilize space is a vital national interest because many of the activities conducted in the medium are critical to U.S. national security and economic well-being."[19] Cohen's statement clearly echoes Mahanian precepts relating the defense of national interests through military means to economic prosperity.

Furthermore, much like Mahan's sea control concept, space shares a similar concept known as space control. Joint Publication 3-14 Space Operations defines the method and purpose of space control as "operations to ensure freedom of action in space for the US and its allies and, when directed, to deny an adversary freedom of action in space. The purpose of these operations is to achieve space superiority."[20] Therefore, the definitions of sea control and space control share similarities, namely in that they both promote unconstrained friendly access to the domain and enable effective deterrence of the same to adversaries.[21]

Moreover, the similarity between sea control and space control is advanced by Mahan's concept of forward engagement. By executing space control actions, the U.S. is able to project power through space-based resources like GPS navigation and remote sensing satellites while benefiting from the economic prosperity offered by a secure space domain. Additionally, SATCOM and ISR platforms assist the U.S. military to coordinate diverse actions across the range of military operations from geographically dispersed environments. It enables rapid consolidation of forces as well as coordination during disaggregation. For example, the increasing prevalence of unmanned drones in operational theaters, combined with enhanced communications, data networks, and precision-guided ordinance, allows for the U.S. military to lethally engage adversaries while limiting the required "boots on the ground" footprint and reducing risk to U.S. troops forward deployed. Further, "satellite communications improve situational awareness and allow forces greater mobility by eliminating the need for ground-based

infrastructure."[22] It is these space-based assets and capabilities that enable the successful ability of the U.S. military to project power abroad through Mahanian forward engagement.

DRIVERS OF MILITARY POWER

Having summarized the similarities of the sea and space from a Mahanian context, this paper now focuses on the second naval theorist: Sir Julian Corbett. First, a review of Corbett's theory offers a linkage between command of the sea and securing sea lines of communication.[vi] Next, adapting Corbett's maritime theory to the twenty-first century space domain translates to present day great power competition and protection of national interests by maintaining the competitive advantage in the space domain.

Corbettian Theory of Naval Power

As a contemporary of Mahan, Sir Julian Corbett studied and wrote about naval strategy, but took a different approach to the role of the navy. In his seminal work *Some Principles of Maritime Strategy*, Corbett sought to define the relationship between the navy and the army. He also offered insights to the strategic advantages and disadvantages of use of the sea. The first prominent theory for adaption to the space domain is Corbett's concept of "command of the sea." As a British scholar, Corbett sought to analyze the methods by which the British fleet had successfully defended the home islands, as well as supported coalition land campaigns on the European continent during previous conflicts. To Corbett, the sea was too large and too vast to be controlled. Instead, the role of the navy was to establish sea lines of communication. "Command of the sea" to Corbett was thus: "control of maritime communications, whether for commercial or military purposes".[23] The navy's role in securing "maritime communications [which] include supply and trade, [but] they also include lines of communication that are of a

[vi] This paper will examine Corbett's thinking on naval forces – stressing defensive action being the stronger form of naval combat to establish control of the sea – below.

strategic nature and are thus critical for a nation's survival."[24] This strategy of defense then enabled flexibility for a nation to generate power in securing the vital sea lines of communication. Further, Corbett offers that this condition of command of the sea is temporary and does not exclude the enemy fleet from operating at sea. This concept survives today in the modern naval terms of sea denial and sea control.

Another prominent theory for adaption to the space domain is Corbett's ideas regarding the "fleet in being." According to Corbett, a "fleet in being" is a concept by which a smaller navy uses maneuver instead of mass or massive firepower to avoid unnecessary deceive engagement and dispute command of the sea. Therefore, the stronger form of naval warfare is the defense, particularly for a smaller navy. "Consequently, keeping its fleet actively 'in being'—not merely in existence but in active and vigorous life—constitutes a defensive strategy for a relatively small maritime power."[25] In this respect, Corbett's concept of the "fleet in being" offers a stark contrast to Mahan's view of the purpose of the navy.

Finally, Corbett's theories advocated for what he referred to as "positions". These might include naval bases, commercial, or nearby focal areas where trade routes converged and if correctly exploited, would lead to favorable conditions for the defender to seek battle.[26] Based on the theory of positions, it was therefore of greater strategic importance and military significance for a navy to seek effective command of the sea near maritime choke points or along frequented trade routes. The strategy offered greater protection to the defender, denied the safety of enemy ports, and threatened enemy access to the benefits of overseas commerce.[27] The navy's role in this respect was to protect friendly positions through economy of force missions and seek exploitation over enemy positions by means of naval blockade and projection of land forces.

Space Applications of Corbettian Theory

Much like Corbett viewed the strategic defense as a method to provide flexibility and maneuver while minimizing risk to the fleet, the space domain provides similarities for the twenty-first century. First, Corbett's theory of "command of the sea" holds value in the application of space. Space, much like the ocean, is vast. The idea of space being exclusively owned by any one nation is prohibited by treaty and equally irrational, much as it would be if applied to the oceans. Moreover, the concepts of sea control and sea denial are similarly applicable to space. As previously mentioned, the growing threat of counterspace weapons and the proliferation of space assets accounts for space becoming increasingly contested, congested, and competitive.[28]

Further, Corbett's naval concept of the "fleet in being" holds value in the twenty-first century application of space. It is important to note that Corbett's naval concept of the "fleet in being" is often attributed to the lesser or smaller naval force. Although the U.S. is not the lesser force in the space domain, there are still lessons to be gained from engaging in an economy of force strategy for space. In order to avoid a digital "blockade" of critical space lines of communication, the U.S. must employ defensive strategies to combat such threats of "decisive engagement" in both the physical and the digital domains. This can be achieved by distributing and diversifying the space-based assets that generate economic wealth for the U.S. and employing a variety of redundant space-based systems, assets, and capabilities that limit the perceived value of an adversarial attack.

Finally, as more assets are launched into orbit, Corbett's theories on strategic "positions" become relevant to space security and U.S. national interests, particularly when high demand orbits like Low Earth Orbit (LEO) and Geosynchronous Earth Orbit (GEO) are considered. With

technological advances continuing into the foreseeable future coupled with reduced "up" costs, the number and variety of space systems expected to be launched will undoubtably increase. While the space lines of communication may not be completely physically, the concept of temporary command of space may extend to the digital domain. The twenty-first century version of Corbett's strategic "positions" in the naval concept are now becoming increasingly digital. Technological assets and military capabilities that can exploit digital choke points and virtual trade routes maintain a strategic advantage.

LINKING THE "E" & "M" IN DIME

The next step in adapting Mahanian and Corbettian theories to twenty-first century space strategy is to examine their linkages to U.S. national interests through the instruments of national power. The established relationship between the sea and space domains lacks a greater context in view of maintaining the competitive advantage by the U.S. over strategic pacing threats like China and Russia. As a method to examine instruments of national power, the acronym "DIME" is a useful construct, connoting the Diplomatic, Informational, Military, and Economic instruments. In this section, the elements of the Diplomatic and Information instruments of national power are set aside and instead this paper focuses upon only the Military and Economic. First, an examination of the Economic instrument of national power will occur, followed by the Military instrument.

The "E"

In reference to the "E" in DIME, Sam Tangredi highlighted in an essay about sea power that one often focuses on naval warfare aspects of sea power due to the dramatic nature of those events; however, he continued by stressing that a container ship sitting offshore has as much to do with sea power as a grey-hulled, capital ship.[29] Arguably the vast majority of world trade is

transported via ocean. Sea power can therefore be explained through access. In turn, the economic instrument of national power is related to the ability to control or influence access of a nation. The space domain shares similar dynamics. The movement of currencies around the world, whether between end users and local retailers or between financial institutions and markets, take place digitally. For example, the space-based services that enable the global economy are heavily supported by satellites providing PNT and SATCOM capabilities around the globe.

Within the context of a competitive advantage, the issue of access is also at the heart of the matter for both sea and space economic instruments of national power. As Tangredi states, "if…the business of the nation is business, than the business of business is getting and keeping access".[30] While an international consensus has been made regarding freedom of the seas and space, competition for access – material and markets – drive international and domestic politics. This strategic dynamic between nations and markets drives public figures and private industry to maneuver to gain and maintain access. Competition leads to consumption of resources and scarcity. While competition can be generally viewed as a net positive, an inverse relationship exists between the potential for conflict and the scarcity of resources. As access to resources diminishes, the fiercer the competition and thus an increase for the potential for open hostilities.

THE "M"

Shifting the focus to the business of warfighting and the instrument of the "M" in DIME, military capabilities can help secure economic interests and provide security to enable market activities. In terms of a strategic competition, it is in the U.S. national interest to mitigate economic risk, both domestically and abroad, particularly given the interconnectedness of the global market. Frank Klotz, a Colonel in the United States Air Force, emphasized the interplay

between the economic and military instruments of national power while serving as a Military Fellow at the Council on Foreign Relations. His statements relate the comparison of history of navies at sea to that of future military requirements to provide security in the space domain as follows:

> as European commerce began to expand to other regions of the world in earlier centuries, the opening of new trade routes and establishment of overseas outposts were initially undertaken by ostensibly private enterprises, such as the British East India Company. However, the European powers eventually found it necessary to create large navies and expeditionary forces to protect the sea lanes as well as the foreign holdings of their merchants. In other words, the flag followed trade. Moreover, conflicts between the great powers that arose from predominantly local disputes frequently entailed clashes among rival military forces at sea and in territories far removed from European shores. In the same manner, national security officials contend, future conflicts on the Earth's surface will inevitably entail attempts to disrupt the new "lines of communication" in space. And, just as navies were called upon to protect the sea lines of communication, the military has a role in protecting the space lines of communication.[31]

It is clear today Colonel Klotz's prediction of the future state of national security affairs and the manner in which the military instrument of national power would be employed in pursuit of securing national economic interests in space is accurate. Further, his statements highlight the importance of a strong military in securing national interests.

APPLICATION OF NAVAL WARFARE CONCEPTS TO SPACE

Although another "Space Race" akin to the Cold War era competition between the U.S. and Soviet Union is not necessarily an inevitable eventuality today between the U.S. and China or Russia, history has shown that "the flag followed trade." The previous section examined the methods by which the instruments of national power relate to a nation's ability to generate power. In the final section, the important role of deterrence, which is the combination of strategic means and national will, in the twenty-first century space strategy is examined below.

Deterrence

As defined by Joint Publication 1-02, deterrence is, "the prevention from action by fear of the consequences…and is a state of mind brought about by the existence of a credible threat of unacceptable counteraction."[32] The essential elements to effective deterrence include the national will to strike and the technical means by which to carry out the attack. During the Cold War, the looming threat of nuclear war between the U.S. and the Soviet Union led to Strategic Arms Limitation Talks (SALT), which reduced the quantity of inter-continental ballistic missiles.[33] As part of the SALT agreements, national technical means (i.e. satellites) were specifically mentioned as means of enforcing the limitations imposed by the SALT series of agreements. The critical role of space-based ISR in performing treaty verification cannot be overstated. Although the Soviets were the first spacefaring nation with the launch of Sputnik, it was the highly classified U.S. spy satellite CORONA that enabled the U.S. to achieve competitive advantage prior to disarmament negotiations. According to the declassified report from the Central Intelligence Agency, "the value of CORONA to the U.S. intelligence effort is given dimension by this statement in a 1968 intelligence report: No new ICBM complexes have been established in the USSR during the past year. So unequivocal a statement could be made only because of the confidence held by the analysts that if they were there, CORONA photography would have disclosed them."

In terms of Cold War disarmament negotiations, deterrence required a third element: mutual understanding with a willingness to disclose capabilities. As noted by Farrell and Newman, "deterrence didn't start to work properly until everyone understood everyone else's capabilities, goals and core sensitivities well enough to avoid basic mistakes, miscalculation, and destabilizing patterns of retaliation and counterretaliation."[34] In this capacity, it was only after

the intelligence gathering efforts by both the U.S. and the Soviet Union did the value of space-based intelligence collections begin to influence deterrence options. Further, similar applications of deterrence persist today due in large part to the technological sophistication of space-based ISR. A recent Center for a New American Security (CNAS) report on verifying U.S. and United Nations sanctions on foreign exports highlights that, "the rapid expansion of publicly available satellite imaging capabilities over the past five years has already facilitated improved tracking of Iranian oil shipments and detection of illicit North Korean imports of oil and exports of coal and other natural resources regulated by U.N. sanctions."[35]

Deterrence in Space

Despite the end of the Cold War and collapse of the Soviet Union, elements of nuclear deterrence remain valid in the space domain. Counterspace weapons proliferation and technological innovation continue to push the limits of scientific development. The growth of commercial markets and the increasing reliance on space infrastructure will only heighten competition in space. In fact, a 2018 report by the National Air and Space Intelligence Center entitled "Competing In Space" states:

> Foreign space competitors will pursue new capabilities to access, operate in, and conduct war using the space domain, while working to deny the same to others. In the near future, competitors will enhance their warfighting capacity by improving space capabilities. Increasingly affordable space systems will heighten space congestion and raise the risk of collision. Development of some space technologies could lead to a misperception of intent, driving countries to adopt a more hostile posture. Understanding the risks created by emerging technologies is critical to maintaining a peaceful space domain.[36]

Despite this assessment, the global risks associated with the weaponization of or loss of access to space serves as a strong deterrent. Much like the threat of nuclear war served as a deterrent

during the Cold War, the potential loss of space-based resources and systems would grind the world economy to a halt. The resulting global catastrophe does not yield a winner, only losers.

CONCLUSION

So what can the theories of Mahan and Corbett offer to maintain the competitive advantage? The principle answer to this question is that elements of both offensive and defensive naval strategies work to compliment one another. This balanced approach serves the purpose to secure the new international open commons of space by protecting access to the space domain and the economic benefits gained from that access against the threats posed to the United States by strategic competitors like China and Russia.

The U.S. must adapt Mahan's strategies of offensive military capability and strength in space as a means to guarantee the economic well-being of the nation. In military terms, the creation of the U.S. Space Force is a major step in the right direction. Just as breaking off Army Air Corps capabilities from the ground-oriented Army and establishing the U.S. Air Force in 1947 created the organizational sinews of air power, the U.S. Space Force will ensure a deliberate focus on developing military strategies and capabilities for securing space. In the Mahanian model, U.S. offensive strike power in space would create a powerful arm – the space equivalent of a fleet of Mahan's big-gun capital ships– would give pause to leaders in Russia or China considering hostile acts against U.S. space interests. In economic terms, although the U.S. free market economy is dissimilar to the Mahanian era of mercantile or "nationalist" economies, Mahan's linkage of sea power to economic vitality offers parallel lessons for today. Mahan's advocacy for a healthy merchant marine suggests U.S. government programs to incentivize civilian education and interest in space, as well as tax incentives for commercial investment in

space, would ensure a vibrant national commercial base for construction of an array of space communications and space travel capabilities, among others, furthering U.S. leadership in space.

The U.S. must also adapt Corbett's concepts of defensive-minded military capabilities and resilience in space as a means to achieve "command of the sea" and a "fleet in being." Continued research and development of protection measures for space systems will avoid "digital chokepoints." Here too, U.S. governmental leadership would likely be needed to incentivize commercial sector investments in redundancy and encryption, even if redundant capabilities were not viewed as profit-making in the near term. Likewise, the technological trend toward fielding huge fleets of small satellites – rather than the historical investment in large, "exquisite" but few satellites, would also echo Corbettian emphasis on small combatants over large naval combatants. Large numbers of small satellites would contribute immensely to resilience of the overall U.S. space presence, such that the loss of any one satellite would not take down the entire U.S. space capability.

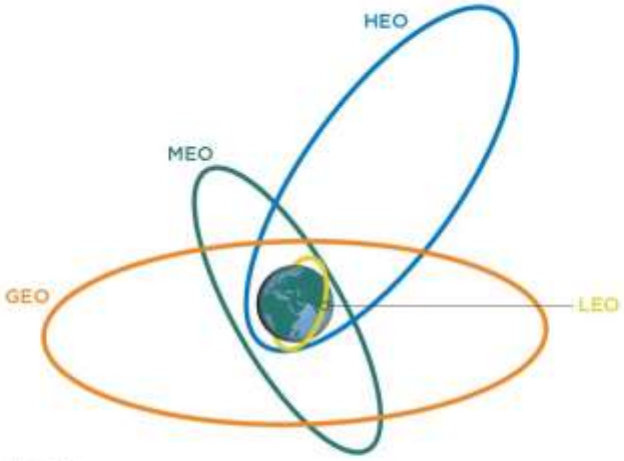
A balanced Mahanian- and Corbettian-informed approach to securing U.S. national interests would in turn allow the U.S. to negotiate from a position of strength in establishing and maintaining diplomatic and treaty norms that could further reduce the chances of inadvertent hostilities or space accidents that escalate to a conflict in space. Instilling a cooperative, rather than conflictual approach to space – even as each state looked to its own military capabilities as its final arbiter – could help ensure that all nations and peoples enjoy the economic fruits of space. Starting small, with, for example, U.S. initiatives for greater international cooperation in tracking orbital debris that threaten all nations' satellites, could form the foundation of trust for more far-reaching space arms control regimes and the like.

Although diplomatic and international engagement might dampen the risk of conflict, ultimately, securing U.S. interests in space requires military capabilities. The adaptation of nineteenth century naval strategy to twenty first century space strategy offers practical solutions to maintain the competitive advantage over strategic pacing threats and secure U.S. national interests.

In conclusion, by applying concepts from two prominent naval strategists, Alfred Thayer Mahan and Sir Julian Corbett, nineteenth century theories of sea power and naval warfare concepts can provide key insights to inform U.S. approaches to twenty-first century space strategy. The result of this modern adaptation to innovative technological developments and emergent great power competition provides an avenue for the U.S. to maintain the competitive advantage over strategic pacing threats like China and Russia in space. Additionally, the result is a practical remedy to manage the linkage of the military and economic instruments of national power to ensure space stability and security of U.S. vital national interests.

APPENDIX A: Orbit Types and Uses

Orbit Types and Uses[32,33]



Orbits are notional and for illustrative purposes only.

ORBIT	ALTITUDE*	USES
Low Earth Orbit (LEO)	Up to 2,000 km	- Communications - ISR - Human Spaceflight†
Medium Earth Orbit (MEO)	Approx. 2,000 to 35,000 km	- Communications - Position, Navigation, and Timing
Highly Elliptical Orbit (HEO)	LEO altitudes at perigee (nearest to Earth) Approx. 40,000 km at apogee (farthest from Earth)	- Communications - ISR - Missile Warning
Geosynchronous Earth Orbit (GEO)	Approx. 36,000 km	- Communications - ISR - Missile Warning

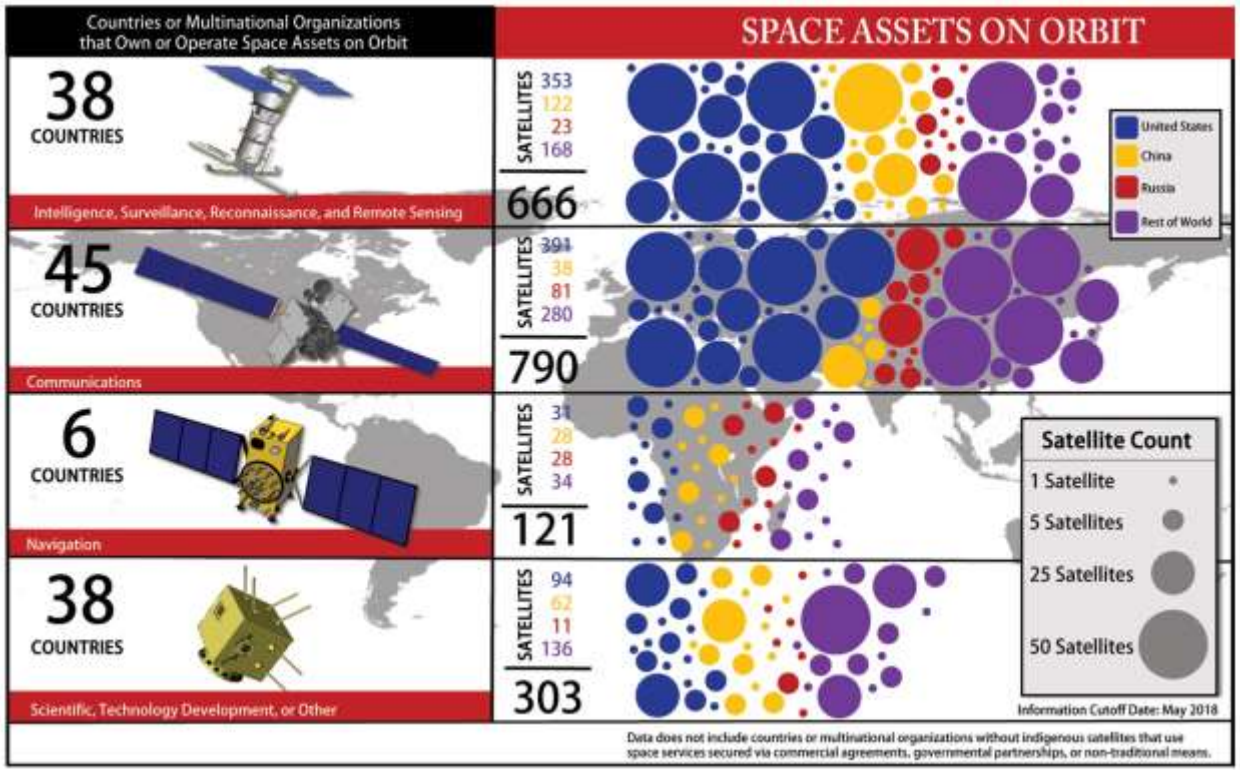
** The advantages of higher orbits for communications and ISR are near-persistent coverage of most of the Earth in view of the satellite, but limited access to polar regions. LEO satellites cover all parts of the world, including the poles, but for shorter periods based on the speed of the satellite.*

† With the exception of nine U.S. Apollo missions to the Moon, all human spaceflight has been completed in LEO.

Visualization: DIA, GI Design • [illegible]

Source: Defense Intelligence Agency, "Challenges to Security in Space". DIA (January, 2019).

APPENDIX B: Space Assets on Orbit



Source: National Air & Space Intelligence Center, "Competing In Space". NSAIC (December, 2018).

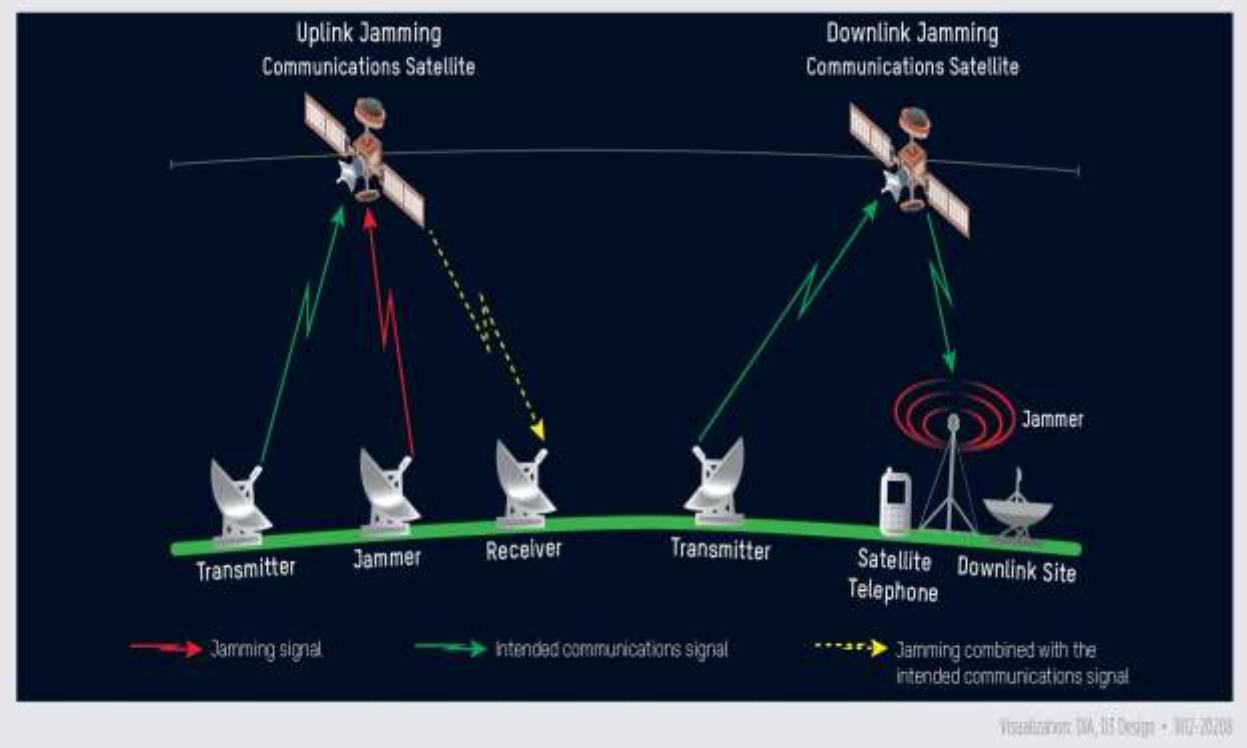
APPENDIX C: Counterspace Weapons

	Kinetic Physical			Non-Kinetic Physical			
Types of Attack	Ground Station Attack	Direct-Ascent ASAT	Co-Orbital ASAT	High Altitude Nuclear Detonation	High-Powered Laser	Laser Dazzling or Blinding	High-Powered Microwave
Attribution	Variable attribution, depending on mode of attack	Launch site can be attributed	Can be attributed by tracking previously known oribt	Launch site can be attributed	Limited attribution	Clear attribution of the laser's location at the time of attack	Limited attribution
Reversibility	Irreversible	Irreversible	Irreversible or reversible depending on capabilities	Irreversible	Irreversible	Reversible or irreversible; attacker may or may not be able to control	Reversible or irreversible; attacker may or may not be able to control
Awareness	May or may not be publicly known	Publicly known depending on trajectory	May or may not be publicly known	Publicly known	Only satellite operator will be aware	Only satellite operator will be aware	Only satellite operator will be aware
Attacker Damage Assessment	Near real-time confirmation of success	Near real-time confirmation of success	Near real-time confirmation of success	Near real-time confirmation of success	Limited confirmation of success if satellite begins to drift uncontrolled	No confirmation of success	Limited confirmation of success if satellite begins to drift uncontrolled
Collateral Damage	Station may control multiple satellites; potential for loss of life	Orbital debris could affect other satellites in similar orbits	May or may not produce orbital debris	Higher radiation levels in orbit would persist for months or years	Could leave target satellite disabled and uncontrollable	None	Could leave target satellite disabled and uncontrollable

	Electronic			Cyber		
Types of Attack	Uplink Jamming	Downlink Jamming	Spoofing	Data Interccept or Monitoring	Data Corruption	Seizure of Control
Attribution	Modest attribution depending on mode of attack	Modest attribution depending on mode of attack	Modest attribution depending on mode of attack	Limited or uncertain attribution	Limited or uncertain attribution	Limited or uncertain attribution
Reversibility	Reversible	Reversible	Reversible	Reversible	Reversible	Irreversible or reversible, depending on mode of attack
Awareness	Satellite operator will be aware; may or may not be known to the public	Satellite operator will be aware; may or may not be known to the public	May or may not be known to the public	May or may not be known to the public	Satellite operator will be aware; may or may not be known to the public	Satellite operator will be aware; may or may not be known to the public
Attacker Damage Assessment	No confirmation of success	Limited confirmation of success if monitoring of the local RF environment is possible	Limited confirmation of success if effects are visible	Near-real time confirmation of success	Near-real time confirmation of success	Near-real time confirmation of success
Collateral Damage	Only dirupts the signals targeted and possible adjacent frequencies	Only disrupts the signals targeted and possible adjacent frequencies	Only corrupts the specific RF signals targeted	None	None	Could leave target satellite disabled and uncontrollable

Source: Todd Harrison, et al, "Space Threat Assessment 2020". CSIS (March, 2020).

APPENDIX D: Electronic Warfare Against Space Systems



Source: Defense Intelligence Agency, "Challenges to Security in Space". DIA (January, 2019).

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