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If the United States chooses to weaponize space to protect national interests along the space line of communication, eight major economic effects emerge. These effects will generate momentum toward an extensive space debris removal industry, updated and economically relevant space agreements, and an incentive-based space innovation and commerce environment. Framed through a modified Strengths-Weaknesses-Opportunities-Threats model, the analysis illuminates both the enablers and challenges contributing to securing national interests in space, deterring space aggression, and maintaining a competitive advantage across the diplomatic, informational, military, and economic instruments as they reach into the space domain. The analysis provides policymakers and strategic planners with considerations regarding alliances, resilience, treaties, and economic security.

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JOINT FORCES STAFF COLLEGE

JOINT ADVANCED WARFIGHTING SCHOOL

Economic Effects of Weaponizing Space: A Modified SWOT Analysis

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A paper submitted to the Faculty of the Joint Advanced Warfighting School in partial satisfaction of the requirements of a Master of Science Degree in Joint Campaign Planning Strategy. The contents of this paper reflect my personal views and are not necessarily endorsed by the Joint Forces Staff College or the Department of Defense.

This paper is entirely my work except as documented in footnotes.

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Abstract

If the United States chooses to weaponize space to protect national interests along the space line of communication, eight major economic effects emerge. These effects will generate momentum toward an extensive space debris removal industry, updated and economically relevant space agreements, and an incentive-based space innovation and commerce environment. Framed through a modified Strengths-Weaknesses-Opportunities-Threats model, the analysis illuminates both the enablers and challenges of securing national interests in space, deterring space aggression, and maintaining a competitive advantage for the diplomatic, informational, military, and economic instruments as they reach into the space domain. The analysis provides policymakers and strategic planners with considerations regarding alliances, resilience, treaties, and economic security.

Key words: space, weaponization, warfare, outer space treaty, SWOT, policy, diplomatic, informational, military, economic, space line of communications

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Chapter 1: Securing the Space Line of Communication

During the 1850s in the western United States, gold discovery and collection emerged as a highly competitive environment. That competition created both lawful and unlawful regional security conditions aimed at preserving imminent wealth. Unanticipated effects included geographic population shifts, displacement for thousands of native and non-Americans, and violence among all actors over access to land and the gold-rich resources. Movement from the east to west coast saw many people struggle to endure the primary journey due to a dangerous and unchartered path. Aside from the security nature of that period, economic effects accelerated and fostered the dominance of agriculture development and profit, mining as a lucrative income, and natural resource extraction technology.[1] Simply put, economic prosperity requires security.

An inevitable weaponization of space will create economic effects extending to the emergence of an extensive space debris removal industry, updated and economically relevant space agreements, and an incentive-based space innovation and commerce environment.

One can make a general connection and comparison between securing economic security in the 1850s and 2020, purely from the continuous expansion and shaping of commercial activity in space. Vague and outdated space laws create unlawful opportunities while cost effective-yet deadly transportation methods emerge. Further, the economic effects are unknown and unknowable due to immature space resource mining and extraction development. As with gold, however, the space resource environment will

[1] "Impact on California's Landscape | American Experience | PBS," Public Broadcasting Service, accessed February 16, 2021, https://www.pbs.org/wgbh/americanexperience/features/goldrush-impact-california.

arguably become contested. Introducing weaponized space capabilities will provide the defensive and offensive capacity to secure economic interests. Since the late 18th Century, the United States created and sustained conditions to ensure its enduring national interests. These interests include protecting the homeland, protecting the citizens, promoting democracy and American values, and promoting economic prosperity. With the evolution of space activities, the United States endorses unrestricted access and freedom in space through policy. The contested nature of space also creates the requirement to protect United States assets in outer space and the Department of Defense to invest in resources to protect and defend them.

Identifying space as part of the global commons is contentious. A 2020 executive order signed by President Donald J. Trump stated, "Outer space is a legally and physically unique domain of human activity, and the United States does not view it as a global common."[2] This order conflicts with the United Nations and international law, which indicate four global commons: the high seas, the atmosphere, Antarctica, and outer space.[3] This tension contributes to the domain's stewardship, which assumes global governance as a recognized global common. As with the security of seas, the problem connects to resources and interests. The Earth's Moon has over nine billion acres of unclaimed property within reach by the United States, China, Russia, and a few others. Like the 1850s resource-competitive environment, states and potentially non-states will inevitably mobilize to secure property and resource rights.

[2] "President Signs Executive Order on Space Resource Utilization," Office of Space Commerce, April 6, 2020, https://www.space.commerce.gov/president-signs-executive-order-on-space-resource-utilization.

[3] "Global Governance and Governance of the Global Commons in the Global Partnership for Development beyond 2015," *United Nations* (United Nations System Task Team, January 2013), https://www.un.org/en/development/desa/policy/untaskteam_undf/thinkpieces/24_thinkpiece_global_governance.pdf.

The Problem

The Outer Space Treaty (OST) provided the world with a collection of broad principles to govern the use and exploration of space. To summarize, the treaty's principles include language regarding how the exploration and use of space will benefit all countries, how it will be free for exploration by all nations, and how space will be free of nuclear and weapons of mass destruction placed in orbit. That states are responsible for governmental and non-governmental space activities, and that states will be liable for damage caused by their space objects.[4] Effective October 10, 1967, the pursuit of commercial and military domination in space has drastically evolved over the last several decades. The inevitable tension and competition have extended to space resource mining and extraction. As the United States considers continuous freedom to operate and move to and from space to support enduring and vital national interests, the demand for space protection increases. The advancement of security, economic prosperity, and scientific knowledge for the nation inherently connects financial security. Preserving freedom of movement and action in space will create many economic effects on the national and global economy due to the increased protective nature of resource extraction opportunities.

Central and Supporting Research Questions

This research pursues the answer to many questions to create a synthesis toward the overall objective of assessing holistic economic effects due to the weaponization of space capability. The central research question asks, “What factors contribute to

[4] “The Outer Space Treaty,” United Nations Office for Outer Space Affairs, January 1967, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

economic change because of introducing and employing weapons in the space environment to protect national interests?"

Multiple supporting research questions will align with the research methodology to advance the pursuit of this central research question. These four supportive research questions create the focused framework to analyze many aspects of space, weaponization, and economics. The author used current and relevant literature to pursue clarity in areas such as the national economy's advantages, national economic prosperity measures, scientific leads for space weapons development, and emerging space-based technology. The four supporting research questions were:

1. Research Question One: What domestic and international strengths exist in economics, space, and weaponization? This first question examines the major forces of economic structure, space capacity, and capability for weaponization.
2. Research Question Two: What domestic and international opportunities exist in economics, space, and weaponization? This second question is concerned with the major options for economic structure, space capacity, and weaponization capability.
3. Research Question Three: What domestic and international weaknesses exist in economics, space, and weaponization? This third question is concerned with the significant domestic defects of economic structure, space capacity, and weaponization capability.
4. Research Question Four: What domestic and international threats exist in economics, space, and weaponization? This fourth and final question is concerned

with the major global threats of economic structure, space capacity, and weaponization capability.

Statement of Findings

Following a thorough analysis and synthesis, eight significant effects emerge to connect the weaponization of space with economics. However, it is essential to clearly define the usage of "effect" and align it within the context of this research. An effect is a change that is a result or consequence of an action or other cause. As this analysis identifies and explores many significant domestic and international factors attributed to securing the space line of communication, inherent consequences emerge either deliberately or unintentionally. Those factors include both enablers and challenges. Those effects create the foundation of the findings. The Discussion and Recommendation chapter provides additional perspectives on these findings.

As a result of strengths and opportunities, economic change exposes four significant effects when weaponization secures the space lines of communication.

1. Innovators and economic risk-takers desire security and confidence in their investments.

2. Dominant and wealthy nations can protect economic interests by securing their space lines of communication.

3. A cooperative while competitive space commerce market will emerge as international space agreements acknowledge the modern space commerce environment.

4. Commercial approaches to space solutions will continue to result in lower costs due to realized incentives.

As a result of weaknesses and threats, economic change exposes four significant effects when weaponization secures the space lines of communication.

1. The loss of finite commercial space capability due to the intense market competition will challenge innovation.

2. The lack of a fully enabled space debris removal industry will result in many unintentional but irreversible impacts on space commerce and the global reliance on information services.

3. The inadequate preservation of property rights in space will challenge off-Earth perceived possessions.

4. Private sector ambitions will only be as strong as a nation’s ability to protect economic prosperity.

Chapter 2: Theory and Policy Background

In 2003, Karl P. Mueller described a polarizing space policy environment. At the heart of each end were the policy perspectives regarding space weaponization guided by two primary world views: sanctuary idealists and pro-weaponization.[1] To broadly appreciate the perspectives, they range from opposition to space weapons because they transcend defense policies (idealists) to avoiding weaponization as it would reduce power relative to adversaries (nationalists) to reducing rival advantages by developing weapons before adversaries (space racers) to full, intense development to create an unassailable capability and protective posture (space hegemony).[2] Figure 1 provides a simple visualization of Mueller's policy perspectives.

POLICY PERSPECTIVES ON US SPACE WEAPONIZATION

Pro-sanctuary perspectives	
Idealists	Oppose all space (and typically other new) weapons, for reasons transcending defense policy considerations
Internationalists	Oppose space weapons because they would cause or contribute to general, arms race, and crisis instability
Nationalists	Seek to avoid space weaponization because it would reduce US power and/or security relative to potential adversaries
Pro-weaponization perspectives	
Space racers	Seek to avoid rivals gaining military or political advantage by developing space weapons before they do
Space controllers	Favor development of space weapons when and insofar as they would usefully enhance US military capabilities
Space hegemonists	Favor intense development of US space weapons in order to make US military and political preponderance unassailable

Figure 1. from Karl P. Mueller's 2003 "Totem and Tattoo" in Astropolitics.[3]

[1] Karl P. Mueller, "Totem and Taboo: Depolarizing the Space Weaponization Debate," *Astropolitics* 1, no. 1 (January 2003): 4–28, https://doi.org/10.1080/1477-760391832499.

[2] Karl P. Mueller, "Totem and Taboo: Depolarizing the Space Weaponization Debate," *Astropolitics* 1, no. 1 (January 2003): 4–28, https://doi.org/10.1080/1477-760391832499.

[3] Karl P. Mueller, "Totem and Taboo: Depolarizing the Space Weaponization Debate," *Astropolitics* 1, no. 1 (January 2003): 4–28, https://doi.org/10.1080/1477-760391832499.

In an era of ongoing competition on a global stage, a power such as the United States should not allow others to surpass or even rival in military capability and capacity.[4] This idea creates immense tension with Mueller's policy perspectives as the second-order effects lean the logic to a hybrid of space controllers and space hegemony. Nations maintaining a neutral stance on weaponization by neither pursuing nor avoiding space security may be too weak. Seeing a capability or policy weakness, competitors will see the vulnerability as "so irresistible that states won't be able to refrain from attacking."[5]

Brent Ziarnick poses a current recommendation to support pro-weaponization perspectives through space controllers by linking scientific control, economic control, and military control. While Mueller's model describes space controllers as those who favor the development of space weapons when the capability would usefully enhance military capabilities, the Ziarnick approach seeks to subdue other actors' ability to harm interests and wealth potential. His three significant components provide a meaningful background for this thesis. They apply the scientific knowledge to operate in space, the wealth generated from space as-a-whole and removing an adversary from the domain while protecting internal capability.[6]

Competition in space can never be ruled out. The tension exists, however, between competition and collaboration when economic factors elevate.[7] Economic-

[4] Karl P. Mueller, "Totem and Taboo: Depolarizing the Space Weaponization Debate," *Astropolitics* 1, no. 1 (January 2003): 4–28, https://doi.org/10.1080/1477-760391832499.

[5] Karl P. Mueller, "Totem and Taboo: Depolarizing the Space Weaponization Debate," *Astropolitics* 1, no. 1 (January 2003): 4–28, https://doi.org/10.1080/1477-760391832499.

[6] Brent D. Ziarnick, "A Practical Guide for Spacepower Strategy," Space Force Journal, January 31, 2021, https://spaceforcejournal.org/a-practical-guide-for-spacepower-strategy.

[7] Nayef Al-Rodhan, "Weaponization and Outer Space Security," Global Policy Journal, March 12, 2018, https://www.globalpolicyjournal.com/blog/12/03/2018/weaponization-and-outer-space-security.

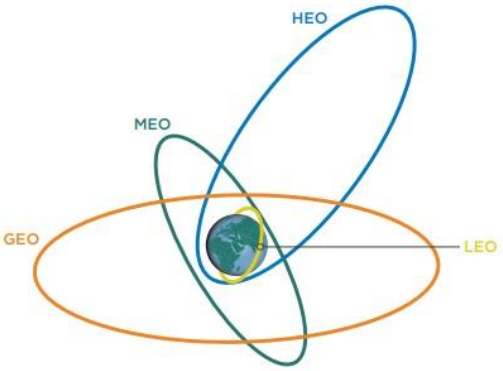
stimulating capability, such as platforms in the space domain, becomes attractive targets for rivals and even terrorists.[8] However, the reality is targeting a capability moving at over 17,000 miles per hour is both problematic and expensive. This problem creates a choice for malign activities extending from space-to-space capability disruption or rendering ground control stations ineffective. Any activity disrupting the space line of communication affects economic security.

Many view space commerce as "commerce in the space industry," but as Mark Sirangelo highlighted during a Space Foundation discussion, space commerce should be viewed as commerce enabled by the space industry.[9] This question helps pursue a wide range of opportunities with seemingly endless economic impacts.

An emerging topic in the space commerce and defense community involves the emerging management of space traffic and space debris. Figure 2 provides a basic visualization of the recognized orbit levels, Low Earth Orbit (LEO), Medium Earth Orbit (MEO), High Elliptical Orbit (HEO), and Geosynchronous Earth Orbit (GEO). Key to each level is managing thousands of functioning space objects and the massive volume of non-functioning objects and debris at each level.

[8] Karl P. Mueller, "Totem and Taboo: Depolarizing the Space Weaponization Debate," *Astropolitics* 1, no. 1 (January 2003): 4–28, https://doi.org/10.1080/1477-760391832499.

[9] "Space Commerce in the Future," Space Foundation, accessed January 12, 2021, "https://www.spacefoundation.org/video_post/space-commerce-in-the-future.



Orbits are notional and for illustrative purposes only.

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

Figure 2: Visualization of LEO, MEO, HEO, and GEO[10]

[10] "Committed to Excellence in Defense of the Nation," *Defense Intelligence Agency* (February 1, 2019), https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space_Threat_V14_020119_sm.pdf.

Chapter 3: Analysis Methodology

The Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis is a valuable process for strategy development and strategy formulation. More importantly, the process helps planners attain a deeper appreciation for both internal and external environmental factors. A basic SWOT model follows the aggregation of internal (strengths and weaknesses) and external (opportunities and threats) factors. For this study, however, a modification of the basic SWOT model widens the aperture.

Viewing the internal and external factors through an enablers and challenges lens reduces the effect of purely internal and external considerations as the topic of weaponizing space takes on global implications. First, strengths and opportunities allow us to identify those areas and factors where dominance is either already attained or where a vulnerability exists that a nation can pursue to create strength. Both factors generate an enabling perspective to be optimized. Second, the factors of weaknesses and threats expose those factors contributing to both domestic and global challenges. Those weaknesses and threats highlight where problems currently exist and illuminate areas where threats may apply to all actors involved. This enablers and challenges approach helps isolate considerations that may not be exclusively domestic to the United States but rather have international elements.

Using relevant current literature, this methodology captures common trends across the spectrum of space, economics, and weaponization. Analyzing each as independent enablers and challenges provide a balanced opportunity to close each analyzed section with a more relevant synthesis. Each section's synthesis will support key hypothesis points by assessing common and connected trends between economics,

the space industry, and space weaponization. The discussion and recommendations chapters review all key synthesis factors and recommend domestic or international actions.

The basic SWOT analysis methodology is not perfect, but it does provide planners with a framework and a start point to identify trends and build toward a dialogue on recommendations. Key considerations when using this research are the inclusion of qualitative factors, the lack of prioritization factors, and a synergy approach that cannot quantitatively determine the relative importance of the factors. These considerations are important because they value the SWOT analysis methodology's human aspect and emphasize understanding the subjective limitations of enablers and challenges in complex domains such as space. Appreciating those enablers and challenges helps create a path to develop an effective strategy.

Chapter 4: Enablers and Challenges (Modified SWOT) Analysis

This chapter and the supporting four sections will employ the analysis methodology discussed in the previous chapter. It provides the analysis and synthesis for the following summary, discussion, and recommendations. Figure 3., below, highlights the 16 enablers and challenges that will emerge from this chapter.

Figure 3. SWOT Analysis

Enablers (Strengths)	**Challenges (Weaknesses)**
1. Entrepreneur Spirit	1. Competition Creates Vulnerability
2. National Economy	2. Agreements
3. Space Commerce	3. Militarize or Weaponize?
4.Weaponization Capability and Strategy	4. Debris Management
Enablers (Opportunities)	**Challenges (Threats)**
1. Emerging Economic Opportunities	1. Economy Drives Innovation
2. Cost Reduction	2. Smaller, Cheaper, and More Objects
3. Agreements	3. China and Russia
4. Cooperation versus Competition	4. Fear, Honor, Interest, and Ambition

Enablers (Strengths) Analysis and Synthesis

Entrepreneurial Spirit

Economic dominance in any domain begins with a nation empowering the entrepreneurial spirit among its population. That spirit thrives by enabling businesses to take on financial risks in the hopes of imminent profit. Britain saw entrepreneurial dominance across the seas during the 18th and 19th centuries.[1] While their naval force protected the sea lines of communication, the innovating entrepreneurs endured sea

[1] Everett Dolman, *Astropolitik: Classical Geopolitics in the Space Age* (London U.A.: Cass, 2002), 148.

passage to transport goods and resources to regional and global markets. That pursuit of innovation and continuous process improvement worked to secure a competitive environment with minimal competition. An essential ingredient to the risk-taking recipe is cost reductions attributable to the industry's competitive environment. British commerce reached many shores with relative freedom of movement through the security of the sea lines of communication and innovative seafaring technology. Integration between a national government and the commerce generators proved to be a national strength.

Like Britain's dominance of the seas in the 18th and 19th centuries, the United States experiences a strong space-centric innovation and economic environment in 2021. The first 50 years of space efforts remained primarily government-centric programs and spending. In 2021, however, nearly 80% of all space activity is commercial and enabled by innovative entrepreneurs seeking a global competitive advantage and market dominance. In the United States, free and decentralized entrepreneurship in the space industry creates optimal costs, quality products, and services.[2] The environment is also critical to sustaining space commerce strength is identifying, monitoring, securing, and controlling space lines of communication.[3] With an active space security strategy enabled by capability, the United States enjoys conditions that advance economic prosperity and secure and control access to and from the domain.[4] Further, the nation enjoys a strong

[2] Everett Dolman, *Astropolitik: Classical Geopolitics in the Space Age* (London U.A.: Cass, 2002), 148.

[3] Everett Dolman, *Astropolitik: Classical Geopolitics in the Space Age* (London U.A.: Cass, 2002), 148.

[4] "Department of Defense Releases Defense Space Strategy," United States Department of Defense, June 17, 2020, https://www.defense.gov/Newsroom/Releases/Release/Article/2223539/department-of-defense-releases-defense-space-strategy.

domestic space industrial base that remains healthy. Essential to this health is the national economy.

National Economy

From a domestic perspective, the strong U.S. national economy allows the innovation and momentum toward economic dominance to continue. One assurance of the economic aspect of space is investments are rich with opportunity. Commercial companies seek near-certainty to reassure and provide confidence and trust to investors.[5] No entrepreneur commits financial resources without assuming risk, but when a nation creates conditions, such as securing and protecting the operating domain, the risk to investment is inherently reduced. This reduction in risk drives U.S. companies to world leadership in space-related commerce and industry. According to the Space Economy Satellite Account, "space economy is the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilizing space."[6] The Space Foundation indicated 2018 global space activity at $414.8 billion.[7] No other nation comes close to civil space budgets as the United States. Further, the commercial aspect represented 79% of all space activity.[8] Space spending remains healthy and hefty.[9]

[5] Joan Johnson-Freese, *Space Warfare in the 21st Century* (London; New York (N.Y.): Routledge, Cop, 2017), 144.

[6] Dominique Dubria, Tina Highfill, and Patrick Georgi, "Measuring the Value of the U.S. Space Economy," Bureau of Economic Analysis, December 1, 2019, https://apps.bea.gov/scb/2019/12-december/1219-commercial-space.htm.

[7] "The Space Report Reveals 2018 Global Space Economy Exceeded $400 Billion for the First Time," Space Foundation, July 15, 2019, https://spacefoundation.org/2019/07/15/the-space-report-reveals-2018-global-space-economy-exceeded-400-billion-for-the-first-time.

[8] "Space Foundation Annual Report 2019" (Space Foundation, n.d.), https://www.spacefoundation.org/wp-content/uploads/2020/02/SpaceFoundation_2019_Report.pdf.

[9] Joan Johnson-Freese, *Space Warfare in the 21st Century* (London; New York (N.Y.): Routledge, Cop, 2017), 17.

A strong space budget and national economy allow a nation like the United States to move quickly and aggressively with space efforts. At $19.48 trillion and the highest of any country, the United States' gross domestic product (GDP) can be connected to an entrepreneurial environment enabled by a decentralized government, advanced education, and strong regulatory factors.[10] With a GDP that nearly doubles the next closest competitor, China, at $12.2 trillion, one could make an argument for economic dominance that will continue to enable a strong space economy as it represents 24% of the global economy.[11] Figure 4, Civil Space Budgets, provides a unique perspective of national space budgets, with the United States budgeting a significantly higher appropriation than nearly all others combined.

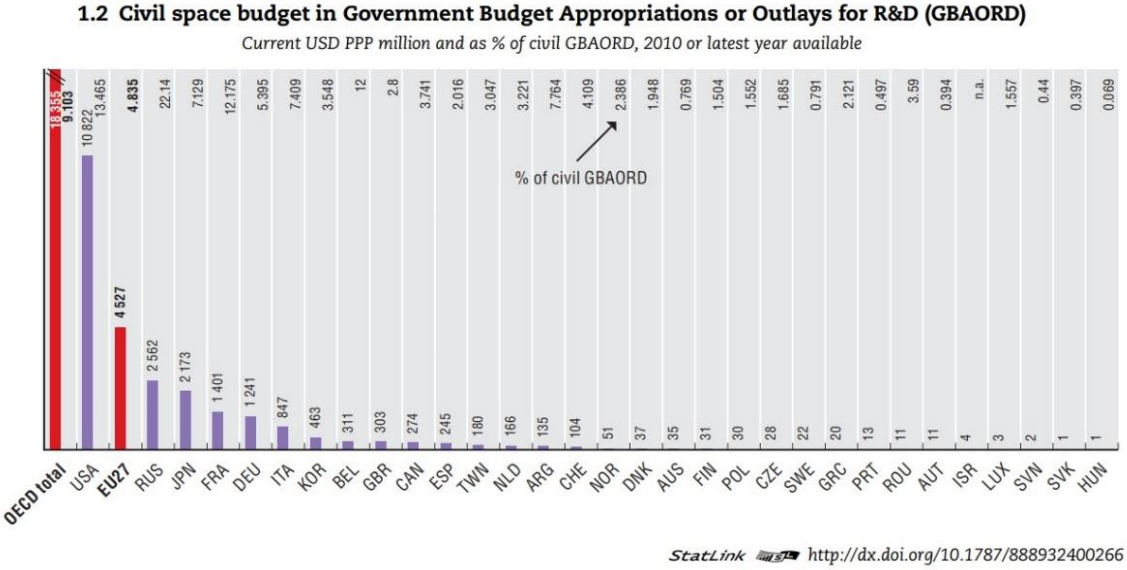


Figure 4. Civil Space Budgets

[10] "Top 15 Countries by GDP in 2020," Global PEO Services, July 23, 2020, https://globalpeoservices.com/top-15-countries-by-gdp-in-2020.

[11] "Top 15 Countries by GDP in 2020," Global PEO Services, July 23, 2020, https://globalpeoservices.com/top-15-countries-by-gdp-in-2020.

National economy strength undoubtedly improves space commerce opportunities to pursue further economic dominance. Space competition stimulates development, and development drives economies.[12] An idea simply referred to as "audacity of greed" implies that while billions of dollars flowed into the wealthy corporate pockets, most Americans endured a period of declining wages, disappearing pensions, and dwindling bank accounts.[13] However, through the individual consumer lens, many economic factors contributed to the personal debt crisis and financial meltdown experienced in 2008. Nevertheless, the entrepreneur spirit thrived with the strong, corporate wealthy and emerged with innovation and risk-taking to continue a nation's stance as an economic power.

Space Commerce

The United States maintains a respectable dominance in the space commerce market. Six unique sectors exist within the market: communications satellites, remote sensing, launch services, human spaceflight, space mining, and solar energy.[14] Each sector consists of varying degrees of development but creates a level of commerce strength not demonstrated by any other nation. However, consumers of the space market stretch across the globe, and each market does impact nations like Russia, for example. With a landmass covering 11 time zones, Russia's reliance on all-things space touches all six commerce sectors.

[12] Joan Johnson-Freese, *Space Warfare in the 21st Century* (London; New York (N.Y.): Routledge, Cop, 2017), 145.

[13] Joan Johnson-Freese, *Space Warfare in the 21st Century* (London; New York (N.Y.): Routledge, Cop, 2017), 145.

[14] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 102-110.

The emergence of unmanned space exploration, unmanned space resource mining, unmanned extraction, and transportation should be considered an innovative enabler to space commerce. Reducing human risk in the volatile space environment also reduces the financial risk considered by entrepreneurs. This enabler continues to evolve rapidly and impacts all six market sectors. Capability development is not limited to the United States, however. Both China and Russia continue to emerge in the space mining and resource extraction sectors, despite near-infancy growth.[15] Connecting each market sector within the space commerce environment is the evolving space transportation industrial base. When secured, the space lines of communication and advanced transportation could enable cost-effective supply chain measures.

Weaponization Capability and Strategy

No domain, whether land, sea, air, cyberspace, or space, is free of risk along its lines of communication. Space is no different and providing confidence to commerce providers through protection is required. Space weaponization includes a comprehensive strategy embracing an imminent need to develop and field capabilities to counter space's malicious use. "War in space is inevitable," but one could strongly argue it is the economic aspect that creates both deterrence and a capacity to defend if required.[16] The United States, Russia, and China each have capabilities providing both deterrence and defensive effect.[17] Those systems' employment may be questionable, but the existence of kinetic and non-kinetic capability is there. The United States dominates the use of space

[15] Joan Johnson-Freese, *Space Warfare in the 21st Century* (London; New York (N.Y.): Routledge, Cop, 2017), 144.

[16] John E. Hyten, "A Sea of Peace or a Theater of War: Dealing with the Inevitable Conflict in Space," April 1, 2000, https://www.ideals.illinois.edu/handle/2142/102028.

[17] Matthew Mowthorpe, *The Militarization and Weaponization of Space* (Lanham, Md, 2004), 76-77; James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 133-137.

by its comprehensive military strategy. The strategy promotes and secures freedom of operations, which have roots in national security and promoting economic prosperity.[18]

Strengths Synthesis

Five key observations support two significant economic effects, pulling together a central theme and strengths that inform enablers. The first economic effect is that innovators and economic risk-takers desire security and confidence in their investments. The second economic effect is that dominant and wealthy nations can protect economic interests by securing their space lines of communication. The pursuit of innovation supports these observations, strong national economies that enable security capability, strong national economies provide innovators confidence, and a space commerce sector that creates many second-order effects. Ultimately, the key enabler is the inherent requirement to secure lines of communication to protect enduring national interests.

Enablers (Opportunities) Analysis and Synthesis

Emerging Economic Opportunities

Declining launch costs, advances in technology, and rising public sector interest positions all contribute to a rapidly developing body of economic opportunity in space. Launch costs, which traditionally created the most prohibitive space movement costs, are quickly declining and should be expected to fall as the trends suggest. The exploration aspect touches on continuous commercial and international technology advances. Exploration, whether for discovery or material profit, promises to drive advances and progresses as demand increases. Public-sector interest rapidly grows and has projections

[18] "Department of Defense Releases Defense Space Strategy," United States Department of Defense, June 17, 2020, https://www.defense.gov/Newsroom/Releases/Release/Article/2223539/department-of-defense-releases-defense-space-strategy.

through 2039 to exceed $1 trillion, a significant increase from $350 billion in 2020.[19] Figure 5, The Global Space Economy Scope of Opportunity, highlights a significant climb between 2027 and 2039. In the short term, satellite broadband internet access is substantial. However, the rise through 2039 represents the second-order impacts beyond connectivity. It is estimated to affect many industries beyond aerospace and defense and touch heavily into information technology hardware and telecommunications.[20]

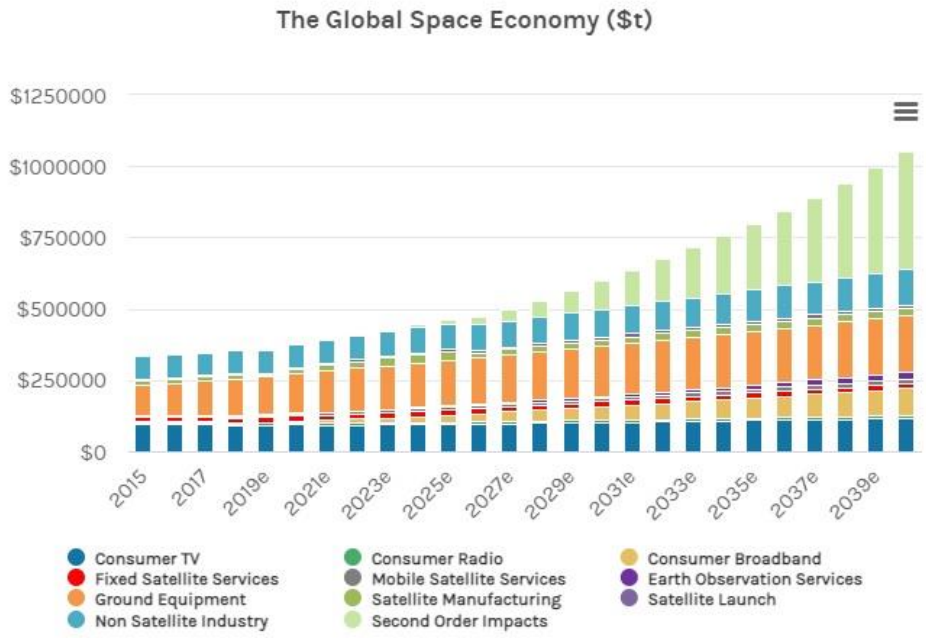


Figure 5. The Global Space Economy Scope of Opportunity[21]

As of 2021, space transportation costs limit most non-informational commerce in space. However, market sectors such as asteroid mining and lunar fuel storage become more realistic as transportation costs decline. Inevitably, prices will decrease, and capability will emerge. Resources for use both in space and on Earth are within the realm

[19] "Space: Investing in the Final Frontier," Morgan Stanley (July 24, 2020), https://www.morganstanley.com/ideas/investing-in-space.

[20] "Space: Investing in the Final Frontier," Morgan Stanley (July 24, 2020), https://www.morganstanley.com/ideas/investing-in-space.

[21] "Space: Investing in the Final Frontier," Morgan Stanley (July 24, 2020), https://www.morganstanley.com/ideas/investing-in-space.

of possible and create incredible economic opportunity.[22] For example, it is possible that a single 500-meter asteroid could generate more platinum than has ever been mined on Earth in history. That same asteroid potentially generates more water-based fuel than has been used in all space missions in history. This single example illustrates the potential for international commerce. Critical to latching on to emerging resource economic opportunities is the entrepreneur's willingness to accept financial risk.

A common trend in modern space literature is that most space resources will be best suited for use in space.[23] The opportunities range between water for processing into liquid hydrogen and oxygen propellant to refuel spacecraft or using regolith as a viable construction material on the lunar surface.[24] A quick search of space mining companies uncovers a reality that few can move past the conceptual and into practical application. As of 2021, no profit-centric space mining enterprise has conducted any space resource extraction for use either in space or on Earth. As a matter of transportation and finite terrestrial resources, an imminent opportunity exists. Harnessing the economic power from space requires sustainable business plans in addition to realized capabilities. To develop and establish space commerce capable of mining lunar ice, power production, or space-based fuel distribution would create a fundamental capacity beyond any current technology innovations.[25]

Cost Reduction

[22] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 110.

[23] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 110.

[24] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 110.

[25]Brent D. Ziarnick, "A Practical Guide for Spacepower Strategy," Space Force Journal, January 31, 2021, https://spaceforcejournal.org/a-practical-guide-for-spacepower-strategy.

Four critical factors enable cost reduction opportunities for space economics. The four, mission engineering, spacecraft design, launch technology, and fuel sources link to the innovative and entrepreneurial spirit that quickly moves the space industry forward. The reduction of fossil fuels use on Earth, the emergence of mass electrical transportation capability, and a general decrease in electronics costs can be optimized when resource extraction becomes available in off-earth capacities. Refueling in space and creating cost-balancing technologies such as reusable launch enablers generate industry and employment opportunities.

A typical cost reduction variable is incentives. When linked to mission engineering, spacecraft design, launch technology, and fuel sources, incentive efforts demonstrate a persistent economic and development focus. For decades, through a government-centric approach with Boeing and Lockheed Martin, incentives to reduce costs across all four primary cost factors would reduce commercial revenue.[26] As recently as 2012, the first privately funded approach toward space changed the cost reduction approach. For example, privately funded SpaceX charges $4,653 per kilogram of satellite for transport, while United Launch Alliance, a joint venture of Lockheed Martin and Boeing, charges between $14,000 and $39,000 per kilogram.[27] The cost reduction approach, according to SpaceX, is based on a model of people, processes, and products to integrate each company for unity of effort. The result is economic synergy for mission

[26] Jorge UNK, "SpaceX: Lowering the Cost of Access to Space," Harvard Business School, December 7, 2015, https://digital.hbs.edu/platform-rctom/submission/spacex-lowering-the-cost-of-access-to-space.

[27] Jorge UNK, "SpaceX: Lowering the Cost of Access to Space," Harvard Business School, December 7, 2015, https://digital.hbs.edu/platform-rctom/submission/spacex-lowering-the-cost-of-access-to-space.

engineering, spacecraft design, launch technology, and fuel. Again, the entrepreneur spirit drives innovation and takes advantage of optimal economic opportunities.

Agreements

Perhaps the most significant opportunity both domestically and globally is with existing agreements. As Johnson-Freese Bacevich indicated in 2002, "the only path to peace and security is a path of action."[28] That path implies continuously moving toward a strategy where a National Security Strategy defends the homeland and deters aggression. The evolution of kinetic and non-kinetic weapons opens possibilities not realized during the development of the OST of 1967. The agreement acknowledges threats such as nuclear weapons but fails to consider the weaponization environment created over the last 50 years. An opportunity to promote the rule of law and principles for safe space commerce should not be passed up. The establishment of a space hegemon to dictate "their way or the space highway" only increases the potential for global and space tension. Multilateral agreements seem most likely, but the reality of enforcement and monitoring is challenging.

Cooperation versus Competition

Domains such as land and sea all experienced long periods of tension and friction until formal agreements set enforceable and broad operating and security conditions. The lack of cooperation has essentially allowed space to become an opportunity plagued with long-term consequences. This opportunity becomes an enabler to advance the cooperative

[28] Joan Johnson-Freese, *Space as a Strategic Asset* (New York: Columbia Univ. Press, 2007), 113.

and competitive nature of space in a manner that benefits all consumers of space. Cooperation is necessary as globalization is all about connectivity.[29]

China and Russia are the most prominent advocates of agreements.[30] This observation is intriguing due to the "great power competition" narrative expressed in the national security environment. However, many nations choose not to work with the United States.[31]

Essential to a nation's cooperative approach toward space is its ability to protect national interests. In an environment lacking cooperation, security effects in space range from capability denial, directed weapons employment, orbital threats, electronic warfare, kinetic energy threats, and nuclear detonation.

Opportunities Synthesis

Linking the four enabling opportunity themes together, key observations support three significant economic effects. The first economic effect is the entrepreneur's willingness to accept financial risk with space investments. The second economic effect is the cooperative while competitive space market drives updating international space agreements nearly 50 years old. The third economic effect is the commercial approach to space solutions resulting in lower costs due to realized incentives. Consumer demand spikes support these observations in information and hardware, entrepreneur's willingness to accept risk, mining in space for use in space, and incentives to reduce space mission costs, including technology and fuel. In addition, the demand creates an opportunity to

[29] James C Moltz, *Asia's Space Race : National Motivations, Regional Rivalries, and International Risks* (New York: Columbia University Press, 2012), 38-39.

[30] Joan Johnson-Freese, *Space as a Strategic Asset* (New York: Columbia Univ. Press, 2007), 135.

[31] James C Moltz, *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks* (New York: Columbia University Press, 2012), 39.

bring the 1967 OST into the 21st Century, develop enforcement and monitoring measures, and a chance for creating cooperative and competitive global space environment.

Challenges (Weaknesses) Analysis and Synthesis

Competition Creates Vulnerability

The entrepreneurial spirit and strength also create a vulnerability in the economic sector. Whether domestic or global, the healthy competition also generates a substantial opportunity for the industry to see very few options for space-based capability survive. In 2021, a limited number of space transportation businesses can provide the research, development, funding, and endurance to survive economically. As the most renowned space industry names in 2021, SpaceX and Blue Origin are so dominant that few competitors rise. The innovation is seen by the primary competition indeed produced a domestic strength with global dominance implications, but it also reduces the industry to few single points of potential failure. SpaceX, for example, drives rapid technological development momentum. The vulnerability of a poor financial or leadership decision can create a space industry disruption with many second and third-order effects. Viewed from another perspective, access vulnerability creates a weakness for trade and markets.

Physical transportation within the space commerce sector is rich with opportunity and plagued with current and potential challenges. Finding a sweet spot for rockets, for example, comes down to a few companies with unique capabilities such as reusable technology.[32] One could argue the loss of that capability would create economic feasibility gaps impacting the entire space industry. Additionally, capabilities such as

[32] Joan Johnson-Freese, *Space Warfare in the 21st Century* (London; New York (N.Y.): Routledge, Cop, 2017), 149.

space-centric lasers are potential shortfalls. Many vendors and providers struggle to keep their doors open for business when the competitive environment pushes most out.[33] A related aspect is a competition in space for essential resources such as orbital slots and frequency spectrum. As most of the space industry is information and data-heavy, a significant vulnerability and challenge is frequency allocation as the International Telecommunications Union has no enforcement powers.[34] This creates a seemingly "first come, first served" mindset that can rarely be mitigated except by and through agreements.

The challenges of each competition-based vulnerability contribute, in part, to a "Pearl Harbor scenario" that is both real and inevitable, according to theorists.[35] Exposure to leverage space for diplomatic, information, military, and economic power in a contested environment weakens both earth-based and space-based dominance.

Agreements

Discussed as an enabling opportunity, international agreements also pose many challenges for many reasons. Political and military tension on Earth creates a stability problem without binding agreements.[36] Whether attributed to an age-old issue of fear, honor, or interest, many obstacles have been presented regarding international agreements and the OST of 1967.[37] With vague international guidelines, defining harmful

[33] Matthew Mowthorpe, *The Militarization and Weaponization of Space* (Lanham, Md, 2004), 158.

[34] Helen Caldicott and Craig R Eisendrath, *War in Heaven: The Arms Race in Outer Space* (New York: New Press, 2007), 104.

[35] Brent Ziarnick, *Developing National Power in Space: A Theoretical Model* (Jefferson, N.C.: Mcfarland & Company, Inc., Publishers, Cop, 2015), 206.

[36] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 119.

[37] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 93-97.

activities continues to become more contentious.[38] Quite simply, international space law is inadequate.

The OST fails to address any protocol for weapons of any kind.[39] Although the treaty prohibits nations from utilizing space to place weapons of mass destruction, it is silent on conventional weapons. International agreements are challenging to enforce and even more challenging to monitor. Further, if even possible, implications of enforcement are unknown, also questioning the treaty's legitimacy. However, since the OST was signed, no clear violation has occurred. The fuzzy area, however, is with debris implications. For example, China deliberately destroyed a disabled satellite in 2007. The international community imposed no clear consequences against China, and the strategic implications were a low earth orbit debris field with seemingly irreversible effects. The OST fails to address debris, despite the apparent indirect use as a weapon.

As the dominant global power, the United States must lead the effort to evolve the OST. Viewed through an agreement lens creates an international vulnerability for other current and future spacefaring nations. The United States currently enjoys space control dominance.[40] U.S. leadership with space agreements while maintaining space control dominance hardly seems ideal for China, Russia, or the European Union.

The space technology industry has many trends and tech industry trade-offs.[41] One could argue the private role is not only increasing but rather dominating. The speed

[38] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 192.

[39] Helen Caldicott and Craig R Eisendrath, *War in Heaven: The Arms Race in Outer Space* (New York: New Press, 2007), 116-119.

[40] Efstathios Fakiolas and Tassos Fakiolas, "Space Control and Global Hegemony," *Korean Journal of Defense Analysis* 21, no. 2 (June 2009): 137–53, https://doi.org/10.1080/10163270902872119.

[41] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 172.

of privately-owned company space technology development outpaces the relevance of agreements. Off-planetary rights are a significant weakness of the current OST. The OST does not contain any language prohibiting private property rights. It only provides restrictions on a nation's right to declare sovereignty for the Moon and other celestial bodies. With the rapid evolution of space transportation and reduced costs, the inevitability of perceived or even realized property rights off-Earth is an agreement weakness that signatories to the treaty must address.

Militarize or Weaponize?

A substantial deviation between militarization and weaponization exists. Militarization, which is already active by many countries, implies intelligence and communications-focused capabilities. However, weaponization encompasses the potential for a nation's aggressive and offensive use of space capability to destroy space-based or ground-based targets. Unlike the ocean, the space domain requires the ability to be stationed in the environment for security. Those capabilities cannot be hidden and are visible to all technologically advanced nations.[42] The United States gains nothing from weapons in space and potentially has the most to lose.[43]

Debris Management

Perhaps the biggest threat to space commerce is the demand for space commerce itself. Revolutionizing communications through space-based technology is the epitome of the entrepreneurial spirit, but it inherently creates significant debris management and risk scenario. Impacts by millimeter-sized debris may not only cause damage but may very

[42] Herbert Scoville, *Can Space Remain a Peaceful Environment?* (Muscatine, Iowa Stanley Foundation, 1978), 13.

[43] Joan Johnson-Freese, *Space as a Strategic Asset* (New York: Columbia Univ. Press, 2007), 134.

well disable a subsystem of an operational spacecraft. Large space debris objects such as other spacecraft, rocket bodies, or fragments create significant danger for other space objects. They have the potential to re-enter the Earth's atmosphere and create a ground population risk.

If a collision occurs, it is difficult to determine if the incident was purposeful or accidental, but the propensity to escalate tensions exists.[44] China's 2007 anti-satellite test and the U.S. destruction of a dead spy satellite increased the reality. The low-altitude destruction burned in the atmosphere but took over a year. China's test contributed to over 150,000 pieces larger than one centimeter and 2,500 pieces over 10 centimeters. The reality is the United States, and other nations cannot track debris between one and 10 centimeters with existing surveillance technology. All 2,500 pieces can create physical destruction on satellites. The bulk of China's debris remains at 850 kilometers (530 miles) above Earth in LEO.[45]

Most scientific satellites and many weather satellites are in a nearly circular LEO.[46] Limitations due to space traffic management to manage debris. Space debris can be a hazard to active satellites and spacecraft. When two satellites collide, they can smash apart into thousands of new pieces, creating lots of new debris. The debris threat will persist for two reasons due to flawed efforts. First, anti-sat tests are inherently destructive and are merely tangentially addressed in current laws. Second, formal rules of the road

[44] Samuel Black and Yousaf Butt, "The Growing Threat of Space Debris," *Bulletin of the Atomic Scientists* 66, no. 2 (March 2010), 1–8, https://doi.org/10.2968/066002001, 1.

[45] Samuel Black and Yousaf Butt, "The Growing Threat of Space Debris," *Bulletin of the Atomic Scientists* 66, no. 2 (March 2010), 1–8, https://doi.org/10.2968/066002001, 2.

[46] Holli Riebeek, "Catalog of Earth Satellite Orbits," Nasa.gov (NASA Earth Observatory, September 4, 2009), https://earthobservatory.nasa.gov/features/OrbitsCatalog.

for space do not exist.[47] An estimated 300,000 pieces of debris larger than one centimeter in low earth orbit. Fewer than 20,000 are being tracked. Two crowding problems exacerbate the debris problem: debris concentration at certain altitudes and the frequent, high-speed approaches occurring over the poles.[48] China and Russia, however, remain publicly committed to a comprehensive, legally binding treaty.[49]

For companies licensed by the Federal Communications Commission, on-board propulsion systems are required to ensure satellites can safely de-orbit. With a 99 percent reliability rate for large satellite constellations, even a few hundred dead or inactive objects that failed to de-orbit would remain in LEO.[50]

The USG Orbital Debris Mitigation Standard Practices contain four objectives: controls of debris released during normal operations, minimizing debris generated by accidental explosions, selection of safe flight profile and operational configuration, and post-mission disposal of space structures.[51] The Inter-Agency Space Debris Coordination Committee is an international governmental forum for the worldwide coordination of activities related to man-made and natural debris in space. This agency includes representation from China, United States, Russia, Canada, India, United Kingdom. Evidence suggests that international cooperation has momentum. Additionally, the

[47] Samuel Black and Yousaf Butt, "The Growing Threat of Space Debris," *Bulletin of the Atomic Scientists* 66, no. 2 (March 2010), 1–8, https://doi.org/10.2968/066002001, 3.

[48] Samuel Black and Yousaf Butt, "The Growing Threat of Space Debris," *Bulletin of the Atomic Scientists* 66, no. 2 (March 2010), 1–8, https://doi.org/10.2968/066002001, 4.

[49] Samuel Black and Yousaf Butt, "The Growing Threat of Space Debris," *Bulletin of the Atomic Scientists* 66, no. 2 (March 2010), 1–8, https://doi.org/10.2968/066002001, 5.

[50] Jonathan O'Callaghan, "SpaceX's Starlink Could Cause Cascades of Space Junk," Scientific American, May 13, 2019, https://www.scientificamerican.com/article/spacexs-starlink-could-cause-cascades-of-space-junk.

[51] "U.S. Government Orbital Debris Mitigation Standard Practices," Inter-Agency Space Debris Coordination Committee, accessed December 31, 2020, "https://www.iadc-home.org/references/pdfview/id/78.

United States Space Command led and signed agreements with over two dozen spacefaring countries in a collective effort to share space data.[52] The data attempts to create controls to manage and de-conflict preventable space object collisions.

Weaknesses Synthesis

Three critical economic effects emerge from an analysis of weaknesses. The first economic effect is the loss of finite commercial space capability due to intense market competition. The second economic effect is the lack of a fully enabled space debris removal industry resulting in many unintentional but irreversible impacts to space commerce. The third economic effect is the inadequate preservation of property rights in space. Vulnerabilities support these observations. For instance, due to intense competition, poor financial or leader decisions can disrupt a capability. The loss of capacity can create a gap across the space commerce sector and impact the DIME elements. Debris is the greatest threat to space commerce as it can be both unintentional yet irreversible. Possession of a removal capability in contrast to agreements is inadequate. However, political and military tensions create agreement stability weakness. The OST may be insufficient to address 21st-century problems. Off-planet rights are not discussed in the OST. Still, they are part of global commons not recognized by many. The implications of aggressive or offensive use of space include winners, losers, and security of interests.

[52] Sandra Erwin, "Space Command to Expand Network of Allies That Help Monitor Orbital Traffic," SpaceNews, January 29, 2021, https://spacenews.com/space-command-to-expand-network-of-allies-that-help-monitor-orbital-traffic.

Economy Drives Innovation

Relevant technology and innovations cannot be counted on to arrive on time and on a schedule.[53] This relevant technology includes the basics: the rockets, the engines, the batteries, and many other requirements. The economic system determines technology production.[54] An economic system that fails to incentive innovation faces stagnant opportunity development. While tourist travel catches attention, the real money in space is with information transmission. A cutoff of information services would have a catastrophic effect on the world economy.[55] Emergence of a single point of failure due to over-reliance on a single aspect of a single domain which impacts the other instruments of power, threatening national interests.

Smaller, Cheaper, and More Objects

Space capability is becoming smaller and cheaper.[56] Smaller and less expensive are the actual threats because they cannot be tracked and controlled.[57] ESA does not require registration on smaller space objects.[58] The impact of debris is significant.[59] The impact of debris threatens all aspects of commercial benefits. Debris removal requires

[53] Brent Ziarnick, *Developing National Power in Space: A Theoretical Model* (Jefferson, N.C.: Mcfarland & Company, Inc., Publishers, Cop, 2015), 110.

[54] Brent Ziarnick, *Developing National Power in Space: A Theoretical Model* (Jefferson, N.C.: Mcfarland & Company, Inc., Publishers, Cop, 2015), 113.

[55] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 92.

[56] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 103.

[57] Joan Johnson-Freese, *Space as a Strategic Asset* (New York: Columbia Univ. Press, 2007), 138.

[58] James Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 115.

[59] "Space Debris Monitoring and Removal Market," Market Future Research, accessed January 12, 2021, https://www.marketresearchfuture.com/reports/space-debris-monitoring-removal-market-8274.

serious efforts.[60] Within the United States, SpaceX secured permission to launch over 12,000 satellites through 2027 to enable Internet connectivity.[61] While these controllable objects are relatively small, event 3 percent failure's volume and effect contribute to over 1,000 new pieces of space debris. SpaceX further indicates that its de-orbit timeline could take up to five years for defunct satellites.[62] "SpaceX and eight other companies have and will continue to operate thousands of satellites in LEO.[63]

China and Russia

China and Russia have varying interests, strategies, and capabilities in the commercial and security space environment. China officially advocates for the peaceful use of space, and it is pursuing agreements at the United Nations on the non-weaponization of space.[64] Russian military doctrine does view space as a warfighting domain and a contributor to winning the terrestrial conflict.[65] However, Russia maintains a stance regarding space weaponization to stop U.S. weaponization efforts.[66] This stance is expanded by its counterspace weapons capabilities development and national military reforms to space, cyberspace, and electronic warfare across each instrument of power and

[60] Brent Ziarnick, *Developing National Power in Space: A Theoretical Model* (Jefferson, N.C.: Mcfarland & Company, Inc., Publishers, Cop, 2015), 205.

[61] Morgan McFall-Johnsen, "About 3% of SpaceX's Starlink Satellites May Have Failed," Business Insider, November 3, 2020, https://www.businessinsider.com/spacex-starlink-internet-satellites-percent-failure-rate-space-debris-risk-2020-10.

[62] Morgan McFall-Johnsen, "About 3% of SpaceX's Starlink Satellites May Have Failed," Business Insider, November 3, 2020, https://www.businessinsider.com/spacex-starlink-internet-satellites-percent-failure-rate-space-debris-risk-2020-10.

[63] Jonathan O'Callaghan, "SpaceX's Starlink Could Cause Cascades of Space Junk," Scientific American, May 13, 2019, https://www.scientificamerican.com/article/spacexs-starlink-could-cause-cascades-of-space-junk.

[64] "Statement for the Record Worldwide Threat Assessment of the Us Intelligence Community," *Director of National Intelligence* (February 13, 2018), https://www.dni.gov/files/documents/Newsroom/Testimonies/2018-ATA---Unclassified-SSCI.pdf, 13.

[65] "Oleg Bozhov, "How They Will Wage War in the Future: Tanks Rumbled across the Sky,"," *MK.RU*, August 13, 2016, http://www.mk.ru.

[66] "Committed to Excellence in Defense of the Nation," *Defense Intelligence Agency* (February 1, 2019), https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space_Threat_V14_020119_sm.pdf.

throughout military operations. On the other hand, Russia merely sees its role as an enduring space leader on the international stage. Budgetary constraints and technology development struggles have fundamentally reduced Russia's momentum.[67]

China's intent and strategic approach is based on its expectation that future wars will mostly be fought outside its borders and likely involve conflict in the maritime domain. The information-centric aspect of future warfare requires space superiority and information dominance to deny adversary capability. China's capacity includes electronic warfare, directed energy weapons, cyberspace threats, and kinetic energy threats, all in advanced development posture. This capability creates a deterrence effect to disrupt, degrade, or even damage adversary satellites and sensors required for ground-based operations.

Russia's intent and strategy deviate strongly from China's space approach. Russia sees space services integrated across its forces and optimizes over six decades of space experience. However, Russia's primary stance is to avoid becoming over-reliant on space for national security.[68] Russia views dependence on space as the critical vulnerability of the United States.[69] Therefore, Russian counter-space capabilities are centralized with space situational awareness through surveillance networks to establish information dominance. Russia's electronic warfare directed energy weapons, orbital threats, and

[67] Asif Siddiqi, "Russia Is the Only Nation That Regularly Sends Humans to Orbit. But Its Space Program Is in Trouble.," Slate Magazine, March 21, 2017, https://slate.com/technology/2017/03/russias-space-program-is-in-trouble.html.

[68] "Committed to Excellence in Defense of the Nation," *Defense Intelligence Agency* (February 1, 2019), https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space_Threat_V14_020119_sm.pdf.

[69] "This Is the Achilles' Heel of Washington's Military Power," sputniknews.com, January 30, 2016, https://sputniknews.com/military/201601301033971479-us-space-satellites.

ground-based kinetic threats appear secondary to the mere weaponization of information through cyberspace threats.

Fear, Honor, Interests, and Ambitions

Perhaps the space environment's greatest challenge is the irresistible impulses felt and subsequent behavior by all spacefaring and non-spacefaring political communities. What makes space different, however, is ambition. With the private sector emerging so aggressively and dominantly, the ambition aspect potentially consumes national interests. Promoting and protecting prosperity contributes to the body of fear, honor, and interest all governments pursue for survivability. Asian fear, honor, interest, and ambition seek international recognition.[70] China may be one of the biggest advocates of space agreements.

Economic benefits created by one nation create opportunities for adversaries.[71] As seen through economic and social transactions, the prestige aligned with global players links political institutions with economic, military, and informational power. Russian honor and prestige on the global stage serve to remain a player, despite limited spacefaring capability. Uniting through alliances and partnerships with perceived adversaries creates both unity of effort and cost reduction potential. These factors threaten the honor element of political communities. An additional element is increased space spending potentially reduces spending for developing countries in need of financial assistance.[72]

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[70] James C Moltz, *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks* (New York: Columbia University Press, 2012), 25.

[71] Brent Ziarnick, *Developing National Power in Space: A Theoretical Model* (Jefferson, N.C.: Mcfarland & Company, Inc., Publishers, Cop, 2015), 205.

[72] Helen Caldicott and Craig R Eisendrath, *War in Heaven: The Arms Race in Outer Space* (New York: New Press, 2007), 98.

Finally, an attack on a United States space system may be irresistible to China.[73] The military or commercial nature of the space capability may likely be undeterminable, but the motivations and ambitions to pursue domestic and global dominance by diminishing another's capability is real.

Threats Synthesis

Three key economic effects emerge from an analysis of threats. The first economic effect is economic systems must incentivize innovation. The second economic effect is space debris removal, and management threatens all reliance on information services. The third economic effect is private-sector ambitions are only as strong as a nation's ability to protect economic prosperity. These observations are supported by technology that will rarely arrive on time with the requirement and an economy that must support innovation.

[73] Joan Johnson-Freese, *Space as a Strategic Asset* (New York: Columbia Univ. Press, 2007), 197.

Chapter 5: Discussion and Recommendations

Overall Summary

An inevitable weaponization of space will create economic effects extending to the emergence of an extensive space debris removal industry, updated and economically relevant space agreements, and an incentive-based space innovation and commerce environment.

As a result of strengths and opportunities, economic change exposes four significant effects when weaponization secures the space lines of communication.

1. Innovators and economic risk-takers desire security and confidence in their investments.

2. Dominant and wealthy nations will protect economic interests by securing their space lines of communication.

3. A cooperative while competitive space commerce market will emerge as international space agreements acknowledge the modern space commerce environment.

4. Commercial approaches to space solutions will continue to result in lower costs due to realized incentives.

Economic effects based on weaknesses and threats expose four significant challenges when weaponization is introduced to secure the space lines of communication.

As a result of weaknesses and threats, economic change exposes four significant effects when weaponization secures the space lines of communication.

1. The loss of finite commercial space capability due to the intense market competition will challenge innovation.

2. The lack of a fully enabled space debris removal industry will result in many unintentional but irreversible impacts on space commerce and the global reliance on information services.

3. The inadequate preservation of property rights in space will challenge off-Earth perceived possessions.

4. Private sector ambitions will only be as strong as a nation's ability to protect economic prosperity.

Recommendations

Securing and protecting the space line of communication ensures holistic economic security. Vulnerabilities to trade, materiel, and information impact nearly all aspects of domestic and international life and well-being. Space is either safe for all or no one. So, developing international agreements and the principles to guide space security and subsequent interstate relations on Earth are essential.[1]

1. Establish a space debris removal industry across an expanding space alliance. This effort would share resources and create a standard capacity. Further, overlapping military initiatives will reduce the uncontrollable cost aspect. More importantly, individual investor risk could be reduced due to increased freedom of movement along the space line of communication. Balancing military and commercial approach toward space debris management prepares and postures the security of U.S. economic interests.

2. Updating the OST of 1967 is essential to improve the antiquated language developed in the 1960s and bring the international agreement into the future. This

[1] Nayef Al-Rodhan, "Weaponization and Outer Space Security," Global Policy Journal, March 12, 2018, https://www.globalpolicyjournal.com/blog/12/03/2018/weaponization-and-outer-space-security.

opportunity will mitigate the effects of vague property rights and weaponization introduction.

3. Continue to create private-sector incentives for space industry innovation.

Importance and Relevance

This topic is relevant due to the impact of multiple warfighting domains and instruments of national power. As of 2021, space is contested and, therefore, a warfighting domain. Further, space activity contributes to the pursuit of all strategic ends and connects each instrument of national power. However, the economic tool becomes particularly essential due to the unknown and unknowable growth in the space industry. This specific financial sector's security contributes to national security. Current and aspiring strategists will attain a deeper appreciation for this topic through a holistic assessment of internal and external risk analysis.

The economic effects of weaponizing space extend to many national and international audiences. These include economic policymakers, military space forces, strategic planners, the space debris removal industry, and the collective private space industry. Further, as an element of the contested global environment, one could strongly argue that China’s dominant space nations and Russia could see similar economic conditions. Finally, the countries aligned with the European Space Agency have an interest as well.

The modified SWOT framework was practical for analyzing and creating a simplified picture of a complicated situation. But it can be an oversimplification, which is one of the limitations of SWOT analysis. Another is that it is primarily a summary tool and does not necessarily provide clear plans or strategic approaches. Evolving identified

enablers and challenges and translating them into actions is a critical part of the process. Still, it relies on the ability of the analyst or strategist to identify essential factors and use them to develop an effective strategy. Understanding the challenges and enablers that influence economic factors of weaponizing space is better appreciated with a SWOT review.

A broad comparison between the major subjects in this analysis illuminated the connection to the “gold rush” seen in the western United States in the 1850s. The time-related changes appear to transcend time, and very similar trends connect economics with security. Additionally, the relationship between multiple variables such as outdated treaties or the private space industry exposed an unknown and unknowable future.

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