Deterrence and Space Strategy

A Framework from the Study of History and Theory

Dennis M. Rice
Major, USSF

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Abstract

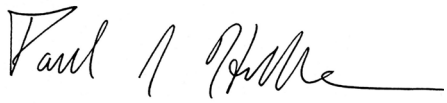
If the United States wishes to sustain the strategic advantages provided by outer space, then it needs a "way" to tailor activities across instruments of national power for space deterrence. This research studied the historiography of deterrence, United States deterrence policies (1950 to 1962), the historiography of the militarization of space (1940s to 1990s), and the evolution of space strategic principles for insights that built a space deterrence framework for strategists and policy makers. The proposed framework emphasizes the interaction of denial and punishment ideas across the competition continuum. Subsequently, activities across the instruments of national power and domains (land, sea, air, space, and cyber) converge to deter incendiary actions that could render space systems ineffective. A key implication is the United States needs to initiate or bolster space cooperation with allies, partners, and adversaries to achieve a strong denial mechanism that remains supported by a complementary punishment-threat mechanism.

About the Author

Maj Dennis Rice is an intelligence officer in the United States Space Force. He began his career as a distinguished graduate of both the Air Force Reserve Officer Training Corps at San Diego State University and the Air Force Intelligence Officer School. After an assignment as a neuroscience researcher, Maj Rice served in Korea, where he led airborne surveillance and reconnaissance missions as a mission operations commander. He then helped stand up a new cyber intelligence squadron before he was selected into the National Security Agency's Junior Officer Cryptologic Career Program. Afterward, he was assigned to the Pacific, where he deployed and went underway with US Seventh Fleet; he then supported Pacific Air Forces as an intelligence squadron director of operations. Major Rice transferred to the US Space Force in 2021 and is now supporting the stand up of US Space Forces Indo-Pacific. He holds a bachelor of science in physiology and neuroscience from the University of California San Diego, a master of science and technology intelligence from the National Intelligence University, and a master of military art and science from the US Army Command and General Staff College, where he was an Art of War Scholar.

Forward

Following the establishment of the U.S. Space Force in 2019, Air University Press launched the Schriever Paper series to provide a forum for discussion of topics focused on space in general and the Space Force in particular. Named for Gen Bernard A. Schriever, the founder of the space and missile force, the series highlights contemporary issues and future challenges in space and the establishment and development of space forces and the domain writ large.



DR. PAUL HOFFMAN
Director, Air University Press

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Benji and Sammy, this is for you. If you are reading this, I want you to know that it was your future that motivated me to work through this. May your future, and that of your own children, involve the expansion of humanity throughout the solar system, free of the terrestrial squabbles over territory and resources. In reading this work, and perhaps more like it, please remember me kindly and know that even when I was called away from you, I was working to make your future better.

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Introduction

In 2007, China successfully destroyed one of its own derelict weather satellites in a successful antisatellite (ASAT) weapon test.[1] This event helped reignite American concern over space weapons, which became dormant after the collapse of the Soviet Union. In 2008, the United States (US) destroyed its own malfunctioning satellite with a ship-borne missile and further fueled public concern over space weapons.[2] Then in 2019, India destroyed one of its own satellites, joining the US, Russia, and China in the list of nations that have successfully demonstrated ASAT capability.[3] Also in 2019, then acting Defense Secretary Patrick M. Shanahan accused China and Russia of weaponizing space, specifically, China's and Russia's development of satellite jamming capabilities, directed energy weapons, and advancements in ASAT missiles.[4] Shanahan then presented the Defense Department's plan to improve US space capabilities to mitigate adversarial threats.[5] Then in 2021, Russia destroyed one of its own satellites, reminding the world that they were still one of the most prominent players in outer space.[6] Despite the aggressive posturing in and toward outer space, it is still possible to keep outer space a warfare-free domain. If one considers the adverse effects to international economies and ways of life, then keeping outer space a warfare-free zone is imperative. However, idealistic views cannot deter any nation with sufficient will and means from using outer space to achieve strategic objectives. Thus, US grand strategy must incorporate a methodology specific to space that utilizes all the national instruments of power to deter harmful actions in outer space. To develop such an approach, the histories of deterrence and space strategy offer some insight.

Research Questions

The primary question for this research is: how can deterrence theory apply to space strategy as a method to deter actions that render space capabilities ineffective?

Two secondary questions help answer the primary question. The first is, what insights are applicable to space strategy from studying the history of deterrence theory and policy? The second is, what insights from the history of space militarization remain applicable to the development of a modern deterrence framework for outer space?

The first section introduces the importance of outer-space challenges to outer-space deterrence and current US space policy. The second focuses on the first secondary question and examines the historiography of deterrence and relevant theoretical concepts. Section 3 addresses the second secondary question and analyzes the historiography of the militarization of space and

relevant space-strategic principles. Section 4 responds to the primary question and discusses the resulting space deterrence framework. Finally, section 5 concludes with implications and areas for future study.

The Importance of Outer Space

Outer space activities have global impact beyond international military competition as demonstrated by the various national space policies worldwide. The Aerospace Center for Space Policy and Strategy compiled a few policies from the United Kingdom, Canada, Australia, Japan, Iran, Germany, France, and Finland as examples.[7] Common themes across these national policies include the impact of outer space on their respective nation's economies, space-based system criticality to civil and military security purposes, and the imperative for their respective nations to be significant players in the expanding efforts into outer space.

Notably, since the beginning of the Cold War, the development of intercontinental ballistic missile (ICBM) technology significantly influenced competition for outer space. In a realist perspective, Everett C. Dolman asserted that some nations have used the pursuit of space launch as a cover to develop operational ICBMs. Furthermore, through the more acceptable pursuit of scientific knowledge and peaceful cohabitation, some nations have skirted international sanctions prohibiting the transfer of ICBM technology.[8] ICBMs and space are historically linked because of the overlap in missile booster technology and space launch capabilities. However, this research mostly focuses on the nonmissile related aspects of outer space activities.

According to Ann E. Robertson, the US, Russia, China, Japan, India, Iran, and Israel had the ability to launch satellites by the twenty-first century.[9] In a quotation from Marc Kaufman, Robertson illustrated the shift in geostrategic rationales for going into space. "The global competition today is being driven by national pride, newly earned wealth, a growing cadre of highly educated men and women, and the confidence that achievements in space will bring substantial soft power as well as military benefits. The planet-wide eagerness to join the space-faring club is palpable."[10] The number of nations vying for prominence in outer space ventures naturally complicates the operational environment. However, the array of interests in outer space also provides a plethora of opportunities for potential space deterrence strategies. The following section represents the depth and breadth of international interests in outer space. The list includes notable countries and international space organizations, however, there are others with space programs not listed owing to time constraints.

United States

According to US President Joseph R. Biden, space benefits the economy through global navigation, aid to crop yield predictions, water and power grid management, and global telecommunications.[11] Moreover, development of space technologies fosters innovation, creates new industries, and leads to new discoveries that improve the quality of life for people around the globe.[12] Space capabilities also help address challenges with climate change and support communities in response to natural disasters. Finally, through exploration and discovery, space attracts talented people across the US and brings forth a hope for a brighter future.[13]

Next are a few US government organizations that have demonstrated their stake in outer space. First, unsurprisingly, is the National Aeronautics and Space Administration (NASA). In the 2022 *NASA Strategic Plan,* Administrator Bill Nelson wrote that NASA is working toward:

> Strengthening the United States' global leadership in space and aeronautics; tackling the climate crisis; building a sustainable human presence at the Moon and continuing human exploration on towards Mars; spurring innovation that builds back better and creates jobs; leading an alliance of international partners to enhance cooperation in space and stimulate commercial activities in low Earth orbit; and advancing diversity, equity, inclusion and accessibility in a way that inspires present and future generations.[14]

A notable impact of NASA's activities is the effect on the economy. NASA helps drive US economic growth and creates space industry jobs by reducing risks for US companies, removing entry barriers for new businesses, and supplying small businesses with training and expertise.[15]

Next is the Department of Transportation. In a 2019 speech at the Kennedy Space Center, then Transportation Secretary Elaine L. Chao remarked that the cost of launching satellites into orbit had fallen by 20 percent in the last five years. Chao also highlighted that the global space economy approached $400 billion per year and anticipated substantial growth over the next few years. Notably, Chao revealed that in 2017, the US regained the top position in the world for the number of space launches. As the US department that oversees the approval of space launches, Chao committed to a strong partnership with NASA to ensure US leadership in outer space.[16]

Likewise, Department of Homeland Security Secretary Alejandro N. Mayorkas wrote that American space activity had undergone a technological and cultural shift that was driving technological advancement, scientific discovery,

and economic opportunity. Moreover, the American space economy was no longer the exclusive domain of the government. Mayorkas added that the homeland security enterprise relied on space-based systems for information and communication to achieve mission success. Henceforth, the Department of Homeland Security would support security of government- and private-sector space-based systems and their associated supply chains to bolster national essential functions and national critical functions.[17]

Similarly, the US Department of Energy asserted its stake in outer space concerns as the largest sponsor of scientific research and development through partnerships with national laboratories and universities. Furthermore, the Department of Energy would develop nuclear and nonnuclear space-capable energy technology in support of US space customers.[18]

For the Department of Defense, space-based systems are a critical enabler of military activities ranging from cooperative operations to large-scale combat. Activities include operations that support natural disaster relief, humanitarian assistance, homeland defense, and security cooperations with nations who have faced more aggressive regimes. The following table lists representative military-space-based systems and their purposes.

Table 1. United States Military Space Systems

Space system	*Purpose*
Advanced Extremely High Frequency System, Defense Satellite Communication System, and Wideband Global Satellite (WGS)	Provide tailored, secure, resistant, and global communications to military air, ground, and sea assets that enable critical command and control of forces in all levels of conflict
Defense Meteorological Satellite Program (DMSP)	Provides assured weather data that supports global military operations
Defense Support Program and Space-Based Infrared Systems (SBIRS)	Protect the US and its allies by detecting missile launches and nuclear detonations
Global Broadcast Service (GBS)	Delivers worldwide access to videos and data products for mission support and theater operations
Global Positioning System (GPS)	Provides position, navigation, and timing data to both military and civilian users worldwide

Source: Created by author using information from US Space Force, "Fact Sheets," US Space Force. https://www.spaceforce.mil/About-Us/Fact-Sheets/.

The capabilities these space-based systems provided were so critical that in 2018, President Donald J. Trump reestablished Space Command as a Unified Combatant Command.[19] Soon after, the US Congress and Trump established

the Space Force as the sixth branch of the US military in a move that signaled the increased attention on outer space.[20]

Russia

Russia continued its formidable space presence since the days of the Soviet Union's *Sputnik* and cosmonaut Yuri Gagarin.[21] With a rich tradition in rocket development, Russia was a dominant power in the space launch industry and held multiple launch service contracts with various foreign partners.[22] Furthermore, Russian designs were incorporated in various South Korean and Chinese space programs.[23] Of significant note in 2020, the US ceased reliance on Russia for human space launch.[24] Additionally, the cost of the Russia-Ukraine War that began in 2022 has affected Russia's space cooperation with the West.[25] Thus, Russia's prominence in space requires re-examination.

Despite Russia's waning prominence in the civilian space sector, Russia maintains considerable military space capabilities.[26] In 2001, Russia consolidated all military space assets under its military space forces, including coordination of commercial activities. Russia also has a sizable inventory of ballistic missiles that are maintained as a balance to the US.[27] Finally, Russia has worked with China to develop its own global navigation satellite systems. In 1995, Russia completed its 24-satellite GLONASS system, which supports commercial and military operations.[28]

China

Like Russia, China developed its BeiDou satellite navigation network and boasts having over 400 million users across 120 countries.[29] In 2018, China and Russia signed an agreement to improve compatibility and interoperability between their two satellite navigation systems. They have also tested equipment along Belt and Road passage routes and agreed to host each other's ground stations.[30] However, despite this level of cooperation, data flows between China and Russia are limited.[31]

Moving beyond satellite navigation systems, China's space program is considered one of the most ambitious space programs in the world today.[32] China's officials have maintained that their intentions in outer space have been for space exploration, but their space technology has the potential for military use.[33] Furthermore, China's leaders consider a successful national space program to be crucial to the legitimacy of the ruling regime.[34] According to Kevin Rudd, "Xi [Jinping] has made clear that for China, 'becoming an aerospace power has always been the dream we have been striving for.' "[35] China's space program also enhances its military prestige since any rocket with satellite launching

capabilities can also potentially launch multiple warheads.[36] China also appears to be developing its national security based on an asymmetric strategy to exploit the US military's dependence on space-based assets.[37]

China invested considerable resources in improving military space applications, developing human spaceflight, and conducting lunar and Martian exploration missions. In the last ten years, China also doubled its space launches per year and placed three space stations in orbit. Two of China's space stations have deorbited, but the third space station, launched in 2021, remains in orbit.[38] Finally, China launched a robotic lander and rover to the dark side of the moon, as well as an orbiter, lander, and rover to Mars.[39]

Japan

Japan has become a significant player in the satellite industry and in space exploration.[40] Japanese Aerospace Exploration Agency President, Keiji Tachikawa, stated that under Japan's Basic Space Law,[41] space pursuits contributed to building prosperity, aided national security, promoted diplomacy, developed industries, and invested in national dreams and the next generation through projects in planetary space exploration and human space activity.[42] Former Japan Minister of Education, Science, and Technology Takeo Kawamura was also cited in a statement that warned, "If the current state of affairs is left unattended, Japan is doomed to be outdone by China and India and fall into the ranks of underdeveloped countries as far as the space industry is concerned."[43] One of Japan's latest space projects is its partnership with NASA, the European Space Agency, and the Canadian Space Agency to build a lunar orbiting outpost called the Gateway program. The Gateway will serve as a rendezvous point for astronauts and serves as a springboard for robotic and human missions to the moon and to Mars.[44]

South Korea

South Korea has invested heavily in space technology and launched several satellites with help from other countries.[45] The Korea Aerospace Research Institute has also pursued its own launch vehicle with assistance from Russia. In April 2008, South Korea sent its first astronaut into space and planned to launch a lunar probe by 2025.[46] From 2017 to 2021, South Korea grew its space industry jobs from 6,708 to 7,317 and signed space cooperation agreements with the US, Luxembourg, Australia, and United Arab Emirates.[47] National leaders have insisted that South Korean interest in space has been for scientific and peaceful purposes; however, its space technology has commercial and military utility.[48]

India

India is another formidable player in the international space industry.[49] It has a strong foothold in satellite construction and launch services with a reputation for high-quality engineering.[50] The Indian Space Research Organization has also successfully launched lunar probes, a Mars orbiter, and developed a regional navigation satellite network and satellite communications system.[51] Because of India's ongoing tensions with Pakistan and a growing Afghanistan threat, Indian leaders view satellite reconnaissance as critical to providing intelligence about insurgent activities.[52] Moreover, the Indian military expressed interest in developing ASAT weapons to balance China's increasing space activity.[53]

Multinational Space Organizations

The following multinational space organizations are highlighted to further demonstrate the global impact of outer space. Several nations have joined these organizations to increase their prominence in space matters. For example, China heads the Asia-Pacific Space Cooperation Organization and is joined by Bangladesh, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey. The Asia-Pacific Space Cooperation Organization was established in 2008 to provide a cooperative mechanism for developing countries to utilize the peaceful use of space to drive further development.[54] The organization's notable milestones include a data sharing service platform, a space segment network, interconnection of ground systems, a ground-based optical space-object observation system, and a disaster monitoring network.[55]

Another multinational space organization is the European Space Agency. The European Space Agency has 22 member states across Europe whose stated purpose is "to provide for, and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems."[56] The Agency's highlights over the years include several milestones in space exploration and discovery, such as Mars imaging missions.[57] Additionally, the European Space Agency is investing in technology to be able to protect vital space-based and ground-based infrastructure from extreme space weather events and systems to provide early warning of dangerous asteroids bound for Earth.[58]

One of the most famous international space cooperation efforts is the International Space Station. The International Space Station program has brought together international flight crews, launch vehicles, globally distributed launch, training, engineering, communication networks, and scientific research. Fifteen

countries remain partners in the program, and the International Space Station has been visited by astronauts from 18 countries. To date, the International Space Station is one of the most ambitious international collaborations ever attempted.[59] However, Russia announced in 2022 that it will cease participating in International Space Station projects in 2024 and pursue its own orbiting outpost.[60]

The wide and deep international interest in outer space demonstrates the magnitude of potential consequences if outer space became a warzone. Furthermore, unlike terrestrial warzones, orbital mechanics make it more difficult to isolate the battlespace and limit collateral damage. Therefore, national leaders must consider whether their strategic aims are sufficient to offset potential global consequences. A space deterrence framework helps to preserve space-based systems and space projects that enable the economies of multiple nations. In the Space Deterrence Framework section, the global interest in outer space and potential consequences are core elements of the proposed space deterrence framework.

Threats and Challenges

Several challenges threaten the ongoing expansion and use of outer space. One of the biggest challenges is the ongoing competition between international powers. Another is related to the natural effects of a growing space industry. In a Defense Intelligence Agency report, intelligence analysts highlighted that space is a critical enabler to military forces in operations, exercises, and logistics worldwide.[61] US competitors acknowledge space's critical role through their extensive development of space and counterspace capabilities. Counterspace systems range from temporary degradation to permanent destruction of space-based systems.[62] China and Russia possess some of the world's most capable space and counterspace capabilities.

China

China officially advocates for the peaceful use of space and continues to pursue agreements in the United Nations (UN) on the nonweaponization of space.[63] However, China also continues to develop counterspace weapons and has even reorganized its military forces to improve integration with space, cyberspace, and electronic warfare.[64] China's military, the People's Liberation Army (PLA), considers space superiority critical to conducting modern "informatized warfare" because it gives the ability to control the space-enabled information sphere and deny adversaries their own space-based capabilities.[65]

To that end, China has invested in various space capabilities that support intelligence, surveillance, reconnaissance, satellite communications, positioning, timing, navigation, human spaceflight, and space exploration.[66] As of January 2022, there are 497 active Chinese satellites orbiting Earth that provide the aforementioned capabilities.[67]

China also invested in electronic warfare, cyber, directed energy, and ASAT technology to potentially deny an adversary space capabilities.[68] The PLA regularly incorporates electronic warfare capabilities into exercises where jamming and antijamming techniques of space-based communications, radar, and navigation systems are honed.[69] Similarly, the PLA emphasizes offensive cyber as a mechanism to support operations against adversary space-based systems.[70] China also invested in ground-based laser weapons that can disrupt, degrade, or damage electro-optical sensors as well as destroy other satellite components.[71] During the 2007 ASAT test, China demonstrated the ability to intercept targets in low-Earth orbit.[72] However, the US Department of Defense reports that China intends to pursue ASAT weapons that can reach geosynchronous orbit, which demonstrates even more advanced capability.[73] Finally, China fielded sophisticated orbital satellites capable of inspection and repair of other satellites. The fear surrounding this technology is that it can also be used to attack other nation's satellites.[74]

Russia

Russia aims to maintain its status as a lead nuclear and space power.[75] Russia advocates for space arms control agreements in international forums to prevent the weaponization of space.[76] However, Russia also views space as a warfighting domain and believes that achieving space supremacy is the key to winning future conflicts.[77] Furthermore, Russia is wary of being unduly dependent on space and thus developed terrestrial redundancies to complement or replace space-based systems.[78] Russia also considers space a critical enabler of US military precision strike and power projection capabilities. Therefore, Russia developed several counterspace systems to offset the US military's perceived advantage.[79]

As of January 2022, 164 active Russian satellites provided services in communications, intelligence, surveillance, reconnaissance, positioning, navigation, timing, and science and technology development.[80] Russia also fielded several ground-based electronic warfare systems intended for jamming Global Positioning Systems, satellite communications, and radar systems.[81] Additionally, Russia invested heavily in cyberspace operations to control space-based information collection and transmission.[82] Russia fielded ground-based laser systems

to potentially blind adversary satellite sensors and, by 2030, will also field directed energy systems with high enough power to damage satellite structures. Finally, Russia developed ASAT weapons capable of destroying low-Earth orbit satellites, tested space-based ASAT capabilities, and pursued dual-use orbital capabilities while claiming that the systems are for servicing its own satellites.[83]

Commercial Space Industry and Human Space Flight

In addition to competition between countries, the growth of the commercial space industry adds further complexity to the operational environment. One of the greatest contributors is the invention of reusable space launch systems, which provide huge cost savings compared to legacy single-use systems.[84] Reusable systems kickstarted the space tourism industry, shuttling private individuals into suborbital and orbital flight. Companies worldwide are racing to be part of this growing market.[85]

Human spaceflight and space operations have also increased. Driven by the potentially large volume of natural resources on the moon, Mars, and asteroids, nations and private companies have begun a new economic competition. While this new race is in its infancy, it is likely to increase the density of space activity in near-Earth orbit, further crowding the operational environment.[86] The growing density of human spaceflight and space operations at first seems tangential to space deterrence. However, the significance of a human presence in strategic locations to support deterrence objectives is illustrated in the Space Deterrence Framework section.

Orbital Space Debris

A key concern is as near-Earth space becomes more crowded, so does the probability of collisions. As of January 2022, the Union of Concerned Scientists tracked over 25,000 objects larger than ten centimeters in various orbits near Earth.[87] There is even greater concern over uncategorized lethal untrackable debris. Lethal untrackable debris are objects between five millimeters and ten centimeters that, despite their small size, travel with enough velocity to damage any intercepted space systems. Between 600,000 to 900,000 uncatalogued-lethal-untrackable debris are assessed to be in low-Earth orbit. Before 2007, space debris was mostly from the upper stages of space launch vehicles. Now, nearly one-half of all orbital space debris comes from three major events: China's destruction of its derelict weather satellite in 2007, the accidental collision of a US communications satellites with a derelict Russian satellite in 2009, and the Russian ASAT test in 2021.[88]

If orbital space debris is not sufficiently remediated, the inevitable result is the phenomenon called the Kessler Syndrome. Donald Kessler postulated that the growing quantity of orbital debris increased the likelihood of collisions. Each collision then creates more debris, resulting in a cascading effect of an uncontrollable and potentially unrecoverable condition of ever-increasing debris that renders an orbit unusable.[89]

The combined effects of overaggressive national competition and unmanaged commercial growth have the potential to worsen orbital space debris. This can be a deterring factor by itself but an unreliable one in the face of an adversary's unlimited strategic aims. How can the US respond to these outer-space related challenges? A possible approach is considering the challenge holistically and incorporating activities in multiple domains and across the instruments of national power. More detail will be discussed in the Space Deterrence Framework section, but first, what is the current United States Space Strategy?

Current United States Space Strategy

The current United States Space Strategy is found across various official documents: the 2022 National Security Strategy, 2022 National Defense Strategy, 2021 Space Priorities Framework, 2020 Defense Space Strategy, and the Space Force's 2020 Space Capstone Publication. There was a reported update to the Space Strategy Review as part of the 2022 National Defense Strategy, however it has not been released.[90] Although spread across various documents, the underlying theme is the grand objective to maintain the strategic advantage in outer space through the following methods: protect and maintain freedom of maneuver to and in outer space; [91] increase resiliency of space capabilities to deny benefits of aggression;[92] and cooperate with allies, partners, and industry.[93] There is also an underlying aspiration to deter adversaries from activities harmful to US space capabilities. However, the "ways" and "means" to achieve or maintain strategic advantage in outer space were unclear.

What gave slightly more clarity was the discussion of integrated deterrence in the 2022 National Security Strategy and National Defense Strategy. Integrated deterrence was defined as "the seamless combination of capabilities to convince potential adversaries that the costs of their hostile activities outweigh their benefits."[94] The holistic concept of integrated deterrence is on the right path; however, Strategic Command designed it for the overarching national defense. The National Defense Strategy expanded slightly and included three deterrence methods: denial, resilience, and cost imposition.[95] These methods are sound, but they are primarily considered from a military instrument perspective only. The 2020 Defense Space Strategy focused on space, but its deterrence goals

were more aspirational and predominantly focused on building joint military means to achieve deterrence. A core motivation for this research is to build the ways (or methods) to achieve deterrence within the context of the "ends" laid out in US space strategy. In the effort to build the ways (or methods) to achieve deterrence in outer space, this research turns to the historiographies of deterrence, militarization of space, applicable theories, and relevant strategic principles to formulate a framework.

DETERRENCE HISTORIOGRAPHY AND THEORY

The primary question is how can deterrence theory apply to space strategy as a method to deter actions that render space capabilities ineffective? Subsequently, a secondary question is what insights are applicable to space strategy from studying the history of deterrence theory and policy? Thus, the research begins with an objective to understand the concept of deterrence.

Historiography of Deterrence

The etymology of "deterrence" can be traced to ancient Latin and is composed of two components. First, to use "fear." Second, to push somebody "away from" a course of action they may desire to pursue.[96] In 1954, William W. Kaufmann defined deterrence as, "preventing certain types of contingencies from arising."[97] Additionally, Alexander L. George and Richard Smoke wrote that it was "the persuasion of one's opponent that the costs and/or risks of a given course of action he might take outweigh its benefits."[98] From the etymology alone, the US space strategy's focus on resilience seems to be missing the fear element of deterrence. Moreover, the focus on technology development seems to miss the psychological element that causes an opponent to perceive increased costs. The review of deterrence historiography attempts to remedy these observed, missing elements and incorporate them into the proposed space deterrence framework.

Origins of Deterrence

Claudio Cioffi-Revilla argued that deterrence was demonstrated as early as 7500 BC in Jericho, Palestine.[99] Jericho's inhabitants built fortifications that consisted of an outside ditch, an enclosing wall, and a massive tower that signaled consequences to potential attackers.[100] Cioffi-Revilla asserted that the Jericho fortifications were an example of deterrence because they intimidated neighboring groups, controlled nearby territory, and provided local security.[101] Ideas of deterrence are also found in Thucydides' *Peloponnesian War* accounts.

Thucydides described instances where the two opponents, Athens and Sparta, maneuvered for allies or other advantages so that their opponent would believe that beginning or expanding a war would not be worth the risks or costs.[102] Other early writers like Emperor Leo of Byzantium and Machiavelli emphasized a "show of force" to persuade enemies that the cost and risks of aggressive actions exceeded the gains.[103] Yves Winter clarified that Machiavelli's use of "force" referred to the military as an instrument to defend the regime.[104]

One of the initial insights highlighted from ancient history is that the concept of deterrence is old. Therefore, modern deterrence strategies have much to gain from historical study. Another insight is that deterrence is supported by observable means, such as fortifications or a military.

Aftermath of the Thirty Years War and Napoleonic War

Moving forward in time, a result from the Thirty Years War highlighted positioning and maneuvering as useful concepts to deterrence. During the war, Italian *condotierri* (captains) engaged in battle maneuvers to avoid high casualties or unacceptable costs.[105] Consequently, monarchies adopted "limited warfare," where the threat of inflicting high cost played as great a role as the actual infliction.[106] In this limited warfare period, while the capture of a fortress or town was the ultimate goal, the game was often decided, at times bloodlessly, by skillful maneuver into superior positions.[107]

Starting in the eighteenth century and peaking in the late nineteenth, European powers adopted a balance of power system where alliances played a key deterrence function. Military capability also played a role; however, the rough balance of stable deterrence endured primarily through shifting diplomatic alliances.[108] European nations believed that alliance parity rendered any war profitless.[109] This belief resulted from the Napoleonic Wars where the scale of social disruption was so great that the fear of any war created a deterrence effect.[110] George and Smoke highlighted that contemporary deterrence theory concepts like commitments, signaling, fear of escalation, and mutual assumption of rationality, were implicitly part of the balance of power system without explicitly using the terminology.[111] This example demonstrated the role of fear in deterrence, which in this historical period used the atrocities of recent events like the Thirty Years War and Napoleonic Wars as a mechanism to incite fear and deter opponents from certain actions.

Impact of Capital Ships and Airplanes

At the end of the nineteenth century, two developments foreshadowed the twentieth century concepts of deterrence. The first was the Anglo-German

naval race. For about 20 years, England and Germany sought to outbuild each other in capital ships.[112] Simultaneously, each side developed a corresponding strategy. On Germany's side, the "risk theory" argued that a sufficiently large German fleet could render the British fleet unusable for fear of losing it in combat.[113] On England's side, the Royal Navy was divided on the extent to which it should target commercial ships in future wars. One concern was that targeting trade ships could cause unnecessary suffering to the civilian population. However, the Royal Navy was careful to not have such restrictions because they were also considering how to force concessions through interference of trade.[114] Sir Julian Corbett argued that exempting foreign trade from attack eliminated a "great deterrent" to an enemy's behavior. In a quotation from Prussian General Von der Goltz, Corbett argued that "after shattering the hostile main army, we will still have the forcing of a peace as a separate, and in certain circumstances, a more difficult task . . . to make the enemy's country feel the burdens of war with such weight that the desire for peace will prevail."[115] The Royal Navy eventually came to the revelation that it needed naval allies, thus it approached Japan and the US.[116]

The German side of the capital ship race highlighted an important concept of deterrence, the possibility of miscalculation and misperception. Alfred von Tirpitz, the creator of "risk theory," argued that a large enough fleet deterred England from siding against Germany because of the risk of destructive naval conflict.[117] Tirpitz's theory had the opposite effect. Germany's naval build up instead brought Germany to England's full attention and hostility.[118] On England's side, its debate on trade interference highlighted an alternative to persuade populations without direct destruction.

The second development was the airplane. Shortly before the First World War, an aircraft arms race ensued, in part motivated by the potential capability to drop bombs hundreds of miles behind enemy lines.[119] Around 1915, military theorists believed that major cities were vulnerable to destruction by air, even while defending military forces were strong.[120] In 1917, Germany tested the theory and executed a bombing offensive on London.[121] The public reaction to bombings in the First World War teetered on panic, and people believed that more destructive bombs, incendiaries, and poison gas would be used in future wars.[122] However, the war ended before either side inflicted widespread damage on other cities or the civilian populace. In the interwar period, air power theorists like Giulio Douhet, Billy Mitchell, and Hugh Trenchard built on this concept and advanced the future role of air power. Air power theorists presumed the existence of destructive power like that of 1945 atomic bombs. They argued that such power could cause populations to surrender or governments to hold back attacks due to fear of retaliation.[123] Fictional writers like H. G. Wells helped

embed the potential horror of poison gas attacks on cities into the public psyche.[124] The resulting reaction began to shape the contemporary notion of mutual-deterrent balance.[125]

Air power's influence on deterrence is another demonstration of fear's effect. However, a key highlight is the influence of fictional writers, who had an information messaging effect on the population to help spread fear. Consequently, the resulting deterrence framework discussed later considers the significant potential of the information instrument of power.

Impact of Nuclear Weapons

George and Smoke concluded that atomic bombs and the ideological clash between the US and Soviet Union set the stage for the emergence of contemporary deterrence theory.[126] Before nuclear weapons, deterrence lacked the distinction between the power to hurt and the power to defeat military forces because it was not possible to hurt an enemy (burn cities, seize property, etc.) until military forces were defeated. Nuclear weapons made it possible to inflict massive damage without first destroying an opponent's military forces.[127] Thus, once the "threat to hurt or cause mass damage" could be separated from the "threat to engage and destroy forces," the modern sense of deterrence was conceived. [128] After the US dropped the atomic bomb on Hiroshima, an often-quoted line in the book *The Absolute Weapon* captured the new reality: "Thus, the chief purpose of our military establishment has been to win wars. From now on its chief purpose must be to avert them. It can have almost no other useful purpose."[129]

Nuclear weapons brought to the fore what had always been the underlying motivator of deterrence: fear. The current US space strategy's focus on resilience fails to invoke fear in adversaries. This conceptual gap will be remedied later in the Space Deterrence section. Like nuclear weapons, the destruction of space-based capabilities can hurt without destruction of military forces. However, a key distinction is that the destruction of space-based systems is more akin to England's consideration of suffering during its debate on targeting sea-based trade. Specifically, imposing suffering could be a forcing function to compel populations. In a space-specific example, the destruction of satellites could deny their owner of weather services that support agriculture, energy, and water management.[130] The impact of satellite weather information can also provide cost savings in two forms: 1) People are more likely to invest in loss-reduction activities when better information is available, and 2) better information can also reduce economic costs that arise when uncertainty about adverse weather causes government authorities, people, and business to "err

on the side of caution" and undertake what later turn out to be unnecessary loss-reduction activities.[131]

Moreover, according to the 1997 to 1998 El Niño and Southern Oscillation Study, satellite weather services also assist organizations to make better life-saving decisions.[132] Thus, the loss of satellite weather services impacts cost-saving and life-saving efforts, which imposes a slow suffering effect, like the targeting of sea-based trade. Unfortunately, the impact from the loss of satellite navigation, communication, or intelligence has not been properly studied. Nonetheless, as introduced earlier, the impact of space is global. Therefore, loss of space capabilities will, at a minimum, be globally disruptive to national economies, global communications, and commercial and military operations. Accordingly, in parallel with England's sea-based trade interference debate, the threat of space-based system destruction is a potential deterrence element.

United States Deterrence Policies: 1950 to 1962

Between 1945 and 1949, the US enjoyed the exclusive possession of atomic weapons, which provided a significant deterrent against Soviet aggression. Nevertheless, US military leaders sought to maintain large military forces as a deterrent, but domestic pressures and budget constraints forced military reduction. To alleviate the diminished military combat power, the US pursued military alliances to increase potential combat power. Accordingly, military alliances, which were historically terminated in peacetime, became an instrument of deterrence.[133]

In 1950, a National Security Council Report, NSC-68, assessed that by 1954, the Soviet Union would be capable of delivering 100 atomic bombs to the US. Combined with the Central Intelligence Agency's assessments of Soviet technology, the assessed atomic delivery capability that the Soviet Union could achieve by 1954 became the planning factor for US strategy.[134] In 1953, President Dwight D. Eisenhower approved NSC 162/2, which included nuclear weapon options to defend against the Soviets.[135]

> The risk of the Soviet aggression will be minimized by maintaining a strong security posture, with emphasis on adequate offensive retaliatory strength and defensive strength. This must be based on massive atomic capability, including necessary bases; an integrated and effective continental defense system; ready forces of the United States and its allies suitably deployed and adequate to deter or initially to counter aggression, and to discharge required initial tasks in the event of a general war; and

an adequate mobilization base; all supported by the determined spirit of the US people.[136]

During his State of the Union speech on 7 January 1954, Eisenhower publicized the US policy to deter aggression by maintaining a "massive capability to strike back."[137] Five days later, Secretary of State John F. Dulles delivered a speech to the Council of Foreign Relations and announced "massive retaliation" as a new strategic doctrine. During his speech, Dulles explained that it was not cost-effective for the US to try and match the "the mighty land-power of the Communist world." [138] He explained that the US had to make clear to potential attackers that resistance would not just be confined to the point of attack. Dulles stated that the US would invest in a "deterrent of massive retaliatory power," to reinforce local defenses.[139] He explained that "the way to deter aggression is for the free community to be willing and able to respond vigorously at places and with means of its own choosing."[140] Thus, massive retaliation, which emphasized offensive striking power, became the strategic theory component of the transforming military force structure within the context of the New Look Policy.[141] More importantly, nuclear weapons would be considered during active hostilities. The Soviet Union's lack of a nuclear delivery platform at that time gave the US escalation dominance. Specifically, it meant that the Soviet Union had to contend with the threat of US nuclear weapons in every potential aggressive action.[142]

However, as the Soviet Union's strategic rocket and bomber forces grew, the massive retaliation policy weakened. A key event was the successful launch of *Sputnik*, which showcased the Soviet Union's progress in rocket technology and correspondingly, its intercontinental ballistic missile capability.[143] Consequently, it became apparent that the US strategic nuclear forces were vulnerable to surprise attack.[144] Furthermore, it seemed that the Soviet Union was less and less likely to believe in the US's escalatory threat. US Army leaders like General Matthew B. Ridgway and General Maxwell D. Taylor expressly criticized the massive retaliation *policy.*[145] General Taylor explained:

> The deterrence of war in this age of high yield weapons is the greatest challenge that this nation has ever faced. It is no longer a task that can be entrusted solely to the soldier, the statesman or the diplomat, because the deterrence of conflict rests on the concerted efforts of all Americans. If we are to deter the great catastrophe of another world conflict we can do so only by the unified efforts of all of us-each contributing according to his station. Only by merging all our strength, military, economic, political and moral—in harmonious and effective combination, can one ensure the future of America and the peace of the world. Militarily, this integrated

> effort requires not one single form of military force, but a tridimensional balance of forces applicable to objectives on land, at sea, and in the air. It demands a political-military strategy flexibly adjusted to the needs of unforeseen situations, not geared to any single weapons system or single concept of future war. In short, it should embrace all reasonable measures to prevent general and local war, and at the same time contain the potentiality of waging any war large or small, in such a way as to achieve our national objectives.[146]

According to US Army LTC Peter F. Wittefried, massive retaliation policy failed to distinguish "deterrence" (discouraging the enemy from taking military action) and "defense" (reducing costs and risks in the event deterrence was not successful).[147] Furthermore, it failed to account for the "defense value" of military forces (their effect in mitigating the adverse consequences of enemy moves).[148] Thus, Wittefried concluded that massive retaliation's lack of defense value severely limited its usefulness in local or limited wars.[149]

In reaction, Eisenhower supplemented massive retaliation with "graduated deterrence."[150] Cedric Winship Tarr Jr. defined graduated deterrence as, "military policy which prepares for the use of nuclear as well as conventional weapons to deter and, if necessary, halt local aggression."[151] In a quotation from *On Limiting Atomic War,* Tarr wrote: "The words 'graduated deterrence' imply, in fact, using smaller atomic weapons in smaller wars and the larger ones only in global war. And the idea behind this distinction is the idea of threatening realistic retaliation against aggression only with weapons 'graduated' to the scale of attack."[152] George and Smoke described graduated deterrence as the incorporation and use of "tactical" nuclear weapons restricted to the local theater before resorting to "strategic" nuclear weapons.[153] Critics were quick to rebuke that graduated deterrence was only useful while the Soviet Union was incapable of tactical nuclear weapons. Once the Soviet Union achieved the capability, the assumption was that once tactical nuclear weapons were used, the situation would inevitably spiral to the use of strategic nuclear weapons. Thus, the tactical threat amounted to being a strategic one, and the expected result of graduated deterrence was not distinguishable from massive retaliation.[154]

In 1959, Taylor published *The Uncertain Trumpet,* which was read by those, like Senator John F. Kennedy, who opposed Eisenhower's security policies.[155] Taylor outlined a program called "flexible response," which was intended to address the deficiencies of massive retaliation. Specifically, Taylor argued for the capability to react to a full spectrum of threats, ranging from nuclear war to infiltrations. He also argued that it was just as necessary to deter limited wars as it was to deter general war because of the danger of expanding con-

flicts.[156] Compared to massive retaliation, flexible response required a larger conventional force, along with special forces, to complement strategic nuclear forces. Together, the combined forces served as the deterrent.[157] Another distinguishing factor was that the large conventional forces provided a wider range of nonnuclear defense options to minimize damage and loss, should deterrence fail.[158]

At the onset of Kennedy's presidency, the essence of flexible response was adopted. During his inaugural address, he explained, "For only when our arms are sufficient beyond doubt can we be certain beyond doubt that they will never be employed."[159] Thus, Defense Secretary Robert S. McNamara prioritized the increased survivability of US strategic nuclear forces, adding a larger arsenal and a mixture of delivery systems.[160] McNamara also focused public discussions of strategic nuclear topics on concepts of assured destruction and damage limitation. The hope was that the larger US nuclear arsenal provided a damage-limiting capability because it forced the Soviet Union to target US nuclear weapons, before attacking cities.[161] Another concept of future nuclear war then emerged. If it came, then it was believed that it would most likely be caused by the escalation of a lesser conflict. Therefore, deterrence of nuclear war came to depend on the control of escalation.[162]

The evolution of US deterrence policy highlights politics and budgets as key influencers. Consequently, it is logical for deterrence policy to shift because of new political and fiscal constraints, in addition to adapting to strategic environment changes. Moreover, effective deterrence strategies incorporate various and complementary sets of capabilities. The next section's discussion on deterrence theory further elaborates on this complementary multi-faceted approach to achieve a greater deterrence effect. It is worth noting that deterrence theory materialized because of the nuclear deterrence crisis and that psychology was a major component. Specifically, an underlying deterrence mechanism is to get one's opponent to believe a threat.

Abstract Deterrence Theory

According to Stephen L. Quackenbush and Frank C. Zagare, two strands of realist theory constituted classical deterrence theory: structural deterrence theory and decision-theoretic deterrence theory. Structural deterrence theory focused on the relationship between system structure and cost of conflict. Decision-theoretic deterrence theory explored the same problem through a framework that focused on actor choices.[163]

Structural Deterrence Theory

Structural deterrence theory had two propositions. The first proposition was that under parity conditions, the probability of war was inversely related to the cost of warfare.[164] As John J. Mearsheimer explained, "the more horrible the prospects of war, the less likely it is to occur."[165] The second proposition was that if power was unevenly distributed, deterrence was unlikely to succeed because the stronger party could simply attack to force compliance.[166] Consequently, logically consistent structural theorists opposed minimum deterrence policies. Instead, they argued that an overkill strategy that raised the cost of war would reduce the probability of it occurring. When applied to nuclear weapons, structural theorists recommended limited proliferation to achieve the deterrent balance.[167] For example, Mearsheimer once concluded that Germany should attain nuclear weapons to avoid war in post-Cold War Europe.[168] Similarly, Kenneth Waltz cited the relative peace between nuclear capable Pakistan and India, then argued that a nuclear Iran that countered Israel would help stabilize the region.[169]

Critics of structural deterrence theory pointed to the First and Second World Wars, which both started under parity conditions, to demonstrate the theory's shortcomings. Structural deterrence theory was also unable to explain why the US did not attack the Soviet Union before the Soviets acquired a nuclear capability.[170] Richard Ned Lebow suggested that moral and psychological costs of aggression explained why states have not capitalized on similar windows of opportunity.[171] Thus, structural deterrence theory alone does not seem to account properly for relevant variables.

The first proposition of structural deterrence theory offers an early framework for modern space strategy. Specifically, by substantially increasing the cost, the probability of active conflict in outer space is lowered. Under structural deterrence theory's logic, the high cost must be inflicted equally on both or all sides for effective deterrence. Tying together the insights from the historiography of deterrence, the revelation is that a space deterrence strategy requires both an offensive (the threat that invokes fear and-or pain) element and a defensive (increases the cost) element. This will be further explored in the Space Deterrence Framework section.

Decision-Theoretic Deterrence Theory

Decision-theoretic deterrence theory focused on hypothesized behaviors of players. Key assumptions form its foundation and are worth noting early on. Christopher H. Achen and Duncan Snidal postulated the assumptions as rational actor, principal explanatory, and principal substantive.[172] Rational actor

assumed that given preferences and choice options, actors sought to optimize preferences in light of other actors' preferences and options.[173] Sidney Veba simplified a rational actor as an individual who made a "cool and clear-headed ends-means calculation" when considering all possible courses of action in response to events.[174] Principal explanatory assumed that variations in outcomes could be explained by differences in actors' opportunities. In other words, the influence of an actor's preferences, norms, roles, or culture, were analytically suspended during theoretical postulation. Principal substantiative assumed that the state acts as if it were a single unitary actor.[175]

Thomas C. Schelling's game theory significantly influenced decision-theoretic deterrence.[176] Its basic form involved an initiator and a defender. In this simple game, the defender's objective was to prevent the initiator's desired action. If the expected punishment was greater than the expected gain, then the initiator was deterred.[177] Key assumptions were that the initiator was deterrable, and that the defender's retaliation threat was credible. Conversely, if the initiator believed it was not in the defender's interest to retaliate (lack of credibility), or if the defender lacked the means or will to retaliate (lack of capability), then the initiator would attack.[178] A key conclusion was that if the attacker was deterrable, then successful deterrence was contingent on the defender's credibility and observable capability. The model also postulated that deterrence would fail for sufficiently determined attackers and that not all opponents are deterrable.[179]

Notably, the simple model was limited to situations where the costs of inflicting punishment flowed in one direction. Once the relationship accounted for the choices of both actors simultaneously, then the logic fractured.[180] Using Table 2 (below) as a reference, each state had two broad strategic choices, to cooperate or to not cooperate. If each state cooperated, then the status quo reigned. If one cooperated and the other did not, the uncooperative state gained the advantage. If neither cooperated, then conflict ensued. An additional assumption was that each side preferred an advantage to the status quo, but that status quo was preferred to the other side gaining the advantage. Consequently, the symmetrical model demonstrated that "rational" actors could not be deterred. Even if each side initially chose to cooperate, there was an incentive to not cooperate because of the prospect of gaining advantage.[181]

Table 2. The Paradox of Mutual Deterrence

Possible Inputs	Nation B: Cooperate	Nation B: Not Cooperate
Nation A: Cooperate	Status Quo (3, 3)	Advantage to B (2, 4)
Nation A: Not Cooperate	Advantage to A (4, 2)	Conflict (1, 1)

Author's note: the values in brackets (A, B) represent preferred outcomes. Higher values represent a more preferred outcome for the specific player. For example, status quo (3, 3) is preferred over conflict (1,1). However, the desired outcome for each player is to gain an advantage over the other.

Source: Created by the author with information from Frank C. Zagare, "Rationality and Deterrence," *World Politics* 42, no. 2 (January 1990): 249, https://www.jstor.org/stable/2010465.

To explain further, say nation B became uncooperative to gain a momentary advantage (2, 4). Nation A then would be faced with two options: cooperate and remain at a disadvantage (2, 4), or execute its deterrent threat and enter conflict (1, 1). Assuming rationality, the inference is that nation A preferred cooperation (2, 4) over conflict (1, 1). Nation A chooses thus because conflict was the least desirable condition. If nation A was then expected not to retaliate, then nation B would have had no hesitation to upset the status quo. The conclusion would be the same if nation A took the first uncooperative action.[182]

Consequently, the decision-theoretic model demonstrated that parity conditions incentivized the initiator. The reactionary nation, the defender, was left with their less favorable conditions; either to accept the initiator's new advantage or punish the initiator through conflict.[183] The implication was the reactionary literature of "the rationality of irrationality," the danger of total disarmament, and the value of aiming for strategic equivalence with national superpowers.[184] To combat this conclusion, Schelling recommended purposeful ambiguity and "threat[s] that left something to chance."[185] The deployment of US military forces in Europe was one example. There they served as a "trip wire" to convince Russia that another European war would physically involve US forces whether the United States intended to or not.[186] Therefore, the threat of responding with conflict, the irrational choice, became a key factor in deterring the initiator.

The deterrence-theoretic model again highlighted the psychological aspect of deterrence. Consequently, to be deterred, the opponent must be able to perceive an intended threat. US space strategy needs at least one retaliatory threat. The threat(s) can be space-based or terrestrial-based, which will be expounded upon in the Space Deterrence Framework section. The threat(s) must also be purposefully ambiguous, as Schelling recommended. To achieve this nuanced intimidation, the next section expands on a subcategory of deterrence: punishment and denial.

Punishment and Denial

According to Glenn H. Snyder, the unacceptable cost to the target could be achieved in two forms: punitive action (punishment) or defensive resistance (denial).[187] The following examples demonstrated the differences.

Deterrence by Punishment

1. "Do not launch a nuclear attack on us, or we shall retaliate with a massive response that will destroy you" (United States to Soviet Union, and vice versa during the Cold War, ca. 1960s–1980s).
2. "Do not interfere with the UN inspections or we shall respond with force, if necessary" (United States to Iraq, ca. 1998).
3. "Do not attempt to threaten our city's surrounding lands or we shall launch an army to destroy you" (Lagash to Umma, ca. 2450 BC).[188]

Deterrence by Denial

1. The Berlin Wall, as well as Soviet and North Atlantic Treaty Organization (NATO) forces in Berlin, denied unauthorized movement across sectors during the Cold War.
2. The Patriot missile defense system provided Israel and the Persian Gulf allies denial deterrence against Iraq during the Gulf War.
3. US and UN military forces stationed in Korea, and other "trip-wire" deployments that automatically commit a defense.[189]

Snyder explained that the deterrent value depended on the effects of four essential factors in the enemy's cost-gain calculus: (1) the enemy's assessed probability of a military response; (2) the expected costs from the response; (3) valuation of the territorial prize; (4) probability of success in the territorial aim.[190] Snyder used these factors and postulated the Soviet Union's cost-gain calculus of the US's massive retaliation policy.[191] He arrived at a Soviet Union view that the US was unlikely to follow through on their massive response threat. This was because a massive response invited an equally massive counterresponse. Thus, if the US executed their massive punishment strategy, it would quickly incur a high cost from the counterresponse while achieving zero gain.[192] Alternatively, if the US did not follow through, they would lose prestige and be less effective at deterrence in the future.[193] Thus, the key problem was the interaction of credibility.

William W. Kaufmann explained that deterrence credibility was influenced by enemy, domestic, and allied audiences. Moreover, credibility is affected by capability, cost, and intentions.[194] Kaufmann asserted specific requirements when dealing with the enemy audience. First, the threat had to be meaningful to the intended enemy to have effect. Second, the enemy had to be persuaded that a capability existed to execute the threat. Third, the threat will inflict greater cost on the antagonist than the antagonist's perceived gains.[195] Once the threat's capability and cost were determined, it must be followed by activities to strengthen its credibility. Kaufmann argued that a threat that was consistent with the country's recent behavior was more likely to seem plausible than one that broke tradition. The credibility of the threat also depended on the consistency of its communication. Once communicated, the threat would also be made more credible if followed by actions consistent with the message.[196] Finally, the intended threat also had to be supported by domestic and allied audiences. This last consideration suggested a crucial requirement in that the potential costs must seem worth incurring. Failure to consider the acceptance of domestic and allied audiences could result in deterring the deterrer.[197]

Credibility was also affected by the interaction of punishment and denial strategies. Snyder used the NATO military strategy to deter Soviet aggression around the late 1950s to explain this interaction. The chief instrument of deterrence was the combined capability of US and British strategic air forces to deliver heavy bombing against targets across the Soviet Union and Warsaw Pact: the sword (punishment).[198] However, the frontline ground, sea, and tactical air forces guarding the border areas also provided deterrent value: the shield (denial). The shield forces alone were not adequate to deny any territory from the Soviet leadership. The shield forces' true value was their complementary role to the sword forces.[199] The simple fact of the shield forces' presence forced the involvement of the US and Great Britain in the event of Soviet Union attack. Once involved, the likelihood of the sword's use increased. Therefore, the value of the shield forces was not only for their direct denial capability, but also for their indirect and complementary effect that strengthened the probability of the sword's activation.[200]

Punishment and denial's interaction, however, was not fully positive. For example, a strong denial capability tended to erode the credibility of the retaliatory response because it presented less costly alternatives.[201] Moreover, denial strategies, which used mostly conventional forces, were relatively simpler for analysis by the enemy. Therefore, where punishment strategy presented uncertainty to the enemy, a denial strategy gave way to more clarity.[202]

Another noteworthy interaction was the advertised intent of punishment and denial strategies. In the same NATO example, Gen Lauris Norstad, supreme allied commander, described three functions for the NATO Shield:

1. To hold or delay a Soviet attack "until the total weight of the retaliatory power could be brought to bear."
2. To deter wars "arising from miscalculation, border incident or probing operation invited by weakness on the NATO periphery."
3. To provide "essential military and political flexibility."[203]

The first publicized function was noteworthy because it did not describe the NATO Shield as an expected blocking mechanism against aggression from the Soviet Union. Instead, it declared that it was a key component of the retaliatory response, indicating to the Soviets that the only motive for the shield forces was for the inevitable retaliation.[204]

Punishment and denial deterrence concepts have clear applications to space strategy. The interaction between them generates the most interesting discussions. How "massive" must the punishment be? What is the appropriate size of defense or denial forces? What balance of punishment and denial forces is feasible with current fiscal limitations? While these are not questions intended to be answered by the scope of this research, they are questions policymakers and strategists must consider. So, how do current US deterrence perspectives rate against these historical and theoretical principles?

Integrated Deterrence

Today's version of deterrence is called "integrated deterrence," "the seamless combination of capabilities to convince potential adversaries that the costs of their hostile activities outweigh their benefits."[205] It entails integration across land, maritime, air, cyber, and space domains, across regions, across the spectrum of conflict, across the US government, and with allies and partners.[206] The National Defense Strategy expands on the methods to achieve deterrence through three logics: (1) denial, (2) resilience, and (3) cost imposition.[207] The three methods are mostly consistent with historical ideas, except where resilience replaced defense and cost imposition replaced punishment. As an overarching strategic policy, integrated deterrence is the right path. However, for space deterrence purposes, it lacks the specificity for the complementary integration of activities across domains, regions, conflict spectrum, US Government, and allies and partners.

The Department of Defense joint publications are another set of documents that elaborate on deterrence, specifically, the application of deterrence across the competition continuum.[208] The joint staff defined the competition continuum as, "a world of enduring competition conducted through a mixture of cooperation, competition, and armed conflict."[209] The joint staff developed the competition continuum through the lens of the US in relation with another strategic actor (state or nonstate) and enabled the US to describe complex relationships with other strategic actors, which could be at multiple simultaneous interactions along the continuum. For example, "the US might be in a state of competition with a strategic competitor regarding some interests, such as freedom of navigation in disputed areas, and cooperation in others, such as counterpiracy."[210] According to the joint staff, deterrence was applicable across the competition continuum.[211]

For example, during cooperation, the US's collaboration with allies and partners was viewed as a deterrent against aggression by others.[212] An example of this view is the Fifth Article of NATO, which is summarized by the concept of collective defense.[213] The Fifth Article specified that:

> The Parties agree that an armed attack against one or more of them in Europe or North America shall be considered an attack against them all and consequently they agree that, if such an armed attack occurs, each of them, in exercise of the right of individual or collective self-defense recognized by Article 51 of the Charter of the United Nations, will assist the Party or Parties so attacked by taking forthwith, individually and in concert with the other Parties, such action as it deems necessary, including the use of armed force, to restore and maintain the security of the North Atlantic area.[214]

The joint staff perspective was less clear on deterrence during the competition. They stated that it was a similar nuance to cooperation but that it might be more difficult to judge.[215] Robert P. Haffa Jr. attempted to clarify by explaining the role of military forces in deterrence during Great Power Competition. Specifically, that military forces demonstrated the capability and credibility necessary to carry out a deterrent threat.[216]

Deterrence continues during armed conflict when the joint force seeks to stifle the war's expansion.[217] This has so far been observed in the Russian-Ukrainian War. Benjamin Jensen argued that although the war's initiation demonstrated deterrence failures, it is a deterrent success insofar as confining the war in Ukraine and limiting the use of weapons of mass destruction.[218]

Like integrated deterrence, the joint publication lacks the specificity on how a set of activities can achieve deterrence. However, for the purposes of this

research, the joint staff's competition continuum discussion provides a useful segment for the space deterrence framework discussed in that section.

Conclusion

In this section, the addressed secondary question was what insights are applicable to space strategy from studying the history of deterrence theory and policy? The historiographical study lent several insights. One was that deterrence can be traced as far back as antiquity and that its core principle was constant: invoke fear to prevent another from an undesirable action. Another insight is the use of various instruments of national power, like diplomacy complemented by the military. The evolution of US deterrence policy highlighted the influences of politics and budgets, which subsequently implies that deterrence strategies should be dynamic. The theoretical study added further depth to the insights offered by US deterrence policies, specifically the role of enemy, domestic, and allied audiences. Credibility was another key highlight and was influenced by the interaction of punishment and denial concepts. Finally, the latest US joint publications offered a new taxonomy on deterrence in a complex environment. Together, these form a deterrence foundation for a potential framework within a space strategy. The next section focuses on historiography and principles centered on the space domain to gain similar insights.

MILITARIZATION OF SPACE AND STRATEGIC PRINCIPLES

A space strategy with historical underpinnings provides an encompassing context for investigating the nuances of military operations in space.

—John J. Klein, *Space Warfare: Strategy, Principles, and Policy*

Once again, the primary question of this paper is how can deterrence theory apply to space strategy as a method to deter actions that render space capabilities ineffective? There are two secondary questions, one of which pertained to deterrence and was discussed in the previous section. The other secondary question is, what insights from the history of space militarization remain applicable to the development of a modern deterrence framework for outer space? This chapter follows the flow in the previous section, beginning with the historiography of space militarization and followed by relevant space strategy principles.

Historiography of the Militarization of Space: 1940s to 1990s

The Soviet Union's successful launch of their *Sputnik* Satellite on 4 October 1957, marked a key milestone for humankind's activity in outer space. Not to be outdone, the US soon followed with the launch of the Explorer 1 Satellite on 31 January *1958.*[219] Though these achievements were significant milestones, the contest for outer space began even earlier. RAND Corporation researchers traced the literary ideas of space weapons to H. G. Well's *The War of the Worlds,* where much of the imagined weaponry was realized years later.[220] The potential for real space weaponry began with the development of rocketry as early as 1903 in Russia.[221] During the Second World War, two coincidental developments eventually combined and significantly influenced the race to outer space: the V-2 Rocket in Germany and the nuclear bomb in the US.[222] The pursuit to extend the reach of nuclear tipped ballistic missiles incidentally provided the platform for placing satellites into orbit.[223]

In the late 1940s, RAND's engineers stated two potential impacts for the future of satellites: 1) A satellite with appropriate instrumentation can be expected to be one of the most potent scientific tools in the twentieth century.2) The achievement of a satellite craft by the US would inflame the imagination of mankind and would probably produce repercussions in the world comparable to the explosion of the atomic bomb.[224]

Eventually, the engineering group postulated that a man-made satellite would be a critical Unites States asset in the emerging Cold War against the Soviet Union.[225] Louis Ridenour also highlighted the military value of satellites in areas of reconnaissance, navigation, intelligence gathering, and targeting. However, despite the potential military advantage, more immediate concerns with the emerging struggle with the Soviet Union allocated the US's limited budget toward airpower and nuclear weapons.[226] Research on satellites for military purposes nonetheless continued under the stewardship of US Air Force leaders. Gen Henry H. Arnold wanted to sustain a relationship with military scientists and universities, which he believed were essential during the Second World War and would also be critical in the future.[227] Meanwhile, leaders like Gen Curtis E. Lemay and Col Bernard A. Schriever advanced the premise that air and space were inseparable and so claimed the Air Force's primacy in space.[228] In the final years of Harry S. Truman's presidency, RAND scientist Paul Kecskemeti argued that satellites had significant political prestige value that could improve the US's position vis-à-vis the Soviet Union.[229] After the feasibility study of satellites concluded, follow-on studies considered the potential psychological and political impacts of the Earth-orbiting systems.

The work conducted by the team of RAND engineers and Air Force personnel laid the foundation for the US's future space policy.[230]

Building upon RAND and the Air Force's satellite research, Eisenhower acknowledged the potential of satellites,[231] specifically, the value of intelligence gathering to break the Soviet Union's cloud of secrecy and the psychological benefits of maintaining the lead over the Soviet Union.[232] In May 1955, the National Security Council issued the United States' first space policy, NSC-5520, US Scientific Satellite Program, and accelerated the US space program.[233] Unfortunately, the scientific satellite program (Project Vanguard) ran into several cost and schedule overruns. Eisenhower considered terminating the program; however, advisors warned that doing so would give the Soviet Union an international propaganda advantage.[234]

Concerned that the Soviet Union would beat the US in space, Eisenhower started an information campaign to depict the Soviet Union's space program as a military effort. Meanwhile, Eisenhower championed Project Vanguard as an open scientific frontier critical for international cooperation.[235] The Soviet Union ultimately won international prestige after the successful launch of *Sputnik* on 4 October 1957.[236] The UN quickly responded and issued an opinion that the right of freedom of space was only applicable to peaceful spacecraft missions.[237] Simultaneously, Eisenhower and his staff further committed to de-emphasizing the importance of *Sputnik*, calling it a publicity stunt, and worked to bolster the US's international prestige.[238]

To advance the US's portrayal for peaceful purposes in space, Eisenhower denied the use of military boosters for Vanguard satellites and prohibited the development or public mention of any kind of orbital weapons.[239] Additionally, in April 1958, Eisenhower lobbied to establish NASA. He wrote, "[T]he highest priority should go of course to space research with a military application, but because national morale, and to some extent national prestige, could be affected by the results of peaceful space research, this should likewise be pushed, but through a separate agency."[240] As the NSC continued the work to portray the US as a peaceful nation in space, Eisenhower realized that the Soviet Union's *Sputnik* success provided the chance to commit the US to civilian and nonaggressive military use of space.[241] Interestingly, in August 1958, while still emphasizing the nonmilitary elements of space, the NSC provided guidance on military satellite development, which included ideas for deploying weapons in space.[242]

The Air Force, a vocal supporter of space weapons since 1956, already considered bombardment from space superior to ballistic missiles. However, Eisenhower's scientific advisors countered that space was unsuitable for effective weapons.[243] Air Force leaders like Gen Homer Boushey, deputy director

for research and development, insisted that the US was "in a race for the control of space."[244] However, Eisenhower steadfastly disagreed and permitted nothing more than studies of weapons in space.[245] Eisenhower portrayed satellites for communication, surveillance, and weather forecasting as nonaggressive systems that supported stability and security, which countered Soviet militarism. This distinction allowed future US presidents to argue that US satellites enabled the free world to peek behind the Iron Curtain and maintain international stability.[246] Meanwhile, due to domestic political pressures, Eisenhower could not ignore the Soviet Union's moves to control space. Therefore, Eisenhower began work to enlarge the US space program.[247]

In the early days of Kennedy's presidency, uncertainty grew over a potential nuclear arms race in space.[248] Moreover, concerns arose from the Soviet Union's supposed intent to deploy orbital bombs.[249] Thus, pressure mounted to improve the US's ASAT and ballistic missile defense systems.[250] In response, Kennedy increased the budget for military space systems and gave the Air Force primacy over development. Kennedy however, still permitted the Army and Navy to pursue their own systems.[251] Notable ASAT tests were two air-launched ballistic missiles. The Air Force conducted the first test in 1959, and the Navy conducted a second test in 1962.[252] In 1963, the Army tested the Nike Zeus ground-launched system and successfully intercepted an Agena D Satellite.[253] Meanwhile, also in 1963, the Soviet Union tested their first ASAT interceptor.[254] Consequently, international concerns grew over arms control. To counter the global criticism of the US Military Space Program, Kennedy started negotiations with the Soviet Union and led the international drive to ban weapons from space. In so doing, he established the US as the lead nation in this effort.[255]

In October 1963, negotiations culminated in the UN General Assembly with the finalization of Resolution 1884 (XVIII). The UN Resolution called on states to refrain from placing nuclear and other mass destruction type weapons in Earth's orbit and on celestial bodies.[256] Despite this milestone, the concern over the Soviet Union's intention to deploy orbital bombs did not recede. These fears materialized in November 1967 when Defense Secretary Robert McNamara announced that the Soviet Union had developed a Fractional Orbital Bombardment System.[257] As negotiations continued, US leaders carefully considered adding to the limits already imposed by previous space agreements. A key consideration was to retain US freedom of action and avoid further criticism about the legitimacy of the US Military Space Program.[258] As a result, although significant as an international treaty, the 1967 Outer Space Treaty was not too far off from the 1963 UN resolution.[259]

Not more than a year later, the Soviet Union conducted their first unambiguous "killer satellite" test, a satellite system designed to intercept other satel-

lites.[260] From 1968 to 1972, the Soviet Union conducted seven clearly identifiable killer satellite tests, five of which were considered successful.[261] Around the same time, the US military continued to improve their ground-launched missile systems, demonstrated by the Air Force test of the Thor System, which had improved capabilities over the Nike Zeus.[262]

Between 1971 and 1976, US concern grew over Soviet photoreconnaissance satellites, especially with systems like the Soviet Ocean Surveillance System that tracked US and NATO warships.[263] Moreover, fears compounded in 1976 when the Soviet Union resumed killer satellite testing.[264] Killer satellite tests continued and averaged one test per year until 1982.[265] Adding even more strain, US Defense Department officials suspected that the Soviet Union was developing directed energy weapons, like lasers and particle beams. In 1975, fears materialized when three US satellites were reportedly "blinded." Investigations into the blinding incidents ultimately acquitted the Soviet Union of wrongdoing, but some critics remained unconvinced.[266] Notably, US space defense development during this period, especially during the peaks of US involvement in Vietnam, took a backseat to the Air Force's traditional missions.[267]

US space defense, specifically ASAT programs, became a higher priority during the presidential transition between Gerald R. Ford and James E. Carter.[268] During this period, President-elect Carter expressed a strong desire for "real" arms control, which should have further restrained ASAT development. However, President Ford hastily authorized ASAT programs in a move to influence Carter's presidency.[269] The ASAT programs were justified under Carter's administration in what became known as the "two-track policy." The view was that an ASAT program would support a US bargaining position and serve as a hedge if negotiations failed.[270] The increasing pace of the Soviet Union's military space activities motivated the improvement of US ASAT capabilities; however, the pace was tempered due to strategic arms limitations talks (SALT II).[271] The subsequent period of Ronald Reagan's presidency, witnessed an accelerated pace of the militarization of space.

According to Paul B. Stares, the early 1980s was a "fundamental watershed in the militarization of space" and a chance for significant ASAT arms control was lost.[272] Major contributors to Stares's assessment were the initiation of the US Strategic Defense Initiative and the inflexibility of the associated US policy, which hardened the Soviet Union's position. Strategic Defense Initiative supporters pointed to a proven Soviet ASAT system, which was more effective than the US's capabilities, and argued that an agreement to limit ASAT development would only favor the Soviet Union.[273] Stares concluded that after a series of posturing on both sides, the Reagan administration "squandered an opportunity to take advantage of unprecedented Soviet flexibility on this issue."[274]

The Strategic Defense Initiative explored a suite of systems that ranged from interceptors to directed energy weapons to defend against the Soviet Union's ballistic missiles and nuclear weapons.[275] One example was the Air-Launched Miniature Vehicle, which the Air Force started to develop in 1982. In 1984, it was tested twice and launched at empty points in outer space. In 1985, the Air Force used an Air-Launched Miniature Vehicle to destroy an aging Solwind Satellite that created more than 900 pieces of orbital debris, which persisted in orbit until 2002.[276] Consequently, the US Congress banned further testing against satellites, in part because such tests damaged strategic arms control negotiations.[277] The Air Force nonetheless continued Air-Launched Miniature Vehicle development without engaging space-borne targets.[278] In 1987, Reagan argued to relieve the Congressional moratorium, stating that a US ASAT program was a critical deterrence capability against Soviet aggression. Specifically, a US ASAT capability would provide a deterrent-in-kind to the threat of Soviet ASAT programs.[279] Congress maintained the moratorium but made an exception for temporary suspension if the Soviets resumed ASAT testing. In 1988, Congress voted against the extension of the ASAT test ban but rejected a $100 million request for a ground-based ASAT system. This gave way to a different form of ASAT weaponry: directed electromagnetic energy.[280]

Directed electromagnetic energy weapons suffered from range and weather limitations that didn't affect missiles, but they produced far less debris. Additionally, unlike missiles that could be traced through trajectory analysis, directed energy weapons provided the user with a degree of deniability. Furthermore, while missiles were designed to destroy, directed energy weapons provided a range of defeat options from temporary sensor disruption to permanent vehicle damage.[281] The megawatt-class mid-infrared advanced chemical laser (MIRACL) was one such directed energy system, whose various components were operated by the Army, Navy, and Air Force.[282] In 1996, the Congressional ban that prevented testing on space targets expired. Thus, a MIRACL test in 1997 successfully illuminated a satellite orbiting at 420 km.[283] However, debate ensued on whether the 1997 MIRACL test was in fact an ASAT test. Air Force Lt Col Randall S. Weidenheimer explained that the parameters of the test indicated that the MIRACL illumination of the satellite amounted to a science experiment.[284]

The study of space militarization demonstrated model examples of diplomatic-information-military national power synchronization and the prudence of flexible policy. As it relates to deterrence, the period encompassing the Eisenhower, Kennedy, and Johnson presidencies showcased nuanced space policies that clearly enabled the militarization of space but kept nuclear weapons and other weapons of mass destruction from outer space. Eisenhower

was especially impressive as he led an information campaign that blunted the Soviet Union's *Sputnik* achievement and maneuvered the US to a stronger international position. Carter's two-track policy also demonstrated a balanced approach as he maintained strategic arms control negotiations while steadily advancing space capabilities. In contrast, Reagan's hardline policies forced the Soviet Union into untenable positions and damaged the possibility of future working relationships. Moreover, these policies set the stage for more aggressive space weapons development but with less ability to temper the opposing side. When considered from the Soviet Union's vantage point, the historiography demonstrated how the Soviet Union's aggressive intent to control space provided the motivation for the US to reciprocate more intently. Tying in the previous chapter's insight to incorporate fear to deter, a comprehensive insight is that an effective space strategy ought to be holistic and firm yet be flexible enough to respond to the action-reaction cycle between players. Considering this insight, how does US contemporary space strategy rate?

United States Space Strategy Revisited

As shown in the Introduction, the current US space strategy is found across various official documents: the 2022 National Security Strategy, 2022 National Defense Strategy, 2021 Space Priorities Framework, 2020 Defense Space Strategy, and the Space Force's 2020 Space Capstone Publication. Before the publication of these latest documents, Joshua P. Carlson summarized US space strategy as "satellite-centric thinking that prioritizes security, stability, and maintaining current advantages."[285] The latest space strategy related documents, especially from the Department of Defense, do not deviate much from Carlson's conclusion. The White House's National Science and Technology Council's publications on the National Cislunar Science and Technology Strategy, National Orbital Debris Implementation Plan, and In-Space Servicing, Assembly, and Manufacturing National Strategy, however, aimed at further positions in outer space.[286] Finally, the latest NASA Strategic Plan laid out reinvigorated goals for scientific discovery, exploration, and human spaceflight.[287] There was also an update to the Space Strategy Review as part of the 2022 National Defense Strategy; however, it remains classified.[288] There is sense in closely guarding this type of information. However, with such high levels of secrecy, how else is the US communicating intent and what is the feedback mechanism to facilitate the action-reaction process? Moreover, how does the summation of these strategies achieve the aspired deterrence? The lack of identifiable ways (or methods) to achieve space deterrence leaves allies, partners, and adversaries to over-speculate, which can lead to unintended perceptions.

To fill the ways (or methods) gap of space deterrence, the research turned to the historiographies of deterrence and space militarization, which provided applicable insight. Next is a related study area that focuses on strategic principles tailored to influence outer space.

Evolution of Space Strategic Principles

In the pursuit to influence outer space for deterrence purposes, it is useful to understand "space power." To better understand space power, Carlson modeled the Navy and Air Force, which respectively distinguished sea power from maritime activities and air power from aviation.[289] Carlson proposed the following definitions:

1. Space power—the military force that can exert influence in and from the domain and create effects in other domains for strategic benefit.
2. Astronautics—elements that are primarily commercial and industrial; it includes all aspects that allow for projection into production, sustainment, training, profit, and expansion in the domain for the purpose of strategic benefit.[290]

Space power theorists like Joshua P. Carlson, John J. Klein, Everett C. Dolman, and David E. Lupton often turned to established principles from preceding "powers," like air power and sea power, to form their ideas. For example, Klein asserted that just as space operations utilized ground facilities, uplinks and downlinks, and the satellites themselves, naval and air operations encompassed home and abroad facilities that supported ships and planes. Additionally, like international waters and international airspace, space is open to all nations, and is free from sovereignty claims. Thus, the histories of sea and air power have served as a guide to developing space strategy as space power theorists derived select tenets from sea and air power theories.[291] This research follows the example of established space power theorists and builds upon their work.

Influence of Air Power

Early thought regarding space forces was that they were simply "high-flying air forces." This was reflected in the word "aerospace," a term generally credited to then-Air Force Chief of Staff, Gen Thomas D. White, when he successfully argued in 1958 that air and space were indivisible.[292] White wrote that "for all practical purposes air and space merge, forming a continuous and indivisible field of operations."[293] According to Klein and M.V. Smith, aerospace integra-

tion advocates believed space power was synonymous with air power because it delivered the same product.[294] The central argument of the aerospace school of thought was that air and space were a "seamless medium unconstrained by arbitrary divisions of the vertical dimension."[295] Thus, a distinct space power theory was unnecessary because aerospace power included space operations.[296]

Another major factor that influenced the integration of air and space were the views of certain Air Force senior leaders concerned with command and control. Former Vice Chairman of the Joint Chiefs of Staff, Lt Gen David Vesely, was quoted as saying, "Whatever differences there are between air and space are not important to the theater commander (strategic level) or the warfighter (tactical level). What is important is the effect on the battlefield. Whether it's weapons, communications, or information, the warriors out there don't care where it came from as long as it has the desired impact on the battlefield."[297] The view of aerospace's "seamless operational medium" was further emphasized in Air Force publications signed off by the Air Force's secretary and chief of staff.[298]

Smith argued that the failure to appreciate the physical differences that influence operations between the two mediums stifles the potential of both air power and space power. On the claim of air and space indivisibility, Smith pointed to the "transverse region" as a functional boundary of air and space. The transverse region is a 65-mile-wide area that, owing to the limits of aerodynamics and orbital mechanics, forms an invisible barrier that separates air and space operations.[299] Additionally, the remoteness and laws of orbital motion create operational characteristics distinct from air power.[300]

According to Colin S. Gray, although outer space is synonymous with the military concept of a "high ground," space was also both global and all but infinite in military depth. Additionally, space power translated as satellites that could be made available globally as either regularly repeating or constantly overhead.[301] As Lt Col Michael R. Mantz concluded:

> Air and space are operationally different. Aircraft have maximum maneuverability, while spacecraft have greater altitude and speed, but can't maneuver [with even a fraction of an aircraft's agility and flexibility]. The principles of war of mass and maneuver certainly do not apply in the same way. Aircraft can mass repeatedly through maneuver over a target, while spacecraft can mass for short periods after great effort, but will disperse almost immediately with a repeat manning unlikely. Aircraft operations are "on demand," while spacecraft operations are "as scheduled" or "when available."[302]

Klein argued that despite the opposing views on the appropriateness of air and space's integration, the two had an interrelationship and dependency from shared activities and boundaries. For example, space vehicles had to first transit through the air domain, before they could reach any desired orbit. Klein concluded that any derived theory and strategy for space ought to consider dependencies on different environments and be holistic in the approach. Thus, the indirect effects of space operations in other domains, nonspace activities, and grand strategy should also be addressed.[303] The proposed space deterrence framework incorporates this insight in the Space Deterrence Framework section.

Influence of Sea Power

The term "sea power," was coined by Alfred Thayer Mahan in his publication of *The Influence of Sea Power upon History,* 1660–1783.[304] However, the modern application of sea power toward space power is best reflected by expanded principles of maritime strategy, which were built on Mahan's initial sea power concepts. Maritime pertained to overarching activities and interests regarding the oceans and seas. These included the activities related to interrelationships of science, technology, cartography, industry, economics, trade, politics, international affairs, imperial growth, communications, migration, international law, social affairs, and leadership.[305] Maritime also included the interaction between land and sea operations, which was an important consideration due to the historical need to protect coastal ports for trade.[306] On maritime strategy, many historians have recognized Sir Julian Stafford Corbett for his exposition of maritime principles in his 1911 book, *Some Principles of Maritime Strategy.*[307] Klein derived from Corbett's work on maritime principles and developed analogous strategic principles for space warfare, illustrated in table 3.

Table 3. Maritime and Space Warfare Principles

Maritime Strategic Principles	Strategic Principles for Space Warfare
National power implications	Space is tied to national power
Interdependence with other operations	Space operations are interdependent with others
Maritime communications	Celestial lines of communication
Strategic positions	Strategic positions
Command of the sea	Command of space
Strategy of the offense	Strategy of offense
Strategy of the defense	Strategy of defense
The power of isolation	--
Disputing command	--
Blockades	Blocking
--	Space as a barrier
Cruisers	--
Dispersal and concentration	Dispersal and concentration
--	Actions by lesser powers

Source: Created by the author with information from John J. Klein, Space Warfare: Strategy, Principles, and Policy (New York: Routledge, 2006), 21–126.

Strategic Principles for Space Warfare most Relevant to Deterrence

Klein's strategic principles for space warfare provide valuable concepts to apply in a space deterrence framework. The strategic principles are grounded in established maritime principles and modified thus to apply to space warfare. Many of the space warfare strategic principles overlap and are applicable to deterrence. However, the following section focuses on the principles most critical to the space deterrence framework discussion and are discussed in more detail later in the space deterrence section.

Interdependence with other operations. Corbett argued for the close cooperation between ground and sea forces. It was this mutual relationship between the army and the navy that encompassed a maritime strategy, which ultimately sought to achieve political objectives. Moreover, although fleets

could significantly impact an enemy's trade and economy, it was unlikely for such actions to determine the outcome of war. As was often the case, wars only concluded after ground forces landed on enemy territory.[308] Comparably, space activities contribute significantly to civil and military activities on land, sea, and air, especially the activities related to intelligence, communication, weather services, and navigation. However, despite the considerable contributions of space operations, a war's outcome is unlikely to be determined through space activities alone. Thus, space strategy must consider its interdependency with other domains.[309] For example, a land force that targets a ground link station can easily impact space through the independent application of land warfare tactics. Therefore, space forces must rely on land forces to protect their critical ground stations.

Celestial lines of communication. Corbett described three types of maritime lines of communications: (1) those that supported the fleet, (2) those needed by an overseas army, and (3) trade routes.[310] On land, the lines of communication of opposing forces ran in opposite directions, where one end was at the most forward force and the other end at some rear support area. At sea, lines of communications of opposing forces often tended to be approximately parallel or even one and the same.[311] Thus, the primary purpose of any fleet was to control lines of communication because guarding one's own effectively equated to seizing those of the enemy.[312] According to Klein, celestial lines of communication were those in and through space used for the movement of trade, materiel, supplies, personnel, spacecraft, electromagnetic transmissions, and some military effects.[313] By ensuring access to "lines of passage and communication" in space, a state could protect its diplomatic, information, military, and economic interests. Like lines of communications at sea, those in space often ran parallel or were shared with the enemy. Moreover, since lines of communications between opposing forces could be one and the same, the attack of an enemy's celestial lines of communication could often affect one's own.[314]

This is directly applicable in a deterrence-through-denial methodology. For example, two opposing players, nation A and nation B, could simultaneously place spacecraft in a specific celestial line of communication or orbit. If nation A acted to render nation B's spacecraft unresponsive, nation A would have to maneuver their spacecraft to avoid damage from the resulting debris.

Another key aspect of celestial lines of communications is related to space launch. In space launch, there is an optimal path to achieve orbit, and any deviation from the optimal path adds to the cost. Too high a cost could make the launch untenable.[315] Several factors, like available technology, can influence space launch, but one of the most critical is the launch location. According to Everett C. Dolman, the launch center location is intrinsically related to orbital

efficiency.[316] For example, because of the Earth's spin, eastbound launches along the equator benefit from a 1,670 kph (kilometers per hour) velocity boost. If launched further from the equator, closer to the poles, eastbound space vehicles benefit less from the Earth's spin. In a westbound launch along the equator however, the earth's spin has a deleterious effect. Consequently, an eastbound launch closer to the equator requires less thrust to achieve the same orbit with the same payload. Thus, the more efficient eastbound launch along the equator can expend less fuel or can carry a heavier payload.[317] In a real-world example:

> A European Ariane rocket launched due east from the French Space Center at Kourou, French Guiana, just 5° north of the equator, receives a 17 percent fuel efficiency advantage over a US rocket launched due east from Cape Canaveral, about 28.5° north of the equator. In perhaps a more powerful example, a Space Shuttle launched due east from Cape Canaveral has a cargo capacity of 13,600 kg. A Space Shuttle launched due west from roughly the same latitude (from the US Western Space Range at Vandenberg Air Force Base), can barely achieve orbit with its cargo bay empty.[318]

Therefore, depending on the desired orbit, control of certain launch locations equates to strategic advantages. This strategic principle also complements deterrence through denial. However, before that discussion, it is useful to first understand an associated principle: strategic positions.

Strategic positions. Mahan saw the sea as a "wide common, over which men may pass in all directions, but on which some well-worn paths [emerge for] controlling reasons."[319] The controlling reasons were the efficiency of transporting trade and the earth's geography, which had natural corridors. The state that achieved control of the corridors acquires so much commercial benefit that, through the resulting wealth, it would dominate militarily and politically. Critical to Mahan's theory were chokepoints, "globally strategic waterways dominated by point locations."[320] Mahan identified seven global sea lane chokepoints: the straits of Dover, Gibraltar, and Malacca, the Cape of Good Hope, Malta, the Suez Canal, and the St. Lawrence Seaway. Later geo-strategists added the Panama Canal, Tsushima, and many others to the list. Control of these chokepoints was tantamount to command of the sea. A competitor state that avoided these chokepoints incurred great cost from lost time and additional fuel. In war, the additional time for military transport could be the difference between winning or losing. Thus, the state in control of these natural corridors gained dominance over global military movement and trade.[321]The same ideas are applicable to strategic positions on Earth and in outer space.

The first application is in space launch. The nature of orbital mechanics, the characteristics of orbital types, and the earth's rotation leads to optimal launch locations, giving those locations strategic value, much like Mahan's natural corridor concept.[322] Launch locations influence the type of technology necessary to reach the desired orbit, thus affecting cost. Consequently, nations whose sovereign territories are already at optimal launch locations gain an advantage. However, only a few nations even possess space launch centers, and their capabilities can provide strategic leverage.[323] With respect to deterrence, consider the influence of launch locations over a nation's reconstitution capability. As previously discussed, launch locations influence the amount of necessary fuel and payload limitations, which translates to cost. Thus, a nation with more optimal launch locations, gains a strategic advantage because it could reconstitute damaged space systems at a cheaper cost.

Another area related to strategic positions and launch locations is antipodal zones. These are the regions on the opposite side of the globe relative to the launch site. For example, the antipodal zone of Cape Canaveral, a US eastern launch site, is in the middle of the Indian Ocean (28° 27' 2.8" south latitude, 99° 28' 24.2" east longitude), over 750 nautical miles off the coast of western Australia.[324] On the path to orbit, spacecraft have no choice but to pass through the launch site's antipodal zone. According to Martin E. B. France, a hostile actor could deny a nation's ability to enter outer space through control of antipodal zones.[325] For example, if an actor wanted to deny the US the ability to reconstitute its degraded space systems, a naval force with adequate interceptors could position appropriately in the Indian Ocean as a signal to the US.

There are also chokepoints in outer space with strategic value. The closest to Earth are known as Low-Earth Orbits (LEO). Further from Earth, but also strategically valuable, are Geostationary Orbits (GEO). Over the years the extensive activity in the LEO and GEO regions made-up 90 percent of all satellite operations.[326] Notably, LEO holds many military satellites and is the realm of ASAT weapons. Manned space stations and the space shuttle also primarily operate in LEO. Furthermore, any nation wishing to explore the vastness of the universe must do so through LEO.[327] Dolman captured the criticality of this concept through the following astropolitical dictum: "Who controls low-Earth orbit controls near-Earth space. Who controls near-Earth space dominates Terra. Who dominates Terra determines the destiny of humankind."[328]

Next is GEO, which is a ring around the equatorial waist of the earth and is the only natural orbit that permits a satellite to be relatively fixed on a given terrestrial point, providing persistent overhead coverage of that terrestrial area. Due to effects like broadcast interference, fewer satellites can operate adjacent to each other, thus making the GEO belt a prime location. GEO space is so

valued that in the 1977 Bogota Declaration, nine equatorial states asserted that their sovereign territory extended upward to the GEO altitude, thus demonstrating that GEO is a contested geopolitical area.[329]

The final position-related strategic area is Lagrange Points. These are points in Earth-moon space where gravitational effects balance out. Consequently, a spacecraft that occupies a Lagrange Point can remain permanently stable and does not have to expend any fuel. Although the value of Lagrange Points remains highly speculative, the points are considered to have immense military and commercial value.[330]

Now consider the strategic positions through a deterrence by denial lens. Paired with the principles of celestial lines of communication, the simple fact of occupying a LEO or GEO position simultaneously denies the value of that position from another. This is related to the next strategic principle.

Command of space. Command of the sea was generally understood as the control of maritime communications for commercial and military purposes.[331] Corbett explained that the concept only existed in war. In peace it was simply the state of having a sufficient fleet at necessary locations so that once war erupted, command could be secured.[332] Corbett also distinguished command because of the size of the area (general or local) and the duration (temporary or permanent). A force achieved general command when the enemy was unable to threaten lines of passage and communication or protect its own. Local command was similar but in a more limited area. General or local command was also influenced by the duration of the achievement, either permanent or temporary.[333] Klein used these concepts to describe command of space.

According to Klein, command of space is inclusive of the often-associated term of "space control." Beyond what space control describes, command of space includes measures achieved outside of hostile actions, which is manifested in three methods: (1) presence, (2) coercion, or (3) force.[334]

"Command through presence" yields automatic influence simply by existing in a specific space. For example, at the height of Great Britain's global empire, the presence of British forces across key global locations forced adversaries to contend with Great Britain from the simple fact of their presence.[335] However, to properly exercise command through presence, the degree of presence is also important. For example, in response to the 1977 Bogota Declaration of the nine equatorial states, the US and the Soviet Union, who had the majority presence in the geostationary belt, simply voted against the declaration. The insight, therefore, is that those with the most active presence and participation in space hold a commensurate ability to influence international norms for access to and use of space.[336]

"Command through coercion" encompasses activities short of open hostilities. It is a range of actions that threatens, implicitly or explicitly, some detrimental action that can include the use of force. A key requirement for coercion is the ability to reach the area where coercive action is desired.[337] Klein asserted that all instruments of national power should be considered in the approach since the target of coercion is often leadership. The 1967 Outer Space Treaty, which prohibited weapons of mass destruction in space, was one example of a diplomatic coercive action that specifically affected outer space.[338]

"Command through force" involves the overt use of violent physical and nonphysical actions to gain command. It is a method for periods of open conflict and employs classical concepts of offense and defense.[339]

Command of space methods logically complements deterrence punishment and denial concepts. For example, a significant US spacecraft presence in LEO can simultaneously enable command through presence and deterrence through denial. By the simple fact of occupying LEO positions, the US can deny certain benefits from an adversary. Simultaneously, if an adversary wanted to influence LEO positions, it would be forced to contend with the United States, like the NATO trip-wire effect of US forces in Europe. Alternatively, a nation with ASAT weapons at key locations, either by land, sea, air, or space, with the operational reach to affect systems in LEO, enables the nation to command through coercion, or force if necessary, thus enabling deterrence through punishment.

Actions by lesser powers. Klein defined "lesser" powers as those that do not exercise command of space to the extent that "superior" or more influential nations in space do. The term "lesser" was not intended pejoratively but rather as an indication of relative standing of those exercising command of space. The terminology was also inclusive of nonstate actors, such as private corporations.[340]

Those with a desire to improve their standing in outer space could take several courses of action. For example, an actor could aggressively build up its presence in outer space. It could also advocate for international space regulations in its favor. Lesser and superior powers could also cooperate through mutually beneficial agreements. For the lesser power, cooperation could help improve relative standing without directly challenging the command of superior powers. The lesser power could also take advantage of a superior's technological capabilities and save on resources for development and training. For the superior power, the cooperative relationship could result in gains in non-space related activities.[341] Klein provided the following example to demonstrate a superior power's potential gains: "The United States has been the dominant military member of those signing the North Atlantic Treaty of 1949, which mutually engaged several countries along with the United States into a

cooperative security agreement. While the military capabilities of these other nations might not match that of the United States, the United States has garnered more diplomatic and economic support than it would have otherwise without such a security arrangement."[342] For deterrence through denial purposes, the actions by lesser powers principle involves the cooperation of US allies and partners. First, recall the trip-wire example of US forces in Europe as a denial deterrent against Russia that, if triggered, threatened to unleash the punishment deterrent of strategic air forces. Now consider that effect if space systems were co-owned or co-operated by the US and its allies or partners. If an adversary wanted to contend with the United States by threatening space systems, then the adversary is also forced to consider the reactions of US allies or partners, thus achieving deterrence through denial, while incorporating deterrence through punishment, from potentially multiple nations.

Conclusion

In this section, the following secondary question was addressed: what insights from the history of space militarization remain applicable to the development of a modern deterrence framework for outer space? An insight from the historiography was the power of synchronizing diplomatic-information-military instruments and the value of flexible policy. For deterrence purposes, the Eisenhower, Kennedy, and Johnson presidencies demonstrated space policies that enabled the militarization of space but exempted weapons of mass destruction. Eisenhower's use of the information instrument was especially impressive as he dulled the Soviet Union's *Sputnik* achievement and positioned the US to a stronger international position. In contrast, Reagan's hardline policies set the stage for more aggressive space weapons development but with less ability to temper the opposing side. The historiography surrounding the Soviet Union also demonstrated how their aggressive intent to control space enabled the US to develop space weapons more intently. The comprehensive insight is then that effective space strategy should be holistic and firm but flexible enough to respond to the actions and reactions of players.

The research then led to the evolution of space strategic principles. The study of air power illuminated the space domain's interdependency with other domains. The study of sea power aided theorists, like John J. Klein, to develop strategic principles specific to space warfare. This research advances those strategic principles to create a space deterrence framework, discussed in the next section.

SPACE DETERRENCE FRAMEWORK

This statement of the Science Advisory Committee makes clear the opportunities which a developing space technology can provide to extend man's knowledge of the earth, the solar system, and the universe. These opportunities reinforce my conviction that we and other nations have a great responsibility to promote the peaceful use of space and to utilize the new knowledge obtainable from space science and technology for the benefit of all mankind.

—Dwight D. Eisenhower, Science Advisory Committee's Paper, "Introduction to Outer Space," 26 March 1958

I think everyone here recognizes how extraordinary space is. Whether it is satellites that orbit the Earth, humans that land on the Moon, or telescopes that peer into the furthest reaches of the universe, space is exciting. It spurs our imaginations, and it forces us to ask big questions. Space—it affects us all, and it connects us all.

—Kamala D. Harris, "Remarks by Vice President Harris on the Ongoing Work to Establish Norms in Space." Speech, Vandenberg AFB, CA, 18 April 2022

During this study, methods to complement US space strategy and deter adversaries from actions harmful to US space capabilities were investigated. The driving question was, how can deterrence theory apply to space strategy as a method to deter actions that render space capabilities ineffective? The result is a space deterrence framework that is grounded by deterrence through denial and punishment concepts across the competition continuum. The framework encourages holistic activities and flexibility across the instruments of national power to support an adaptive deterrence policy capable of responding to a dynamic strategic environment. The framework is broken out by instruments of national power. However, users must consider the entire framework and reflect on how particular actions work together to achieve deterrence.

For orientation, figure 1 represents a set of diplomatic activities that can support deterrence, aligned to their deterrence mechanism and applicability across the competition continuum. For example, a "sanctuary in space" or mutual defense agreement between nations achieves deterrence through denial and is applicable in cooperation, competition, and conflict situations. Alternatively, a demarche is more aligned to punishment and is only applicable in more competitive or open conflict situations. The subsequent frameworks for

information, military, and economic instruments of national power follow this model. All four are intended to support and complement one another.

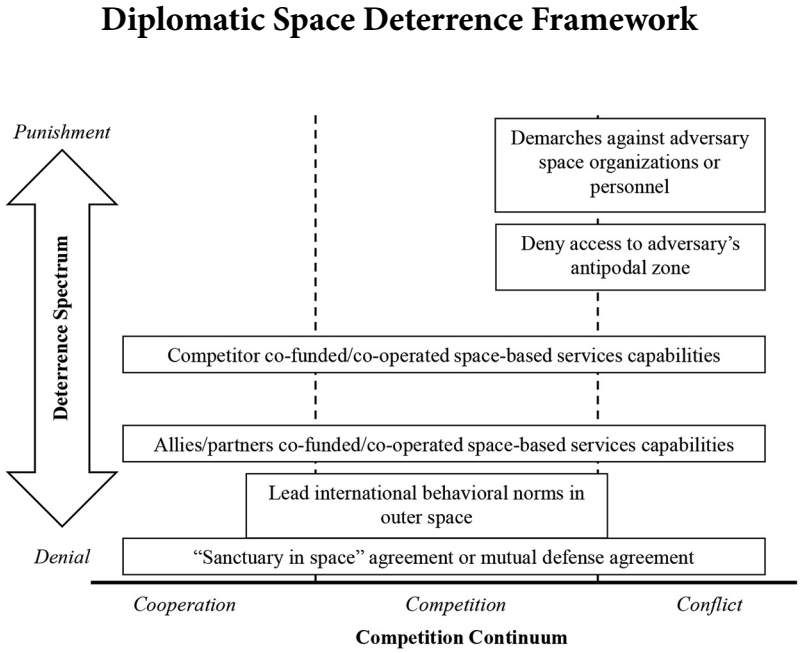

Figure1: Diplomatic Space Deterrence Framework
Source: Created by author.

Diplomatic power provides several options that can deny or punish a nation across the competition continuum. According to Reed J. Fendrick, "[The goal of diplomacy was] usually, but not always, to reach an agreement that could range from those containing significant enforcement mechanisms for implementation (e.g., the Non-Proliferation Treaty) to hortatory proclamations such as the Kellogg-Briand Pact that purported to outlaw war."[343] The 1967 Outer Space Treaty is a space-specific example of diplomatic power. The Outer Space Treaty is a landmark treaty that sets principles for the governance of outer space and, most notably, restricts placement of weapons of mass destruction in outer space or celestial bodies.[344]

Looking through the deterrence lens, the Outer Space Treaty and four other subsidiary legal agreements are examples of diplomatic deterrence instruments that legally deny nations from freely engaging in potentially incendiary behaviors in outer space.[345] However, some have argued that the current outer space

treaties are outdated and do not address modern challenges. For example, Rajeswari Pillai Rajagopalan asserted that the current outer space treaties are subject to expansive legal interpretation and therefore cannot restrict the weaponization of space.[346] Anél Ferreira-Snyman argued that the current treaties are insufficient to address the growing orbital debris problem and are especially detrimental to developing African space powers.[347] Pursuing updates to the current space treaties is one of the diplomatic options that can support deterrence.

A strong denial mechanism is to update current international agreements to designate space as a sanctuary, or an agreement of mutual defense. Short of formal agreements, an alternative is to lead international behavior norms in space. This is akin to the development of the Laws of the Sea, which can trace its roots from historical customs and soft laws.[348] Logically, leading international behavior norms have less denial capability because they lack the formal agreement between parties. Moreover, they are less cooperative because they would otherwise be formalized and are less likely to be adhered to in conflict. Sensibly, this diplomatic form of denial is best supported by information activities to help gain international acceptance and potential diplomatic, military, or economic threats if disregarded.

Another diplomatic activity using the deterrence through denial category is an agreement to cofund and co-operate space systems with allies and partners. This was inspired by Thomas Schelling and Glenn Snyder's analysis of US forces in Eastern Europe and their value as a trip-wire deterrent against the Soviet Union and the Warsaw Pact. This also draws inspiration from Klein's actions by lesser powers strategic principle. Space systems owned and operated by multiple nations complicate targeting for any potential aggressor because they force aggressors to contend with all the stakeholders, whether desired or not. If this logic were extended further, then cooperation with competitors or adversaries could provide a greater deterrence effect. Not only does this utilize deterrence through denial, but the guaranteed mutual-detrimental effect from aggressive actions also results in self-punishment.

Such a paradoxical relationship with competitors is not without precedent. In a draft letter for President Eisenhower intended for Chairman Khrushchev, Undersecretary of State Christian Herter outlined potential space-cooperation areas between the US and the Soviet Union. These programs included a joint program of scientific satellites, satellite tracking, communication frequency agreements, a worldwide communications network, lunar expeditions, international space platform, Mars and Venus probes, and leading an effort to recruit scientists and engineers worldwide to participate in outer space projects.[349] Special Assistant for Science and Technology James R. Killian Jr. also wrote a letter to Christian Herter expressing support for the space cooperation initia-

tives.[350] However, Khrushchev ultimately ignored Eisenhower's invitation for space cooperation because of the Soviet Union's recent *Sputnik* achievement.[351] Eisenhower, and later Kennedy, made repeated calls for US and Soviet Union space cooperation. However, after Yuri Gagarin's achievement as the first man to escape Earth's gravity, Khrushchev remained steadfast. Meanwhile, the Soviet Union's development in other space technology areas, like telecommunications, fell further behind the US. After John Glenn became the first American in orbit, Khrushchev finally softened. What followed was a series of cooperative programs that included the exchange of weather data from satellites, coordinated launching of meteorological satellites, a joint effort to map the earth's geomagnetic field, and cooperation in the experimental relay of communications.[352] These initial programs became the foundation for several cooperative programs that ebbed and flowed with the political tensions that followed world events and changing leaders. According to Roald Sagdeev and Susan Eisenhower, during the last Moscow summit in May 1988, Mikhail Gorbachev even attempted to persuade Ronald Reagan to support a joint mission to Mars.[353]

If such extensive space cooperation was possible at the height of the most well-known superpower competition in recent history, what realities are possible today? Connecting back to space deterrence, this unprecedented degree of space cooperation is uniquely aligned to both denial and punishment mechanisms. Not only does it limit a competitor's potential aggressions, but it also guarantees mutual harm. Logically, diplomacy is the primary instrument to achieve this form of deterrence, but the other instruments can also complement, as later discussions will show.

If denial mechanisms fail to deter, there is still refuge for the diplomatic instrument of power. One is an international sanction to deny an aggressor access to their launch center's antipodal zone. Recall that the antipodal zone is on the opposite side of the globe in relation to the launch site, where rockets pass through on their most energy efficient route to orbit. A legal denial of such strategic positions could impose costs to the aggressor. Unfortunately, the diplomatic instrument in this activity is limited to situations where the antipodal zone is above another sovereign territory. For example, the antipodal zone of China's eastern coast is above South American countries like Chile and Argentina.[354] Thus, if the US wanted to use this denial mechanism, then there must be prearranged agreements with Chile and Argentina to protest China's violation of Chilean and Argentinian airspace sovereignty.

The final diplomatic instrument reserved for tense competition or conflict situations is demarches. The unfortunate limitation of diplomatic actions is their efficacy in deterring an undesirable action. Diplomatic threats often rely

on complimentary actions from the other instruments of power to have any effect. Hence the emphasis on holistic activities across the instrument of national powers. The next framework focuses on the information instrument of power.

Information Space Deterrence Framework

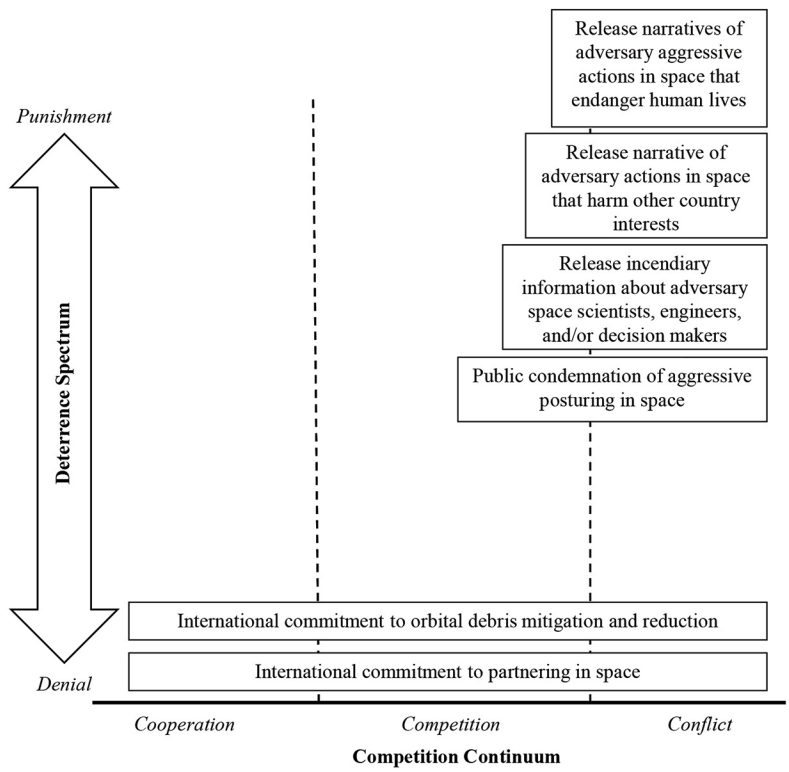

Figure 2: Information Space Deterrence Framework
Source: Created by author.

The effective use of information as an instrument of power is an ongoing challenge for the US. According to Milton Mueller and Karl Grindal, the controversy over the Smith-Mundt Act of 1948 illustrates this challenge. The passage of the law began a debate, which endured for decades, on whether the US Information Agency produced government propaganda and if it was appropriate for dissemination to Americans. Mueller and Grindal added that although the US

Information Agency no longer exists, similar debates arose during the Iraq and Afghanistan wars concerning suspicions of military-domestic propaganda.[355]

Information as a power is nonetheless a useful instrument as Russia has demonstrated through its utilization of (dis)information, much to the frustration of the West.[356] The information instrument's greatest utility is its ability to influence public perception. As demonstrated previously in the discussion of deterrence historiography and theory, Eisenhower skillfully wielded the information instrument to recover from the Soviet Union's *Sputnik* achievement, improved the US's international position, and framed the US's militarization of space for peaceful purposes. Used effectively, actions utilizing information power can have complementary effects with other instruments of power in either a denial or punishment mechanism.

For deterrence through denial purposes, an information campaign can portray the US as a nonaggressive international partner that supports the aims of other instruments of national powers, like the diplomatic pursuit of sanctuary in space or mutual defense agreement. The period leading up to the 1967 Outer Space Treaty is a good example of how the US worked to portray itself as a peace-seeking nation in outer space. Sliding toward a more punishment-aligned mechanism, the portrayal of a peaceful US was complemented with narratives of the Soviet Union's militarism. These complementary narratives helped improve the US's international position, despite its own space-militarization activities.

Tying in the major tenets previously discussed in the historiography of deterrence, the information instrument supports credibility through its influence on domestic, allied, and adversary audiences. For example, a narrative geared toward domestic and allied audiences can help garner support for additional resources to build new capabilities, recruit talent, or approve policy. For the adversary audience, a synchronized narrative across the whole of government supports the credibility of an aspiring partnership or a potential threat. However, a key consideration is that the information instrument must be supported by other national power instruments. For example, a commitment to international partnering or orbital debris mitigation rings hollow if there is no subsequent investment in the military or private sector to support the claim.

Moving further toward the punishment mechanism, information can also be used to cause friction within an adversary's domestic audience, a tactic inspired by Russia's own (dis)information activities in the western nations. For the United States, this can involve the authorities and capabilities of US Cyber Command. For space deterrence purposes, US Cyber Command can conduct operations that target key adversary space scientists, engineers, or decision makers to seed doubt in their ability to contend with the United

States. US Cyber Command can also help spread provocative narratives to disrupt an adversary's relationship with its allies or partners, while masking the United States as the source. Details of such tactics are beyond the scope of this research, but it demonstrates the possible ways information can be used as a punishment mechanism. It is also another example of interdependency across the national power instruments. The next discussion concerns the military space deterrence framework.

Military Space Deterrence Framework

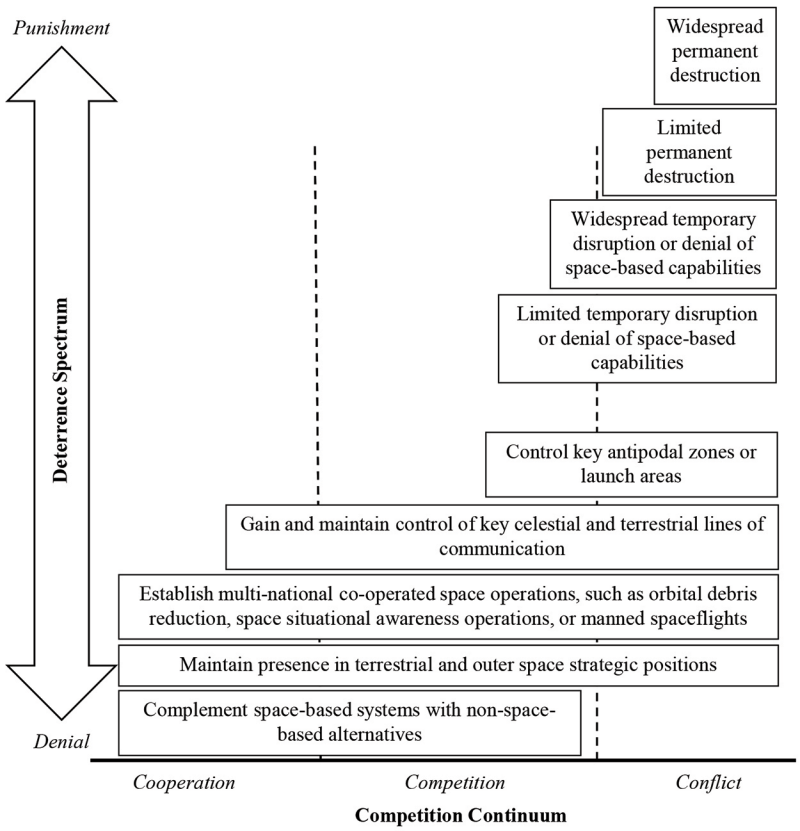

Figure 3: Military Space Deterrence Framework
Source: Created by author.

As the instrument that has historically gauged a nation's power, the military provides the widest range of options that can be applied to space deterrence.[357] In preparation for potential terrestrial conflict, the strategic advantage provided by space-based capabilities is undeniable. China's and Russia's robust development of ASAT weapons designed to cripple space-based systems is a sign that the perceived benefit of targeting space systems is worth the cost of weapons development.[358] For denial purposes, complementing the US military's space-based capabilities with nonspace-based alternatives is one method of decreasing an adversary's perceived benefit for targeting space-based systems. Nonspace-based capabilities provide alternative, contingent, or emergency services and add resiliency to the current space-based capabilities, thus reducing the perceived benefit of targeting space-based systems. According to the Defense Intelligence Agency, Russia has already arrived at this conclusion and has developed terrestrial redundancies to complement or replace space capabilities that may be denied in conflict.[359]

Inspired by Klein's space strategic principles, another option is to gain and maintain presence in terrestrial and outer space strategic positions. Critical to the success of this strategy is a sense of urgency because presence at a strategic position simultaneously denies others that specific strategic benefit. This is consistent with Klein's command through presence and has numerous favorable effects. One is automatically denying the adversary the benefit of those strategic positions. Another is the strategic prepositioning to enact some war plan designed to achieve command of space or control celestial lines of communication. Looking through the deterrence lens, strategic prepositioning also demonstrates the operational reach to activate a potential punishment threat. Alternatively, if command of space is unattainable, then strategic positioning to cause mutual suffering is an option. For example, US spacecraft positioned sufficiently close to an adversary spacecraft imposes mutual collateral damage risk if either party took aggressive action.

The next activity was inspired by the trip-wire denial concept and is a complement to the activity discussed in the diplomatic space deterrence framework, multinational co-operated space operations. Space operations likely to gain multinational support are in orbital debris reduction operations and space-situational awareness. The denial effect of this activity is how it complicates an aggressor's targeting because space systems co-owned and co-operated by multiple nations automatically force aggressors to contend with all stakeholders. This also draws from the "actions by lesser powers" strategic principle and enables a harsher punishment threat from multiple nations. As discussed in the diplomatic space deterrence framework, a logical extension of this idea is military space cooperation with adversaries. One possible area of coopera-

tion with mutual benefit to the US and an adversary like China, is orbital debris mitigation and reduction operations.

Another extension of the tripwire denial strategy involves manned space operations. Like the US forces in Eastern Europe designed to deter Russia, manned space operations in key celestial lines of communications and strategic positions automatically force aggressors to contend with their presence. While the main purpose of manned space operations should be space exploration and discovery, there is an undeniable deterrence through denial benefit if manned space operations were in a potential collateral damage area from an aggressor's actions.

An additional military option is a complement to a previously discussed diplomatic activity, controlling antipodal zones. In this case, the military serves as a backstop to the diplomatic denial of an adversary's antipodal zone. This method is even easier if an antipodal zone is in international waters because military forces can serve as the primary instrument without the complication of another sovereignty.

The next set of military actions is in the realm of deterrence through the threat of punishment. Incorporated into these ideas is the Defense Intelligence Agency's Counterspace Threat Continuum. On one end, the range of actions is reversible and includes temporary methods to deny or disrupt a target's space capability. On the other end, the actions involve unreversible permanent destruction of either space-based systems or terrestrial-based space centers.[360] In a military space deterrence framework, the possible combination of these punishment threats is numerous. A key question is, how massive must the threat of punishment be? Additionally, what information about capabilities should be publicized to make the threat credible? These questions are outside the scope of this research but are notable considerations for a holistic space deterrence strategy. The next framework concerns the economic instrument of power.

Economic Space Deterrence Framework

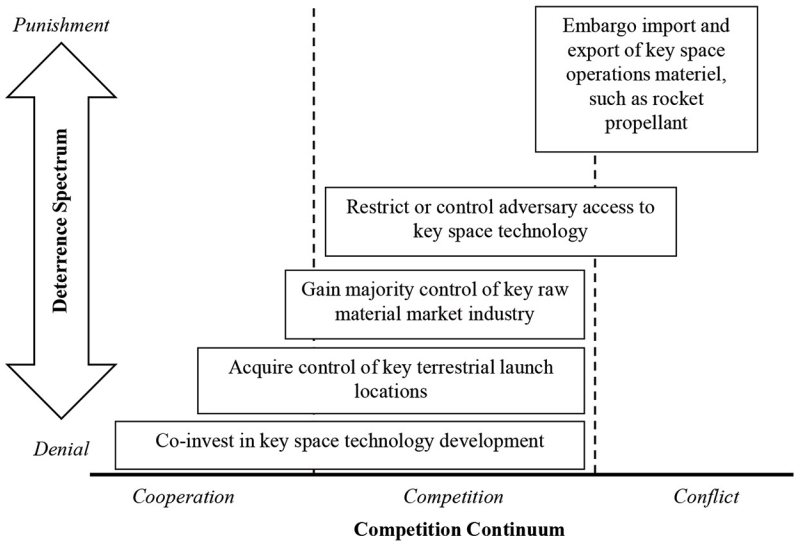

Figure 4: Economic Space Deterrence Framework
Source: Created by author.

According to H. Sonmez Atesoglu, international security theories typically associate economic power as a determinant of military power and, by extension, of security.[361] Similarly, Geoffrey Parker's analysis of the western way of war highlighted the contribution of a robust financial structure to support a type of warfare dependent on advanced technology.[362] Thus, like military power, economic power can significantly influence the relative advantage between nations. It thereby follows that actions through the economic instrument of power can contribute to a space deterrence strategy.

Complementary to activities previously discussed in the diplomatic and military space deterrence frameworks, multinational partnerships are one of the surest deterrence-through-denial mechanisms available. According to Lloyd J. Dumas, economic power can generate security and bind nations together "if it is pursued in the context of building a web of mutually beneficial international economic relationships."[363] Dumas pointed to the European Economic Community to illustrate the binding power of mutually beneficial economic relationships. Before the European Economic Community formed, its member nations fought each other for centuries. Once formed, despite disagreements in various areas, mutual economic relations have moved its members toward

more economic and political integration.[364] On space warfare, Klein discussed the mutual benefit of superior and lesser space power agreements. The superior power could benefit in other nonspace areas while the lesser power gained access to better space technology at a reduced cost.[365] Thus, nations that are members of multinational partnerships with extensive and mutually beneficial ties become more difficult to contend with individually. As a space deterrence mechanism, the more nations are economically intertwined, the greater the effect of deterrence through denial. Alternatively, if such extensive cooperation was unattainable, then the economic instrument can still be used in more competitive situations.

Inspired by the maritime principle of chokepoints, economic power can contribute to the control of key terrestrial real estate in parts of the world considered to be optimal launch locations. In peacetime, control of key terrestrial launch locations can reduce launch cost, thus supporting economic power growth. In armed conflict, control of key launch locations can also bolster reconstitution capacity in the event space systems need replacement. This also follows the strategic position principle because control of the limited launch locations automatically denies others the same benefit.

Alternatively, economic power can be wielded to control raw materials critical to space development. Owing to the harshness of the outer space environment, specific materials like aluminum-lithium alloys, potassium silicate, and silica ceramic tiles are invaluable to the development of resilient space vehicles.[366] Control over these markets provides significant leverage and can support denial strategies. If not raw materials, then the technologies themselves can be controlled and have a similar effect. As competition grows, or escalates to conflict, then the complete embargo of raw materials or technology aligns with the deterrence through punishment mechanism.

With such a broad and complex menu of potential deterrence activities, how can strategists and decision makers ensure that activities across the instruments of national power achieve the desired deterrence goals for outer space? The key is reflecting on the current conditions of the competition continuum with a holistic approach that incorporates parts from each instrument of national power.

Converging Denial and Punishment Activities for Effect

During this study, the discussion about the interaction of denial and punishment mechanisms illuminated the need to balance both for an effective deterrence. To achieve a balance, continual reflection of the current competition-continuum conditions is key. One insight from the US and

Soviet Union's space cooperation is that international relationships can exist at different and simultaneous conditions along the competition continuum. Thus, it is possible to be in overall competition and also to be in cooperation in certain areas. The accurate assessment of the current competitive continuum condition is a critical step in determining the proper balance of denial and punishment mechanisms. Notably, equally critical is the acknowledgment that the conditions will change and will consequently require potential responses.

In cooperative conditions, denial mechanisms offer the greatest deterrence benefits. These involve building multinational partnerships, even with potential adversaries, which can persist in competitive conditions. As conditions approach conflict, there is a logical tendency to move toward punishment mechanisms; however, the status of the previous denial mechanisms must always be considered. For example, the stronger the denial mechanism is prior to conflict, then the less harsh the punishment threat needs to be. This interaction is particularly crucial when deciding where limited resources should be invested.

To illustrate, consider the ongoing competition between the US and China. In the specific objective to deter China from actions that render US space capabilities ineffective, the United States should invite China to cooperative activities related to space. As demonstrated by Eisenhower and Kennedy, this is possible even in periods of great competition. Even if China ignored the invitation, a subsequent information campaign could boost the US's international standing in space matters. If China agreed, the following space cooperation serves as a strong denial deterrent. For example, should the US and China co-invest in capabilities to improve space situational awareness and reduce orbital debris, both nations become so entangled operationally and economically that actions to deny each other's space systems become mutually detrimental. If such a degree of denial deterrence could be achieved, then, even if the two approached conflict with each other, the potential loss of coinvested space systems likely outweighs the perceived benefit of denying each other's systems. Consequently, with such strong denial deterrence in place, the US need not invest too significantly in capabilities for a potential punishment threat.

Additionally, the US should invite allies, like Japan, South Korea, and Australia to coinvest and co-operate in space systems. In so doing, China is forced to contend with an alliance, not only the US, if China chose to disrupt space-based systems. Moreover, the US should pursue partnerships with countries along the equator to secure future space launch sites. In this manner, China is automatically denied those benefits, and US space launch capacity is made more resilient. In addition, the equatorial states gain access to US space

launch capabilities at a reduced cost. Meanwhile, the US gains greater access and influence in the area. But what organization or group of people can possibly determine the approach to pursue? Again, history serves as a guide.

Operations Coordinating Board

An overarching insight of this study is the necessity of coordinated national deterrence policy for space. A historical example for consideration is the Operations Coordinating Board (OCB), which Eisenhower founded during his presidency. The 1953 Executive Order 10483 defined the OCB's purpose as: "SECTION 1. (a) To provide for the integrated implementation of national security policies by the several agencies, there is hereby established an Operations' Coordinating Board, hereinafter referred to as the Board, which shall report to the National Security Council."[367] The OCB consisted of the top second-level officials from agencies involved in national security and chaired by the Undersecretary of State.[368] The 1957 Executive Order 10700 modified the statutory membership to the undersecretary of state, deputy secretary of defense, director of central intelligence, director of US Information Agency, and director of international cooperations administration.[369] Research from archived OCB working group minutes from 1956 to 1958 showed extensive whole of government coordination concerning Earth satellite matters.[370] One example was the discussion of the official US reaction to the Soviet Union's *Sputnik* launch.[371] A notable instance in the minutes was the mention of how to handle an offer from the Soviet Union to fly US space experiments.[372] Another example was contingency planning for a possible Soviet moon vehicle.[373] Another was the feasibility of providing technical assistance and equipment to the United Kingdom and Australia in a cooperative space launch.[374] According to Fred I. Greenstein and Richard H. Immerman, the OCB never quite achieved Eisenhower's expectations.[375] Nonetheless, Eisenhower and his associates believed that the OCB benefited national security because it promoted regular give-and-take from the officials who needed to cooperate with each other.[376]

In the contemporary security environment, it is possible for such extensive coordination to occur using existing national security organizational constructs. But from what can be discerned from public documents, the notable difference in today's handling of space matters is the unclear level of authority possessed by the members of various space working groups.[377] In the OCB, the mandate of director- or deputy-level membership was likely critical to the OCB's perceived positive performance. To achieve the required convergence of national power instruments for space deterrence today, participation from similar high-level officials is critical. Additionally, participation from high-level officials

helps to ensure that the holistic deterrence policy is flexible and changes with time, audiences, capability, and resources.

CONCLUSIONS AND RECOMMENDATIONS

In 2021, President Biden's administration published the US Space Priorities Framework, which listed the broad impact of outer space to everyday human life. One of the most significant impacts was the boon to the economy through global navigation, aid to crop yield predictions, water and power grid management, and global telecommunications.[378] Internationally, several nations similarly acknowledged the importance of outer space and proclaimed their intentions to gain the advantages outer space provides.[379] Motivated by the potential strategic advantages, a few nations also developed systems to protect their own space capabilities and potentially deny others theirs. Infamous events related to this outer space contest are the ASAT kinetic weapons tests, which have been demonstrated, thus far, by the US, Russia, China, and India.[380] Adding to the complexity of the outer space operational environment is the increasing density of outer space operations, which increases the risk of collisions.[381] Born of the criticality to preserve military and civilian capabilities in outer space, this project sought to answer the question: how can deterrence theory apply to space strategy as a method to deter actions that render space capabilities ineffective?

The result is a space deterrence framework that is grounded by denial and punishment deterrence concepts across the competition continuum. The framework mandates holistic activities and flexibility across the instruments of national power to support adaptive deterrence activities capable of responding to a dynamic strategic environment. This enables policy makers to continuously consider the dynamic nature of domestic, allied, and enemy audiences, fluctuating costs, and advancing capabilities to bolster the credibility of the deterrence policy. Additionally, each individual deterrence activity is guided by strategic principles adapted for the challenges of space deterrence. From the proposed framework, a "deterrence menu" of strategic options awaits further consideration for its feasibility, acceptability, and sustainability within current US grand strategy.

Implications

The greatest implication of this study is the urgent need for the US to start or bolster space cooperation with allies, partners, and adversaries to form a strong deterrence through denial. The insights highlighted by the interaction

of denial and punishment deterrence mechanisms, the historical example of space cooperation between the US and the Soviet Union, and complex nature of the competition continuum leads to this conclusion. If the US can achieve space cooperation with its adversaries, specifically China and Russia, then they could become so entangled operationally and economically that any aggression aimed at denying each other's space capabilities could also result in mutual harm. With such a strong denial mechanism in place, the US can therefore save by not investing too heavily in retaliatory punishment threats. A punishment threat is still necessary; however, considering the prudence of holistic activities, the retaliatory response could come from other national power instruments or nonspace domains.

Furthermore, the US should bolster space cooperation with allies and partners, specifically by cofunding and co-operating space systems. Co-owned multinational systems complement existing US systems and increase the resiliency of US space architecture. Simultaneously, multinational space systems complicate an aggressor's targeting. For example, space systems co-owned by the US and some combination of allies like Australia, Canada, South Korea, or Japan deter China from targeting those systems because China faces a greater retaliatory response of an alliance, even if their primary target was only the US.

Additionally, the US should pursue agreements with as many equatorial countries as feasibly possible to secure real estate for future space launch locations. In so doing, the US automatically denies adversaries the benefit of those optimal launch locations. The equatorial nations benefit from access to US space technology, while the US gains access and influence in those areas. Moreover, the US also gains more allies to support international space policies that can further deter incendiary activities in outer space.

Areas for Future Study

The next step for the modern space deterrence strategist is an assessment to determine if the current international conditions permit the US to pursue the activities previously mentioned in the implications. Moreover, the assessment raises the question: What are the possible combinations of denial and punishment activities across the instruments of national power? One RAND Corporation research report seems to dampen the prospect for possible cooperation. The RAND team reviewed Chinese and Russian native-language primary sources and found, "a sustained perception that US military activities related to the space domain are threatening and reflect hostile US intent."[382] An additional noteworthy finding was that:

> Chinese and Russian analyses reviewed for this report generally noted a more positive, cooperative approach toward space by the Clinton and Obama administrations but still focused on their perceived overarching continuity of hostile and aggressive US military space policy. This suggests that existing negative perceptions held in Beijing and Moscow are relatively easily reinforced by those US actions perceived as hostile, while US actions perceived as less hostile do not appear to have a similarly robust effect, producing a seemingly minimal improvement in Chinese and Russian perceptions. This behavior might reflect the natural, human tendency toward confirmation bias. Yet it is important for US decision-makers to understand that this is occurring.[383]

Another conclusion asserted by the RAND team was that both countries perceived US military space-related activities as threats to their own nuclear deterrents.[384] Thus, a potential challenge affecting space deterrence strategy is that "US military activities in space—regardless of US intent—may be linked to US nuclear capabilities and strategy."[385]

Specific to China, one discovered fact during this research that affects possible space deterrence options is the 2011 Wolf Amendment in the annual commerce, justice, and science appropriations bill. According to a Center for Strategic and International Studies commentary, "The language of the Wolf Amendment says that no government funding for NASA, the White House's Office of Science and Technology Policy, or the National Space Council can be used to collaborate with, host, or coordinate bilaterally with China or Chinese-owned companies without certification from the Federal Bureau of Investigations."[386] Congressman Frank Wolf, the sponsor of the amendment, hoped that it would isolate China and force it to more closely abide by human rights norms.[387] According to former NASA Administrator, Charles Frank Bolden Jr., the amendment did not achieve its intentions. Moreover, the amendment did not slow China's space program. Instead, it resulted in the US observing from the outside as China maintained its fifty-year aerospace plan.[388]

Despite these challenges, China's growing efforts in space, which increases their equities in space-related endeavors, coincidentally offers increasing deterrence opportunities. According to Kevin Rudd, "Xi [Jinping] has made clear that for China, 'becoming an aerospace power has always been the dream we have been striving for.' "[389] China's PLA also views space superiority as a key component for modern, information warfare.[390] Accordingly, China has dedicated commendable resources to developing space capabilities like the US. This includes launch capabilities and satellites that provide intelligence, weather

services, command and control, and navigation.[391] Therefore, as China increasingly integrates their national capabilities with space-based services, it inevitably provides additional options for US space deterrence strategists.

Regarding Russia, future researchers must contend with the effects of the ongoing war between Ukraine and Russia. Former NASA Administrator, Charles Frank Bolden Jr. once remarked that "when you can work for 20-plus years with Russia and never leave the International Space Station no matter what's going on down here on the ground, then that says something about the value of that bilateral relationship."[392] Is such a relationship still possible in light of an ongoing conflict where the US provides military and other support to sustain Ukrainian independence in the face of Russian aggression? The RAND team provides a glimmer of possibility. In their study of Chinese and Russian perceptions concerning US military activities in space, they concluded that "[T]he diplomatic history and cultural understanding between the United States and the Union of Soviet Socialist Republics/Russia was perhaps more formative than might be fully appreciated. This history appears to allow the United States to manage its relationship more effectively with Russia—or at least to understand in retrospect which US actions get Moscow's attention."[393]

Another research opportunity is the possible combination of space deterrence mechanism toward adversarial nations that could affect US space capabilities but have fewer space-based equities. These nations are Iran, North Korea, and potentially Pakistan. Space deterrence options toward these countries are likely to rely more on nonspace related actions as they have less to lose in outer space.

There is also much to consider on possible space cooperation opportunities with allies and partners. Guided by this study's space deterrence framework, coinvestment and co-operation of space systems is a compelling denial deterrence mechanism as it complicates targeting for potential aggressors. For the US, it has the added benefit of increasing the resilience of its existing space capabilities, at a potential fraction of the cost. This is also potentially a boon for developing space power nations. The question is: Which nations should the US approach for potential cooperation? Researchers who endeavor to answer this question do well to remember the principles of strategic positions and command of space. A subsequent question here is, beyond equatorial nations, which nations are at strategic geographical locations that enable potential command of space?

Finally, there is the matter of translating space strategy down to space warfare tactics. As national space partnerships deepen, capabilities increase, and strategic positions are gained, space warfare tactics must consequently adapt. Here the principles of strategic positions, command of space, dispersal, con-

centration, offense, and defense must all be considered. Then, as tactics are tested, strategists must develop information campaigns, backed by observable military maneuvers or positions, to project capability. Strategists must of course be careful not to reveal all capabilities. However, as highlighted by the requirements of deterrence, unobservable threats are poor ones at best.

Final Thoughts

Despite the growing threats and challenges that risk space systems and access to outer space, there remains a strong possibility that outer space can continue to be a warfare free zone. To increase the probability of deterrence in outer space, a sense of urgency is required to initiate or bolster space cooperation. Doing so strengthens a denial deterrence mechanism that can reduce the need for punishment threats over time. A punishment threat to deter incendiary behavior in space is still required. However, through the convergence of deterrence activities across the instruments of national power and domains (land, sea, air, space, and cyber), conflict in outer space can still be avoided.

Notes

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380. For details refer to the Introduction. See also Defense Intelligence Agency, "Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion," 4–36.

381. For details refer to the Introduction. See also Defense Intelligence Agency, "Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion," 37.

382. Blanc et al., *Chinese and Russian Perceptions*, 43.

383. Blanc et al., 43–44.

384. Blanc, et al., 45.

385. Blanc et al.

386. Center for Strategic and International Studies, "Bad Idea: The Wolf Amendment."

387. Bolden Jr., "10 Years of the Wolf Amendment," video, 2:00:11.

388. Bolden, "10 Years of the Wolf Amendment."

389. Rudd, *The Avoidable War*, 165.

390. Rudd.

391. Rudd, 165–66.

392. Bolden, "10 Years of the Wolf Amendment."

393. Blanc et al, "Chinese and Russian Perceptions," v.

ABBREVIATIONS

AEHF	Advanced Extremely High Frequency
ASAT	Anti-Satellite
DSCS	Defense Satellite Communication System
DSP	Defense Support Program
FBI	Federal Bureau of Investigation
GEO	Geostationary Orbits
LEO	Low-Earth Orbits
MIRACL	Mid-Infrared Advanced Chemical Laser
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NSC	National Security Council
OCB	Operations Coordinating Board
OSTP	Office of Science and Technology Policy
PLA	People's Liberation Army
UN	United Nations
US	United States

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