Seizing the Stars: Resources, Expansion, and Counterspace Contingencies Across the Space Domain

Joshua E. Duke

Author Note: This first appeared as "Conflict and Controversy in the Space Domain: Legalities, Lethalities, and Celestial Security," in *Wild Blue Yonder*, the DAF Air University blog, on 29 September 2020, and has been updated by the author prior to republication. (https://www.airuniversity.af.edu/Wild-Blue-Yonder/Article-Display/Article/2362296/conflict-and-controversy-in-the-space-domain-legalities-lethalities-and-celesti/)

Abstract

Space is becoming the next frontier for human conflict and competition. The United States, the People's Republic of China (PRC), and the Russian Federation (RF) have all invested deeply in a modern space race to gain or maintain strategic superiority, with plans for lunar bases, celestial resource exploitation, and the colonization of Mars. With technological advancements and a weak regulatory framework governing space operations, the development of space-based and counterspace military assets, advanced space weaponry, space transportation and space resource exploitation operations are an inherent part of mankind's future. This article assumes the inevitability of space exploration—including celestial body resource exploitation, weapon research and developments, and the human colonization of Mars—to show the importance of American leadership of human expansion into space. Power in space will be drawn from technological developments, including new types of weaponry and energy production. The author explores the technologies available in today's space race environment, including potential future energy resources available in space, weapon systems designed for space and counterspace warfare, the legal implications of each, and some potential consequences of different nations gaining the upper hand in the heavens.

Keywords: space, counterspace, ASAT, lunar exploration, space resources, fusion power, China, Russia, united states, international

doi: 10.18278/sesa.4.1.3

space law, helium-3, Mars, anti-satellite, space warfare, weaponization, technology, quantum communications, space exploration, moon, commercialization

Aprovechando las estrellas: recursos, expansión y contingencias contraespaciales a través del dominio espacial

Resumen

El espacio se está convirtiendo en la próxima frontera para el conflicto y la competencia humanos. Estados Unidos, la República Popular China (RPC) y la Federación Rusa (RF) han invertido profundamente en una carrera espacial moderna para ganar o mantener la superioridad estratégica, con planes para bases lunares, explotación de recursos celestiales y la colonización de Marte. Con los avances tecnológicos y un marco regulatorio débil que rige las operaciones espaciales, el desarrollo de activos militares basados en el espacio y contraespaciales, el armamento espacial avanzado, el transporte espacial y las operaciones de explotación de recursos espaciales son una parte inherente del futuro de la humanidad. Este artículo asume la inevitabilidad de la exploración espacial, incluida la explotación de recursos del cuerpo celeste, la investigación y el desarrollo de armas y la colonización humana de Marte, para mostrar la importancia del liderazgo estadounidense en la expansión humana en el espacio. El poder en el espacio se extraerá de los desarrollos tecnológicos, incluidos nuevos tipos de armamento y producción de energía. El autor explora las tecnologías disponibles en el entorno de la carrera espacial actual, incluidos los posibles recursos energéticos futuros disponibles en el espacio, los sistemas de armas diseñados para la guerra espacial y contraespacial, las implicaciones legales de cada uno y algunas consecuencias potenciales de las diferentes naciones que obtienen la ventaja en los cielos.

Palabras clave: espacio, contraespacio, ASAT, exploración lunar, recursos espaciales, energía de fusión, China, Rusia, Estados Unidos, ley espacial internacional, helio-3, Marte, antisatélite, guerra espacial, armamento, tecnología, comunicaciones cuánticas, exploración espacial, luna , comercialización

抢星：跨越太空领域的资源、扩张与反空间突发事件

摘要

太空正成为人类冲突和竞争的下一个边界。美国、中华人民共和国（PRC）与俄罗斯联邦（RF）都在现代太空竞赛中投入巨资，以获得或保持战略优势，计划建设月球基地、开发天体资源以及殖民火星。鉴于技术进步和用于治理太空操作的监管框架薄弱，基于太空的反太空军事资产的开发、先进的太空武器、太空运输、以及太空资源开发操作是人类未来的内在组成部分。本文假设了太空探索的必然性——包括天体资源开发、武器研发以及人类殖民火星——以展示美国领导人类向太空扩张的重要性。太空实力将来自技术发展，包括新型武器和能源生产。作者探究了当今太空竞赛环境中的可用技术，包括太空中潜在的未来能源资源、为太空和反太空战设计的武器系统、每种技术的法律含义、以及在太空领域中占上风的不同国家的一些潜在结果。

关键词：太空，反太空，ASAT，月球探测，太空资源，核聚变能，中国，俄罗斯，美国，国际空间法，氦-3，火星，反卫星，空间战，武器化，技术，量子通信，太空探索， 月球， 商业化

"Adversary action in space is inevitable, and the adversary will generate effects that deny, degrade, and disrupt the space operating environment."

– United States Marine Corps Tentative Manual for Expeditionary Advanced Base Operations 2021: 75.

Introduction

Space is becoming the next frontier for human conflict and competition. The United States, the People's Republic of China (PRC), and the Russian Federation (RF) are the three most powerful nations on Earth, all of which have invested deeply in a modern space race to gain or maintain strategic superiority. Each of these nations has plans for lunar bases, celestial resource exploitation, and the colonization of Mars. The RF and PRC have even announced a partnership to develop a joint Moon base in response to the U.S.-led Artemis project, which includes the establishment of Artemis

Base Camp at the lunar South Pole (La Rocca, 2022, 34; NASA, 2020). All three nations have also developed, or are in the process of developing, a variety of counterspace weaponry, space-based weapon systems, and spacecraft capable of maneuvering in zero gravity, the combination of which can and will be used to control space and potentially the future of mankind. Existing international laws and treaties regulating space initiatives, notably the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty), lack sufficient legally binding language when applied to today's space-based technologies and concepts for developments (United Nations, 1967). There are few international recourses available under the existing regulatory framework to prevent a nation from developing space-based or counterspace military assets, to include weaponry, or to prevent the exploitation of resources in space.

This article assumes the inevitability of space exploration—including celestial body resource exploitation, weapon research and developments, and the human colonization of Mars—to show the importance of American leadership of human expansion into space. As national and international organizations are reducing barriers to entry, while increasing access to space-based activities, a hierarchy will inevitably emerge. Power in space will be drawn from technological developments, including new types of weaponry and energy production. Resource exploitation in space and on other planets will drive industry and economic development on Earth in exponential increments as humans expand into the space domain, driving the need for both a guiding force and international cooperation to avoid conflict. As information age generations look to the stars to answer their needs and ambitions, a parallel generation will emerge—a space age generation—with an eye to protect or to control, depending on who maintains the greatest portion of power in space. American leadership is critical as mankind explores the stars to ensure that both a freedom-centric ideology and free-market capitalism become the guiding tenets of space exploration.

The author explores the technologies available in today's space race environment, including potential future energy resources available in space, weapon systems designed for space and counterspace warfare, the legal implications of each, and some potential consequences of different nations gaining the upper hand in the heavens. Part 1 outlines recent space-relevant technological developments. Part 2 examines lunar exploitation and resources, particularly Helium-3, and the potential for future fusion energy developments. Part 3 explores the potential benefits of exploring, exploiting, and colonizing Mars. Part 4 underscores the severity of the potential and actuality of space weaponization, including an overview of existing and theoretical weaponry and legal implications. Finally, Part 5 concludes with an analysis of the potential implications of recent developments and control over space and celestial bodies with regard to global economic stability and space superiority, emphasizing the absolute need of American leadership as humans expand into the space domain.

1. Space Technologies and Advancements

Advancements in space technology are quickly leading to an inevitable conflict over control in space, which includes control over the Moon through lunar bases and potentially control over the colonization of Mars. The PRC has added several capabilities into its military space program, including "antisatellite [ASAT] interceptors, miniature space mines, and ground-based lasers" that can conduct attacks on other satellites (Hughes, 2011, 24). These capabilities fall under the guise of the Outer Space Treaty's permission to destroy militarized satellites (Pool, 2013). ASAT technologies can easily be used offensively to create a decision advantage in combat. Some analysts believe that the deliberate collision of PRC satellites with older satellites shows that the PRC has experimented with "parasitic satellites" designed to lie dormant in the vicinity of a target until activated, potentially for hacking or debilitating purposes (Hughes, 2011, 25-26). Robotic technologies on satellites have also been demonstrated, including robotic arms, which will likely lead to on-orbit ASATs "designed to hijack, jam, re-purpose, exploit, destroy or covertly monitor" adversary satellites (NATO, 2020, 81).

The PRC has two space planes in development, the Shenlong and Tengyun, and in 2020, they successfully launched a space plane prototype, which orbited Earth for two days before returning to the surface (Defense Intelligence Agency, 2022, 34). The PRC continues to be locked in an intense space race with Russia and the United States, with a short-term goal of controlling the Moon with a lunar base and a longer-term goal of populating Mars under the rule of the PRC (Hughes, 2011). The development of maneuverable space planes and lunar bases is not unique to the PRC. The National Aeronautical and Space Administration (NASA) developed the X-37 and X-37B space planes, and the Russian Federation is developing a maneuverable space plane using nuclear technology for power (Hughes, 2011). All of these nations are expanding their space activities drastically and have planned missions to the moon and Mars over the next 30 years (Defense Intelligence Agency, 2022, 40; NASA, 2020). The nation that achieves these goals first will be positioned to set the standards for life and activities on celestial bodies, be it democracy or dictatorship.

Despite the array of international treaties and agreements promoting peaceful global development of space resources in the name of science and humanity, it is unlikely that space will remain weapon free and likely that it will become the next frontier of global combat. Space weapons in use and under development may use robotics, nanotechnology, cyber weapons and directed energy such as microwaves and lasers (Jensen, 2014). With the establishment of a lunar base, a nation with advanced laser technology, advanced cyber weaponry, maneuverable space planes, satellite targeting capabilities, nano-science stealth technology, artificial intelligence, quantum communications, and self-guiding nanotechnology bullets would undoubtedly have the capacity to rule the Earth as it sees fit. All of these technologies already exist or are in development phases, and they are the future of intelligence and warfare (Jensen, 2014; NATO, 2020). Additionally, the U.S. government and NASA have been encouraging the commercialization of space cargo transportation to meet future American needs for access to the International Space Station (ISS) and to improve the research and development of spaceborne technologies and other developments, most recently through the announcement of the Artemis program (Hughes, 2011; NASA, 2020).

Private sector involvement has opened the market for alternative rocket propulsion technologies that can achieve government and commercial goals for space at lower costs and faster than possible under the existing bureaucracy of NASA. Enhanced private sector involvement in space travel utilizes the free-market system to foster radical developments and investment for both government and private sector programs, incentivizing broader participation, which benefits both. The PRC's communist version of capitalism is also expanding commercialization of space activities, but with authoritarian leadership all private sector investments, including technologies and other space-related innovations, directly benefit the PRC government. Commercializing aspects of standard space operations, such as recent and planned operations involving SpaceX and Blue Origin, will reduce barriers to space over time, including lowering costs, normalization of space tourism, introduction of a space transportation industry, and extraterrestrial resource exploitation activities, particularly asteroid mining and celestial body mining operations. Commercialization of space operations will free up resources for NASA and the newly minted U.S. Space Force to pursue broader goals, such as manned deep space travel, lunar-based activities, and manned missions to Mars.

2. Lunar Power

Rare earth metals and other minerals are quickly becoming scarce in the United States to the point where the international space race to claim the Moon and Mars has become a top priority, not just for control, but for resources available for exploitation. Uranium has even entered the economic radar as a good idea for boosting the American economy instead of remaining too dangerous to mine due to the associated health risks and environmental hazards. Uranium is in abundance on the Moon (Crawford, 2015). Estimates suggest there may also be up to five million tons of Helium-3 (^{3}He) contained within the lunar regolith (Dobransky, 2013). This has the potential to meet all of mankind's power needs for thousands of years when used for fusion power (Dobransky, 2013). On top of the resources potentially available, the Moon provides a unique launching position for future missions to Mars with a faster, more direct, and more efficient path to the Red Planet (Dobransky, 2013). Control over the Moon is an inherent factor in the future of energy production, strategic power, and the human race.

Uranium has long been a part of the nuclear fission enterprise on Earth but comes with high costs, including radioactive waste and extreme health and environmental hazards due to the radiation produced in the fission process. Terrestrial reserves of other energy-producing resources, like oil and natural gas, have also been projected to be exhausted within 50–100 years under current and projected mining and usage rates (Dobransky, 2013). Alternatively, the element tritium (T), which has a half-life of 12.32 years, naturally decays into ^3He (Kolasinski, Shugard, Tewell, and Cowgill, 2010, 5), which can be used to create a new kind of power—fusion power. Fusion power can be generated by combining deuterium (D) with either more D, T, or ^3He, using the following calculations shown in order of their ignition temperatures:

$$D + T = {}^4He \text{ [Helium-4]} + n \text{ [neutrons]} + 17.6 \text{ MeV [Million electron Volts]} \quad (1)$$

$$D + D = T + H \text{ [Hydrogen]} + 4.0 \text{ MeV (50\%)} = {}^3He + n + 3.3 \text{ MeV (50\%)} \quad (2)$$

$$D + {}^3He = {}^4He + H + 18.4 \text{ MeV (Hughes, 2011)} \quad (3)$$

Fusion power can also be created by combining ^3He with more ^3He, creating Helium-4 (^4He) (Dobransky, 2013). The combination of ^3He and ^3He is the most energy efficient, producing the greatest net energy, but also requires the highest ignition temperature to achieve fusion (Dobransky, 2013; Crawford 2015, 157). Fusion power generation using ^3He produces the cleanest and most abundant energy, but is also the most difficult to achieve.

Unfortunately, ^3He exists only in minute amounts on Earth (Dobransky, 2013). The nation that establishes a mining and transportation industry capable of bringing lunar ^3He to Earth, and develops a fusion plant network that transforms ^3He into power, could control a substantial portion of the planet's energy industry for decades. Some scientific estimates discount both the estimates of the potential amount of extractable ^3He in the lunar regolith and the potential to achieve industrial fusion reactors on Earth capable of processing it. Exemplifying this scientific stance are the calculations of Ian Crawford, who believes both prospects are greatly exaggerated and that there are only approximately 220,507 tons of ^3He available in logical extraction areas, such as the titanium-rich lunar basalt flats (Crawford, 2015, 144-145). Despite his dissent, Crawford admits even lunar resources that seem impractical and economically inefficient to transport resources to Earth may provide substantial economic benefits for space-based uses, such as solar power systems and spacecraft fusion engines, which would not require transport back to Earth (Crawford, 2015, 145).

The concept of fusion power has gone through several stages of the Gartner Hype Cycle over many decades, beginning in the middle of the twentieth century when the concept was first being explored, followed by decades of disillusionment after the initial peak of enthusiasm (NATO, 2020, 11-12). Modern technological advancements and increased commercial interest, combined with investment in space exploration activities, have moved the idea of fusion power into the slope of enlightenment as proofs of concept have begun to multiply, and as extraterrestrial resources that can be used in creating fusion power have become targets of opportunity in space for both nations and private investors. Earth's finite resources make lunar and space resource exploitation an inevitability. The most pertinent factor governing future human resource exploitation in space is the question of which nation will achieve a successful and effective industrial supply chain first. The most probable three nations to achieve this are the U.S., the PRC, and the RF, and the three areas that need to be navigated to succeed are facility establishment, production/refinement, and transportation.

Establishing lunar facilities is the easiest of these goals, especially when lunar resources that can be used for building are taken into account, which decreases the amount of materials needed to be brought to the Moon and the time needed for construction. In 2008, a NASA experiment found that lunar regolith has potential construction properties. When scientists heated the regolith and used sulfur as a binding agent, they made "waterless concrete," which can be molded and is nearly as strong as concrete when it hardens (Hughes, 2011, 45-46). This process requires minimal effort and relies primarily on direct heat application and the ability to shape the regolith. Consequently, the entire process can be automated by robots with the appropriate tools on the lunar surface, such as the ones NASA began developing specifically for this purpose in 2009 (Hughes, 2011). The simplicity of the operational requirements means that these three nations already have the technical capability to begin construction using lunar soil after arriving on the Moon. They will also all be capable of bringing any other materials that would be necessary to construct facilities or bases on the lunar surface.

Unlike the U.S., and contrary to existing international law, the PRC's stance on the Moon is that it is territory, despite the prohibition on "national appropriation" of celestial bodies outlined in Article II of the Outer Space Treaty (United Nations 1967) (Hughes, 2011). The PRC has also proposed mining ^3He for future fusion power opportunities (Hughes, 2011). The RF, while not openly pursuing a territorial ambition for the Moon, is exploring and advancing prospects of economic development, including ^3He extraction

(Hughes, 2011). Firms in several countries, including the United States, Great Britain, Japan, and Russia, are also developing spacecraft for tourism, which will inevitably improve technologies useful for other purposes, including space cargo transportation (Defense Intelligence Agency, 2022, 35). Facility development and resource exploitation areas on the Moon are limited. This will exacerbate the race for prime locations and desirable resources, particularly at the poles, where water ice is believed to exist in large quantities (which can be used to sustain lunar human habitation), and in the titanium- and ^{3}He-rich basalt flats of Mare Tranquillitatis and Oceanus Procellarum (Crawford, 2015, 145). Once established, facility operations, such as the planned Artemis Base Camp at the lunar South Pole, can begin to extract and refine resources either for use on the lunar surface or for transportation to Earth (NASA, 2020).

Transportation of materials from the Moon to Earth is a substantial financial and logistical undertaking, and it will not be easy to show a profit after the considerable expenses associated with it. Nevertheless, extraction and transportation of ^{3}He and other resources to Earth, specifically for fusion power production, have been expressed as long-term goals of the PRC and the RF within the next decades. Interestingly, the U.S. has not stated this as a specific goal, but it has already shifted its space transportation industry sufficiently toward the private sector to achieve it, while initiatives of the Artemis program include resource exploitation activities (NASA, 2020, 28-29, 61). U.S.-based private sector organizations will have the most viable opportunity to build the first industrial space transportation system, specifically because of advantages in the American free-market system (Hughes, 2011). By encouraging private sector participation in the space industry and commercializing space transportation, the U.S. has also made production of space technologies competitive with proposals in the National Space Policy (Obama, 2010, 3-5). A competitive industry makes substantial investments in research, development, and production of space transports; engine components for space travel; and tools for use in zero gravity. America cannot afford to fall behind in the race for lunar facility establishment and resource exploitation, to maintain economic and national security, and to secure the future of human expansion into space, as the Moon offers the most efficient launching position for missions to Earth's red neighbor, Mars.

3. Mars Domination

Mars is widely accepted by the scientific community to be the most plausible planet for the first human habitation on a celestial body and, consequently, the most likely location for the first space colony and eventually a second planet for humankind. Thus, Mars is a desirable goal for nations involved in space exploration for many reasons, which the United States plans on pursuing with humans landing on the Red Planet for the first time in the 2030s (NASA, 2020, 59). The territory on Mars will also most likely become marketable for economic value to civilians in the long term, in addition to resource exploitation activities. The Outer Space Treaty prevents ownership of territory on celestial bodies but makes no mention of ownership or sale for profit of structures built on, or items brought to, celestial bodies, just as there is no explicit language in the treaty preventing profit-based resource exploitation on celestial bodies by either governments, organizations, or private nationals (United Nations, 1967).

The inevitability of Mars becoming a second planet inhabited by humanity must be considered, along with all of the implications of living spaces and ownership of property that will eventually follow. Denying this inevitability and claiming it as outlawed by international law due to the prohibition on appropriating territory on a celestial body would essentially equate owning property on Earth as also outlawed by international law. After all, Earth is also a celestial body. Language in the treaty encourages expansion into space and essentially says that if persons, governments, or organizations build something on a celestial body, they own that building and can do what they want with it, including selling it (United Nations, 1967). They cannot, however, claim to own the planet's ground outside the building—yet. Resources on Mars, while still not mapped out as substantially as lunar resources have been, will likewise create new markets for economic prosperity and national wealth, including more ^3He deposits from solar winds like those found in lunar regolith, along with substantially high concentrations of iron (Dobransky, 2013).

In addition to buildings constructed on celestial bodies, spacecraft and facilities constructed in space and on celestial bodies are also considered to be the territory of the owning nation, which means that the UN Charter applies to facilities and spacecraft in space and on celestial bodies. UN Charter Article 2(4), in particular, protects space explorers and potential future residents on Mars by prohibiting the "use of force against the territorial integrity" of another nation party to the treaty (United Nations, 1945), which all space-faring nations are. Article 51 further dictates that if attacked, "the inherent right of ... self-defence" shall not be impaired (United Nations, 1945). Article V of the Outer Space Treaty prescribes that, in space, all humans are bound to "render all possible assistance to" each other as "envoys of Mankind" (United Nations, 1967). Essentially, a peaceful international course is possible—even mandated—for human expansion into space. Unfortunately, the PRC and the RF regard space and celestial bodies as territorial goals, leading to the assumption that attempts will be made to control and defend such territories as necessary to achieve space superiority, control over space resources, and managerial power over the future colonization of Mars (Hughes, 2011).

Control over Mars, in addition to affecting resource exploitation, transportation, and scientific advancements, also has implications for the direction of humanity in space. Establishment of a human colony, or human colonies, on

Mars will eventually lead to territorial spaces, development of the land and air (potentially involving terraforming the planet for atmospheric enhancement), and security issues. While an established colony on the Red Planet is still likely decades away, trends within the PRC and RF governments suggest that any established colony on Mars under their jurisdiction would be authoritarian, weaponized, and secret. Given the nature of weather on Mars, fortified structures are easily justified, and the lack of a conventional weapons ban on celestial bodies makes weaponization of such a colony both legal and desirable, mainly because of the third inherently desired factor—secrecy. The inevitability of PRC and RF presence on Mars also suggests that any U.S. developments will likely include fortifications and weaponization. While the Outer Space Treaty mandates cooperation between nations on celestial bodies, the extreme distance between Earth and Mars means that a compliance verification system with effective monitoring and enforcement will be complicated, if not impossible, for the foreseeable future. For these reasons, a nation that effectively controls near-Earth space and establishes a security presence on the Moon will effectively be in a position to control Mars.

4. Space and Counterspace

Celestial bodies are not the only potential fields of conflict in space, and in the short term, space itself has become a much more immediately relevant focus for spacefaring nations and the world. This is particularly the case in the vicinity of Earth, including orbital paths for communication technologies, weapon platforms, and sensors. Technological improvements and the proliferation of nation-state and private sector interest and capacity to enter space are causing the acceleration of an inevitability—usable orbital space around Earth is diminishing (Koplow, 2014). Satellites and other spaceborne assets orbiting Earth are quickly filling up all of the most useful places to perform their assigned functions within Earth's various orbits, and space debris is complicating matters even further. Increasing numbers of space objects are causing difficulty in establishing safe orbital paths for newly launched spacecraft while increasing the risk to launches destined for deep space (Chanock, 2013). Adding to these complications are international developments of ASAT weapons, many of which add to the approximately 100 million pieces of space debris traveling as fast as 17,500 mph already orbiting Earth (Garcia, 2021; Koplow, 2014, 796-797).

ASATs in use and under development, with attacks initiated using space-based, ground-based, and airborne delivery methods, include essentially three broad areas: kinetic energy (KE), such as missiles, rail guns, or other satellites impacting targets in space; directed energy (DE), which includes lasers and particle beams; and electronic/cyber weapons (Koplow, 2014, 795; Koplow, 2019, 305-306). Counterspace weapons include three categories: space to space, which includes satellites targeting other satellites; space to ground, such as satellite weapons targeting Earth; and ground to space, encompassing ground launched weapons targeting satellites (Harrison, 2021, 3). The Outer Space Treaty, while prohibiting nuclear weapons from being used in any way in space including being stationed in space, "has no specific provision prohibiting the use of conventional weapons, [including lasers], in outer space" (Jensen, 2014, 275), which inherently authorizes them. The Outer Space Treaty also contains no prohibition of such weapons being stationed on space-based platforms, including on celestial bodies, or of them being used to target objects on Earth, in space, or on celestial bodies (Jensen, 2014). In other words, these weapons are legal in every way, regardless of the potential damage they can cause to international stability and humanity.

There are multiple ongoing debates over the nature, definitions, and classifications of several kinds of ASATs currently in operation or in developmental phases. With NATO's 2021 declaration that Article 5 could be invoked in the event of "attacks to, from, or within space," counterspace and counter-counterspace activities have become a very high priority for understanding, developing, and fielding (Calcagno, 2022, 37). Space to space ASATs include several types of satellites designed to initiate operations in close proximity to adversary space assets for purposes of "inspection, manipulation, damage, or capture" (Koplow, 2019, 305). Orbital satellites with robotic arms can also potentially launch cyber-attacks against other satellites to destroy, disable, or control them through direct attachment, parasitically (Defense Intelligence Agency, 2022, 18). Space-based ASATs, such as the prototype Russian ASATs Cosmos 2504 and Cosmos 2536, can also directly impact other satellites to cause kinetic damage (Defense Intelligence Agency, 2022, 29). The RF and the PRC have also fielded several ground-based ASAT systems, including missiles and ground-based lasers that can be used to blind sensors, damage components, or incapacitate satellites (Defense Intelligence Agency, 2022, 17, 28).

Space is a warfighting domain according to Russia, and they have developed missiles designed to destroy assets in space, including space vehicles and satellites, with little regard for creation of space debris (Defense Intelligence Agency, 2022, 21). In November of 2021, Russia tested its Nudol ASAT weapon system, creating over 1,500 trackable pieces of debris, and "tens of thousands of pieces of lethal but nontrackable debris," endangering all spacecraft in Low Earth Orbit (LEO) (Defense Intelligence Agency, 2022, 28). Russia is also "reportedly developing an air-launched ASAT weapon called Burevestnik" that can target spacecraft in LEO (Defense Intelligence Agency, 2022, 29). The PRC and the RF continue advancements in ASAT research and development, fielding new counterspace weapons on a regular basis to hold U.S. and allied space capabilities at risk, including kinetic, directed energy, and cyber-attack mechanisms across the range of space and ground-based systems (Haines, 2021, 8, 11; La Rocca, 2022, 29).

Nearly every KE ASAT results in a large amount of space debris, which causes an abundance of future and immediate problems for space activities, including endangerment of the basic military and commercial functions of satellites for the Global Positioning System (GPS), communications, and recreation. Space debris is therefore a highly undesirable side effect for any nation to risk and potentially dangerous to the integrity of a nation's armed forces. David Koplow (2014) addresses this issue in a substantially relevant and logical way in his article "An Inference about Interference: A Surprising Application of Existing International Law to Inhibit Anti-Satellite Weapons." His stated thesis is as follows: "The [National Technical Means] NTM-protection provisions of arms control treaties already prohibit the testing and use of destructive, debris-creating ASATs, because it is foreseeable that the resulting cloud of space junk will, sooner or later, impermissibly interfere with the operation of another state's NTM satellite, such as by colliding with it or causing it to maneuver away from its preferred orbital parameters into a safer, but less useful, location" (Koplow, 738-739). By "interfering" with these NTM verifications mandated by multiple treaties, Koplow suggests that intentional actions creating space debris are already outlawed by international law, and that the development of debris-creating KE ASATs should cease and be banned immediately (Koplow, 738).

Laser weapons, particle beams, and weapons containing depleted uranium are also under debate due to their radioactivity, as well as nuclear processes used for some of their operations. Some posit that nuclear activities or materials within a weapon system should constitute classifying them as nuclear weapons, thereby outlawing them in space per the Outer Space Treaty's nuclear weapons ban (Crockett, 2012, 687–688). Advocates for these weapons declare that the weapons are not nuclear. Of the three primary types debated, laser weapons use a nuclear or chemical reaction process to fire a radioactive beam, particle beams rapidly fire atomic charged particles at a target, and hypervelocity rod bundle weapons and railguns use depleted uranium as ammunition (Crockett, 2012, 674–682). Finally, the potential exists for the use of a nuclear explosion in space designed to generate an electromagnetic pulse (EMP) attack on an Earth target, which the RF "has worked on developing" in the form of an "EMP ASAT" (Crocket, 2012, 680). The RF and PRC are aggressively pursuing ASAT weapon advancements and preparing for space combat operations, including the RF recently fielding a ground-based laser weapon even as it publicly advocated for space not to be weaponized (Coats, 2019, 17). With the RF's recent developments in ASATs and its stated intent "to station weapons in space" (Clapper, 2016, 9–10), the complete weaponization of space by the RF and other nations—including the U.S. and the PRC—is inevitable, which leads to the question of which nation and which ideology will govern mankind's expansion into the stars.

5. The Future of Space

Space exploration converges on two of Sun Tzu's concepts of the strategic battlespace: "open ground" and the "ground of intersecting highways." The former consists of areas where all sides have "liberty of movement" and the latter of areas where "contiguous states" converge (Tzu, 1910, 46–47). On open ground, Sun Tzu advises not "to block the enemy's way," and on intersecting grounds he suggests to "join hands with your allies" (Tzu, 1910, 47). Space is essentially a combination of these types of ground, where all nations are contiguously connected, and yet it consists of a legally recognized area of free movement for all persons and nations. Interestingly, Sun Tzu's *The Art of War*, written over 2,000 years ago, advocates indirectly for peaceful human expansion into space, where allied nations proceed forth together while intentionally avoiding negative engagements with potential adversaries. Unfortunately, the PRC appears not to be adhering to this wise Chinese philosophical concept, and is instead positioning itself to ensure PRC domination and authoritarianism in the space domain. Interestingly, Sun Tzu's ancient concept of human cooperation and peaceful coexistence is more consistent with the U.S. Department of Defense's (DOD) and intelligence community's (IC) *National Security Space Policy* and the *National Space Policy of the United States of America*, than with the PRC government's policies (Department of Defense, 2011; Obama, 2010).

Executive Order (EO) 13914, signed on 6 April 2020, clarifies the position of the U.S. government that while international cooperation in space exploration is essentially mandatory, America "does not view [space] as a global commons," reiterating that the Outer Space Treaty does in fact protect the individual interests of nations in space, including the right to self-defense (Executive Order, 2020, 1). The policy further clarifies the intent of the United States to harvest materials from celestial bodies and strengthens the implied relationships with both the international community and the private sector concerning space exploration and related developments (Executive Order, 2020, 1). By combining these principles, this renewed position on space developments further complements Sun Tzu's ideas of the strategic battlespace in relation to the space domain moving into the future, regarding space as an area that can be used and exploited by everyone, but acknowledging that claims, defense, and security are also going to be an essential factor in the way mankind moves forward in the space domain.

In addressing the impact of space exploration, and the subsequent superiority gained by the PRC, the RF, or the U.S. in the process, it is important to recognize the three principle issues of the strategic space environment outlined in U.S. national policies: congestion, contestation, and competitiveness. The U.S. IC is mandated by section 1.1 of EO 12333 to "provide ... the necessary information on which to base decisions concerning the development and conduct of foreign, defense, and economic policies, and the protection of United States national interests from foreign security threats," which now include threats from space and threats toward U.S. space assets (Executive Order, 2008, 1). Congestion, contestation, and competitiveness in space now directly impact the IC's ability to effectively pursue its mandate under EO 12333 and must be addressed collectively to ensure the future national security of the United States on Earth and in space. Enhancing the space industrial base's ability to innovate and participate in the expansion of humankind into space fosters a unique opportunity to share with, and benefit from, research and development initiatives related to activities in space.

Combining private sector and government resources together has the potential to greatly accelerate advancements across a wide range of space assets—including spacecraft developments, zero gravity research, energy production, and weapon applications—all of which will help minimize the risks of congestion, contestation, and competitiveness. Congestion in space refers to objects, including active devices and dangerous debris, filling up the usable orbital paths used for government and commercial purposes, primarily satellites. It also applies to finite amounts of bandwidth and frequencies used for transmissions that are currently being exhausted by demand threatening to exceed supply (Department of Defense, 2011). Quantum communication technology research is advancing, with benefits that include unbreakable encryption, and "unhackable satellite services," resulting in "secure communications and signals" transmissions that are "impossible to eavesdrop" using Quantum key distribution, which China successfully achieved in a test in 2020 at a distance over 1,000km (NATO, 2020, 73; La Rocca, 2022, 83, 32). Quantum communications developments also have the potential to decrease congestion of bandwidth and frequencies used for current transmissions, as they operate outside the radio frequency spectrum.

Developments in unmanned vehicle technologies, including swarming technology paired with artificial intelligence, offers a potential solution to space debris (NATO, 2020, 59–66). Swarms of miniaturized space-capable unmanned vehicles with high-powered laser technologies could be deployed to target and eliminate space debris to reduce congestion of near-Earth space. Congestion will also inherently refer to space traffic once an industry exists that requires transportation between the Earth and the Moon, as well as to physical locations for lunar and Martian resource exploitation facilities, extraction points, and places to build and operate on celestial bodies, including the Moon and Mars. This will eventually include a significant focus on the colonization of Mars since large portions of the planet are unsuitable for human habitation due to terrain, radiation, meteoroids, and weather. Short-term intelligence and counterintelligence impacts from the congestion of near-Earth space consist of primarily radio interference, protecting satellites from becoming compromised, effective deployment and concealment of collection platforms, and ensuring the integrity of protected information in transit.

Sharing space in accordance with Sun Tzu's ancient wisdom does not mean ceding it, and while space debris is the primary factor in congestion, contestation is becoming an issue due to potential adversarial ASATs. Contestation is an anticipated inevitability that will grow exponentially as more nations enter space and with further developments and potential use of ASATs, either in war, by accident, or for other reasons. Murphy's Law applies, especially in space. Currently, competitiveness is driving both the potential for contestation as well as the congestion in near-Earth space. Commercial and multi-governmental competition is increasing for space-related research and development, deployment of assets, and physical space for occupation by those assets. Intelligence agencies in many nations, including allies and adversaries of the U.S., are now advancing the deployment, use, and decision advantages of spaceborne intelligence assets, including space-based surveillance and weapons platforms. Reasserting U.S. superiority over the space environment is vital to the continuation of American leadership on Earth and the effectiveness of IC assurance of national security through space superiority. American leadership in space exploration is the only way to ensure that humanity's expansion into the stars is undertaken with the ideologies of liberty and free-market economics leading the way.

America's leadership in ingenuity and technological developments, combined with free-market capitalism, has transformed the face of the world for more than two centuries. Its leadership has created the environment necessary to explore game-changing space technologies, many of which will revolutionize the entire space industry. For example, the Variable Specific Impulse Magnetoplasma Rocket (VASIMR) is an experimental electromagnetic thruster for spacecraft propulsion that will dramatically reduce travel time to Mars and other destinations (Krishna and Kumar, 2014). Commercial spacecraft like the Dream Chaser Cargo System will result in a private sector space travel industry, incentivizing space tourism and, potentially, a space cargo transportation industry (Gold, 2016, 1). SpaceX has begun launching its *Starlink* communication satellite constellation to provide global connectivity, and as of February of 2021, *Starlink* already contained more satellites in orbit than the PRC, with plans to have 12,000 satellites in orbit by 2027 to complete the system (NATO, 2020, 81; Harrison, 2021, 2).

In February 2020, the U.S. department of Energy announced a $50 million investment in Fusion research and development projects across the country (Department of Energy, 2020). One of these is the Plasma Science and Fusion Center at the Massachusetts Institute of Technology with the goal of keeping the United States at the forefront of fusion energy development (Rivenberg, 2020). Another is the Fusion Technology Institute at the University of Wisconsin, which is focusing on advancing research in the field of helium-based fusion power production technologies on Earth (Dobransky, 2013). This technology will address finite terrestrial energy resources and production of ^{3}He-based electricity from lunar regolith. These are just a few examples of the future of space technology research and development, and such technologies were all made possible because of the structure of the American free-market system. The only way to prevent authoritarian leadership in the space domain is to provide an alternative, with liberty and free-market economics driving expansion into space.

Conclusion

The Artemis program concept has the potential to become a global space exploration initiative that benefits all life on Earth, creating opportunities for advancements across the entire spectrum of human life and well-being. The possibility of fusion power production will dramatically impact Earth's energy industry, offsetting the economic balance of power for generations. Ideological power struggles on Earth will inevitably bleed into the space domain impacting how humans are governed in space and on celestial bodies, dictating whether or not freedom and democracy survive. As technologies shrink the world, they are also shrinking space, creating ease of access and commercial opportunities that have never been possible throughout mankind's history. The international community will eventually be forced to unite as one Earth or fall as a house divided, and the implications of space developments are accelerating this decision. Instead of focusing on how best to 'win' in the areas of congestion, contestation, and competitiveness in space, nations should focus on the best ways to reduce these issues, uniting to eliminate space debris, to cooperate in clean fusion energy development, to commercialize space operations, and to lead the world forward into a new era.

The PRC's and RF's posture in and towards space are driving the world towards conflict, and America is the only nation positioned to counter their actions. Space opportunities will inevitably result in new ways and means to achieve power and control, and if the U.S. does not achieve both, then the PRC or the RF will. The biggest challenge for America and the IC will be to balance President Dwight Eisenhower's vision with Sun Tzu's battlefield strategies. Eisenhower understood in 1958 that "through [space] exploration, man hopes to broaden his horizons, add to his knowledge, and improve his way of living on earth" (Office of the Historian, 1958, 2). Sun Tzu knew that "all warfare is based on deception," "the highest form of generalship is to balk the enemy's plans," and the greatest fighters "put themselves beyond the possibility of defeat" to achieve victory (Tzu, 1910, 3, 8, 12). American leaders participating in seizing and maintaining U.S. space superiority shoulder this responsibility and must forge a new path forward that enhances human life on Earth, denies the possibility of victory to U.S. adversaries, and ensures the integrity and security of American assets in the space domain as the world moves forward together into the stars.

References

Calcagno, E. (2022). NATO and its Members: A Space Alliance? in The Expanding Nexus Between Space and Defence. *Istituto Affari Internazionali 22*(1): 35–43. https://www.iai.it/sites/default/files/iai2201.pdf.

Chanock, A. (2013). "The Problems and Potential Solutions Related to the Emergence of Space Weapons in the 21st Century." *Journal of Air Law and Commerce 78*: 697–698.

Clapper, J. (2016). "Worldwide Threat Assessment of the U.S. Intelligence Community." *Office of the Director of National Intelligence*. 9 February. https://www.dni.gov/files/documents/SASC_Unclassified_2016_ATA_SFR_FINAL.pdf.

Coats, D. (2019). Worldwide Threat Assessment of the U.S. Intelligence Community. *Office of the Director of National Intelligence*. 29 January. https://www.dni.gov/files/ODNI/documents/2019-ATA-SFR---SSCI.pdf.

Crawford, I. (2015). Lunar Resources: A Review. *Progress in Physical Geography 39*(2): 137–67.

Crockett, J. (2012). Space Warfare in the Here and Now: The Rules of Engagement for U.S. Weaponized Satellites in the Current Legal Space Regime. *Journal of Air Law and Commerce 77*: 687–88.

Defense Intelligence Agency. (2022). Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion. *Defense Intelligence Agency*. https://www.dia.mil/Portals/110/Documents/News/Military_Power_Publications/Challenges_Security_Space_2022.pdf.

Department of Defense. (2011). National Security Space Strategy: Unclassified Summary. *Department of Defense Archives*. January 3. https://www.dni.gov/files/documents/Newsroom/Reports%20and%20Pubs/2011_nationalsecurityspacestrategy.pdf.

Department of Energy. (2020). Department of Energy Announces $50 Million for Fusion Energy R&D. *Department of Energy*. 13 February. https://www.energy.gov/.

Dobransky, S. (2013). Helium-3: The Future of Energy Security. *International Journal on World Peace 30*(1): 61–88.

Executive Order 12333. (2008). United States Intelligence Activities of December 4, 1981, As Amended by Executive Orders 13284 (2003), 13355 (2004), and 13470 (2008). *Code of Federal Regulations*. Title 3. 30 July. https://dpcld.defense.gov/Portals/49/Documents/Civil/eo-12333-2008.pdf.

Executive Order 13914. (2020). Encouraging International Support for the Recovery and Use of Space Resources. *Federal Register 85*(70). 6 April. https://www.federalregister.gov/.

Garcia, M. (2021). Space Debris and Human Spacecraft. *NASA.gov*. Last Accessed 4 April 2022. http://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

Gold, M. (2016). NASA at a Crossroads: Reasserting American Leadership in Space Exploration, Testimony, *Hearing of the Senate Space, Science, and Competitiveness Subcommittee*. 13 July. https://www.commerce.senate.gov/public/_cache/files/22225dab-2f0d-437e-98d2-288c30ec9791/AC3538D71CDC78C585140280AE91E184.mike-gold-testimony.pdf.

Haines, A. (2021). Annual Threat Assessment of the U.S. Intelligence Community. *Office of the Director of National Intelligence*. 9 April. https://www.odni.gov/files/ODNI/documents/assessments/ATA-2021-Unclassified-Report.pdf.

Harrison, T., Johnson, K. & Young, M. (2021). Defense Against the Dark Arts in Space: Protecting Space Systems from Counterspace Weapons. *Center for Strategic and International Studies*. February. https://aerospace.csis.org/wp-content/uploads/2021/03/032321_HarrisonJohnsonYoung_DefenseAgainstDarkArtsInSpace_Report_Update-compressed.pdf.

Hughes, J. (2011). Confusion Over Space. *The Journal of Social, Political, and Economic Studies 36*(1): 3–54.

Jensen, E. (2014). The Future of the Law of Armed Conflict: Ostriches, Butterflies, and Nanobots. *Michigan Journal of International Law 35*(2): 253–317.

Kolasinski, R. D., Shugard, A. D., Tewell, C. R. & Cowgill, D. F. (2010). Uranium for Hydrogen Storage Applications: A Materials Science Perspective. *Albuquerque, NM: Sandia National Laboratories*. August. https://www.osti.gov/servlets/purl/993617.

Koplow, D. (2014). An Inference about Interference: A Surprising Application of Existing International Law to Inhibit Anti-Satellite Weapons. *University of Pennsylvania Journal of International Law 35*: 746–747.

Koplow, D. (2019). Deterrence as the MacGuffin: The Case for Arms Control in Outer Space. *Journal of National Security Law & Policy 10*(2): 293–349.

Krishna, V. C., & Kumar, A. S. (2014). Magneto Hydro Dynamics-Plasma Dynamic (MHD) for Power Generation and High-Speed Propulsion. *International Journal of Advances in Engineering & Technology 7*(1): 168–175.

La Rocca, G. (2022). Russia and China: West's Systemic Rivals on Orbits in The Expanding Nexus Between Space and Defence. *Istituto Affari Internazionali 22*(1): 25–34. https://www.iai.it/sites/default/files/iai2201.pdf.

La Rocca, G. (2022). The Technology Dimension and Duality in The Expanding Nexus Between Space and Defence. *Istituto Affari Internazionali 22*(1): 83–90. https://www.iai.it/sites/default/files/iai2201.pdf.

NASA. (2020). Artemis Plan: NASA's Lunar Exploration Plan Overview. *National Aeronautics and Space Administration*. https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf.

NATO. (2020). Science & Technology Trends 2020–2040: Exploring the S&T Edge. *NATO Science & Technology Organization*. March. https://www.nato.int/nato_static_fl2014/assets/pdf/2020/4/pdf/190422-ST_Tech_Trends_Report_2020-2040.pdf.

Obama, B. (2010). *National Space Policy of the United States of America*. Washington, D.C.; The White House, 28 June. https://obamawhitehouse.archives.gov/sites/default/files/national_space_policy_6-28-10.pdf.

Office of the Historian. (1958). Statement of Preliminary U.S. Policy on Outer Space. *Department of State*. https://history.state.gov/historicaldocuments/frus1958-60v02/d442.

Pool, P. (2013). War of the Cyber World: The Law of Cyber Warfare. *The International Lawyer 47*(2): 299–323.

Rivenberg, P. (2020). Plasma Science and Fusion Center Receives $1.25M from ARPA-E to Explore Practical Paths to Fusion: MIT Experience with Hearing Plasmas will Support Novel and Low-Cost Approaches to Creating Fusion Energy. *Plasma Science and Fusion Center*. 15 April. https://news.mit.edu/2020/psfc-re ceives-arpa-e-funding-to-explore-practical-fusion-paths-0415.

Tzu, S. (1910). *The Art of War*. Trans. Lionel Giles. London: Luzac and Co. https://sites.ualberta.ca/~enoch/Readings/The_Art_Of_War.pdf.

United Nations. (1967). Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, (hereafter referred to as the Outer Space Treaty). *U.S. Department of State*. 27 January. https://2009-2017.state.gov/t/isn/5181.htm.

United Nations. (1945). United Nations Charter (full text). *United Nations*. https://www.un.org/en/about-us/un-charter/full-text.