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Executive Summary Report

GEOIntelligence

From antiquity to the twentieth century, there were two warfighting domains – land and sea. With the advent of flight early in the twentieth century, air became the third warfighting domain. Decades later came the space age and with that, a fourth domain of warfare that directly relates to and enables the other domains in its relevance, expanse, and complexity.

Before space became a domain, some of the world's greatest minds, (like that of Galileo, Newton, and Einstein) grappled with understanding and explaining space. Their collective insights laid the foundation that eventually informed, catalyzed, and resulted in today's space programs. In less than a century, space has progressed from conceptualization and wonder to exploration and international competition and more. Since the late 1950s when the Soviet Union launched Sputnik igniting a "space race" with the United States, the pace and breadth is steadily increasing to this very day and beyond. The space domain offered opportunities for exploration and commercial use, but it was optimized for warfighting from its beginning – Sputnik was not launched from a rocket designed for space-lift, but from a developmental Intercontinental Ballistic Missile designed to deliver nuclear weapons against the United States for deterrence.

Acknowledging that the earth's atmosphere does not abruptly end where space begins, 100 km (or 62 mi) above sea level is widely accepted as the "edge of space," also known as the "Kármán line." In terms of orbits around the earth that artificial satellites travel, there are many, but the most common are Low Earth Orbit (LEO) at 100 to 1,243 miles above earth; Medium Earth Orbit (MEO) at 1,243 to 22,236 miles; Geostationary Orbit (GEO) at 22,236 miles; and Highly Elliptical Orbit (HEO) where an object comes close to the earth for specific mission reasons, then elongates to distances far from the earth before returning close to the earth.

Space is Competitive:

As nuclear weapons proliferated, there were concerns that space would not be an exception. As such, in 1967 the UN General Assembly (UNGA) negotiated the "Outer Space Treaty" that prohibited nuclear weapons in space as well as the use of celestial bodies (like the moon) from becoming military bases. The challenge with the treaty is that it did not holistically forbid military activities in space, it merely banned select aspects, such as nuclear weapons and bases.

At the time of the treaty, only three nations had viable space programs – the United States, Russia, and China. The cost and complexity of space-related activities and enterprises was high and, therefore, few governments had the option to pursue space. The space race initially focused on global prestige and enabling terrestrial capabilities for Intelligence, Surveillance, and Reconnaissance (ISR). Though Russia challenged the United States for space superiority and achieved some major "firsts," for several decades the U.S. was the dominant space power, acknowledging that China also made steady progress in space during this time.

Recently, as Great Power Competition remerged with Russia and China exercising their positions and power to challenge well-established international norms and rules of law, naturally competition extends into space. In terms of investments in space, today the U.S. still leads the way in space with China and Russia as numbers two and three, respectively, regarding their annual investment in space. Of course, for the United States it is problematic that China and Russia have established closer ties with each other as they try to challenge international norms – and both are actively trying to change the game in space.

As opposed to the early period of space activity, today many nations across the globe have space programs that have produced tens of thousands of assets that take advantage of the space domain. The opportunities in space are almost limitless with many of them providing benefits to humankind; they range from experiments that discover or solve problems on earth, to a wide variety of commercial applications, and more.

Expenditures offer a data point of the importance of space to certain space-faring nations. From an economic perspective, nations have spent billions of dollars on space programs – perhaps $50 billion-plus is budgeted for space programs globally, not counting military or classified programs
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Here is a breakdown of the top nations operating in space, again noting that these estimates do not include military and private expenditures: the United States' NASA leads the way at $24.8 billion; China $5.8 billion; Russia $3.4 billion; France $3.1 billion; Japan $3 billion; Germany $2.1 billion; India $1.5 billion; Italy $1.1 billion; UK $900 million; South Korea $600 million; and Canada $315 million. The European Space Agency, 23 countries in all, collectively spends $7.9 billion with the space budgets of the UK, Italy, Germany, and France making up 70 percent of its budget.

The commercialization of space has put companies in direct competition with totalitarian Russia and China. Commercial companies (e.g. SpaceX; Lockheed Martin-Boeing-United Launch Space Alliance; Blue Origin, Orbital Sciences Corp, et al), are proving the power of free market enterprises in bringing the costs of fielding space capabilities down while increasing technological innovation and enhancing new areas where market forces can continue to more rapidly support areas like farming, mineral exploration and extraction, communication, environmental science, and human travel.

Companies assume tremendous environmental, technological, and financial risk to be first or early movers in any market, but the risks are even higher when it comes to space exploration. A major challenge is the risk of hostile totalitarian nations (specifically China and Russia) attempting to prevent new players from "controlling the heights." This situation is essentially a modern high-tech version of old merchant sailing ships that had to be on the watch for pirates and navies of hostile nations whose purpose was to blockade resource exploitation of the "new world."

Space is Congested:

As of September 2024, the European Space Agency provided several statistics on space objects highlighting the congestion. There have been about 6,740 rocket launches (excluding failures) since the start of the space age in 1957. Those launches have inserted about 19,590 satellites into Earth's orbit with about 13,230 remaining in space and, of those, about 10,200 are operational.

The total number of space objects is regularly tracked by Space Surveillance Networks and maintained in its catalog is around 36,860 objects, with a combined weight estimated at over 13,000 tons.

When rockets launch satellites there are various debris that can remain in space for many years associated with the rocket, payload, etc. Further contributing to the debris are destructive tests. For example, in 2007 China conducted an Anti-Satellite Test (or ASAT) that created over 3,000 pieces of trackable debris. In 2021, Russia conducted an anti-satellite missile test creating over 1,500 trackable pieces of debris. The actual pieces of debris that can endanger space travel and satellites are much higher because only pieces 10 cm or larger are officially tracked. It bears noting that the U.S. was the first nation to test an ASAT capability in 1985 that likewise created space debris. The United States' last ASAT event was in 2008, where the U.S. downed a U.S. satellite that was out of control. The satellite weighing in at 5,000 pounds with 1,000 pounds of dangerous liquid fuel could present a risk to humans when re-entering the earth out of control. To minimize possible injuries when it re-entered the atmosphere, the U.S. military shot down the satellite in such a way to break it apart and destroy the fuel. The shoot down was considered a success with relatively little debris remaining in orbit. This final U.S. ASAT event differs markedly from Chinese and Russian ASAT tests, as the U.S. shootdown was for humanitarian reasons whereas their ASAT events and capabilities are for warfare. To cement this point, the U.S. self-imposed a moratorium on future U.S. ASAT interceptions in 2022.

For context with the congestion in space take, for example, the development and evolution of the automobile in the United States. The automobile has been around for about 150 years, with very small numbers initially but with almost 300 million on the U.S. roads today and growing. Interstate 5 in Los Angeles is the busiest road in the U.S. with up to 500,000 vehicles traveling on it each day. While traffic is heavy on I-5 and delays are frustrating, travel is steady and safe because of laws and rules. The same analogy applies to the ever-increasing air traffic in the United States – consider what air traffic would be like if there was not an aviation control and coordination system and international norms?

As space traffic increases, if the space-faring nations do not create rules to govern it and comply with them, disaster awaits. With the expanding actors (public and private) combined with growing debris, areas of cooperation and business opportunities could emerge in space traffic coordination system and debris removal. The risks of these near-term problems, if left unsolved, could make space movement even more dangerous and costly to all actors. Of course, humans in space are the highest consequence if collisions were to occur to space craft. As of November 2024, the International Space Station, since its insertion into space in 1998, has made 39 maneuvers to avoid space junk.

Despite rapidly increasing numbers of assets, military and civilian applications, and debris, space has few internationally agreed upon regimes or regulations. It is an area where numerous nations are employing both governmental assets and privatized programs, which are increasingly characterized by a tension between collaboration and competition in relation to all elements of power.

As a result, the United States initiated an effort to establish updated international norms found within the original Outer Space Treaty. These norms have become the Artemis Accords. Developed during the first Trump administration, they remained in development through the Biden administration. The main goal is to establish a framework to increase international cooperation in the exploration of the Moon, Mars, and other areas of space. The main drivers for the Accords have been the dramatic increases in nations that now have or are developing space capabilities, along with the rapid commercialization of space. As of January 2025, there are 53 nations that are signatories to the Artemis Accords.

A major challenge with the Accords is that Russia and China have not signed them, nor do they intend to. This course of action sets up a potentially highly volatile future for direct and indirect competition in space unless they can be convinced otherwise. As we have noted in previous papers, China's and Russia's paramount strategic goals focus on displacing the United States as a global power and disrupting the current world rules-based order; even if they cooperate to an extent, it should be viewed through a skeptical lens.

Space is Contested:

In recognition of the importance of maintaining U.S. and allied access to space for the rapidly increasing suite of military and civilian capabilities, the U.S. created an independent "Space Force." This is a service component like the Army, Navy, Air Force, and Marines, and is responsible for organizing, training, and equipping the Space Force. In more detail, this command is responsible for acquisition, operations, and sustainment of space and ground-based systems that operationally control space assets; Positioning, Navigation, and Timing (PNT); Space Situational Awareness (SSA); rapid/secure communications; Intelligence, Surveillance, and Reconnaissance (ISR); weather observation; space launch bases and systems; ground-based telescopes and early warning radars and much more. In an increasingly contested space environment, U.S. space forces are now called upon to provide both offensive and defensive systems and capabilities to ensure access to, and use of space for commercial uses as well as needs across all elements of U.S. national power.

The U.S. also created the Space Force's warfighting companion, called "U.S. Space Command" (SPACECOM). The warfighting organizations are collectively known as "combatant commands." Combatant commands are usually responsible for either geographic regions, like that of U.S. European Command (EUCOM), U.S. Indo-pacific Command (INDOPACOM), and U.S. Central Command (CENTCOM), or functional commands such as U.S. Strategic Command and U.S. Cyber Command. But, SPACECOM does both – it is responsible for a region of sorts, i.e., space above the Kármán line, as well as a function, that of space.

When we look at the elements of power in space, economics is the center of gravity driving private sector exploration of space. However, for the United States' major advanced competitors – China and Russia – it is about "commanding the heights" to include control over resource extraction and military advantages related to data and communication, PNT, ISR, SSA, and offensive counter space capabilities. Much of what these two states pursue is cloaked in a narrative of scientific exploration, all the while aiming to prevent the U.S. and other free market nations from having influence on their national, regional, and global power interests.

It is not just the complexity caused by increasingly crowded orbits, it is also our potential adversaries' active development of terrestrial and space-based military systems designed to degrade or destroy U.S. and Western allies' space-based assets. For example, disturbingly, in 2024 U.S. officials expressed concern that Russia plans to launch a nuclear-armed satellite into orbit. As reported by Air and Space Forces Magazine, Space Development Agency director Derek M. Tournear stated that if Russia would detonate a nuclear weapon in space, it would destroy commercial, civil, and military satellites and would constitute an "attack on the world." Simply stated: space is very much contested with vast implications.

Implications:

"Commanding the heights" is a critical space strategy for Global Powers, comprised of four dimensions: global positioning, natural resource extraction, governance leadership, and national security.

Global Positioning: Satellites in space are key assets for national security and economic growth. PNT and the flow of data not only drive the military's intelligence, telecommunications, tracking, and targeting, but are now critical to commercial shipping, agriculture, emergency services, fleet safety, aircraft operations, and many other applications key to terrestrial life. Space access and security have become essential elements in the resultant cyber domain and the digital economy.

Research of Natural Resources and Climate Change: Rare minerals are central to our global economy for micro-chips, energy sources, and scientific research for climate change impact on our globe. Space provides strategic opportunities for access to new rare minerals and to enhance our collective understanding of our own world, particularly regarding climate. Presence in space provides opportunities to lay claim to natural resources and dominate access to monitoring our globe's climate patterns.

Space Governance: The Global Powers that lead in global positioning, research and exploration of natural resources, and climate change will lead space governance as they will possess control of the critical elements of power in that domain. Ultimately, leadership in space enables control of all domains of warfare, land, sea and air, as well as cyber. The Unites States, which has historically led as the defender of Global Commons, must lead national and international security and the space economy if it is to be the dominant player in space governance, particularly as the space economy progresses to a $1.8 trillion level by 2035. The congestion of space, space debris accumulation, and the growing militarization of space is a major challenge. The failure of China and Russia to participate in the Artemis Accords is an indicator of the potential threat to rule of law and the danger posed by an absence of governance in space.

National Security: Great Power Competition in space does not get much press, but it is real and rapidly growing. Space is an essential and arguably an existential domain for national and international security and economics both terrestrially and extra-terrestrially. Space leadership and governance are key elements not only for the space domain, but also for the inextricably linked and emerging cyber domain, which is central to the future of mankind. Innovation and investment costs and risks will require public-private collaboration for both security and economics to enable free-market nations to deter threats and lead economically.

Space Economics and the Private Sector:

The U.S. space program has relied on key private sector vendors throughout its history to provide technologies to execute its missions. What has changed over the past several decades has been the expansion of the space economy for dual use of technologies for both national security and commercial objectives.

The World Economic Forum and McKinsey have projected that the total addressable market for the space economy will be $1.8 trillion by 2035, up from about $600 billion in 2023. The space economy's annual projected growth of 9 percent is expected to be driven by infrastructure and applications. The infrastructure aspect includes rockets, satellites, and services such Global Positioning Systems. The area of applications includes monitoring, navigation, and research that can be used for both national security and commercial purposes in the digital economy.

In terms of industry, historically, Boeing has been a major player in space since the Apollo program. One of its acquired companies, McDonnell Douglas, built spacecraft for the Mercury program starting in the late 1950s. Lockheed Martin is another long-term major vendor to NASA. Boeing and Lockheed Martin are cornerstone members of the United Launch Alliance (ULA), which was founded in 2006 to provide launch services to the National Space Security Program for U.S. security missions. The U.S. now contracts with several space providers with the heavy lifting now being shared between ULA, Space X, and Blue Origin. The focus for defense has been on the reusable rocket technologies for satellite launches and spacecraft transport. Northrop Grumman Corporation, Sierra Space, and numerous other technology companies are focused on dual-use products to provide both military and commercial solutions for spacecraft and space station technologies.

The dual-use model serves both national security objectives and maximizes value for private companies. Common areas for dual use are observing earth activities, weather monitoring, communication satellites, tracking of orbit activities, PNT support, and launch and transport services. The U.S. government is embracing the concept of dual use that enjoys bipartisan support for the defense sector. China also utilizes private companies for space activities to attract foreign investment for rockets, rocket boosters, and satellites to manage investment and government funding.

Public-Private collaboration is anticipated to continue increasing as the space economy grows and required financial investments rise. The ability to scale and generate returns on investment will require collaboration to foster innovation and mitigate financial risks to grow the space economy and industry. NASA's near-term plans include Artemis missions centered on its lunar strategy, crew expansions for the International Space Station (ISS), commercial space station development, expansion of monitoring capabilities and Mars preparations. All these programs will require involvement by private companies to facilitate and share investment.

Public-private partnership drives innovation and balances financial investment and serves both national defense and commercial uses. The U.S. has a history of many key technological advancements, which started for defense use and later provided transformational commercial products. Two common examples are the cellular phone industry and global positioning capabilities that began in the military domain. The dual use model for private corporations enables

diversification and expansion for its product sets. It also has complexity, which requires governance to guard against misuse and compromise of national security in its commercial programs.

In recognition of the risks to private space endeavors and the benefits and necessity of harnessing the commercial space sector's increasing capabilities and services in this domain, the U.S. has published its first Commercial Space Integration Strategy. According to the DoD, this strategy seeks to leverage the speed of the private sector's technology development and integrate current and future commercial space capabilities and services into our national defense architecture. This is a big step forward in capitalizing on what U.S. private companies do best – innovate quickly.