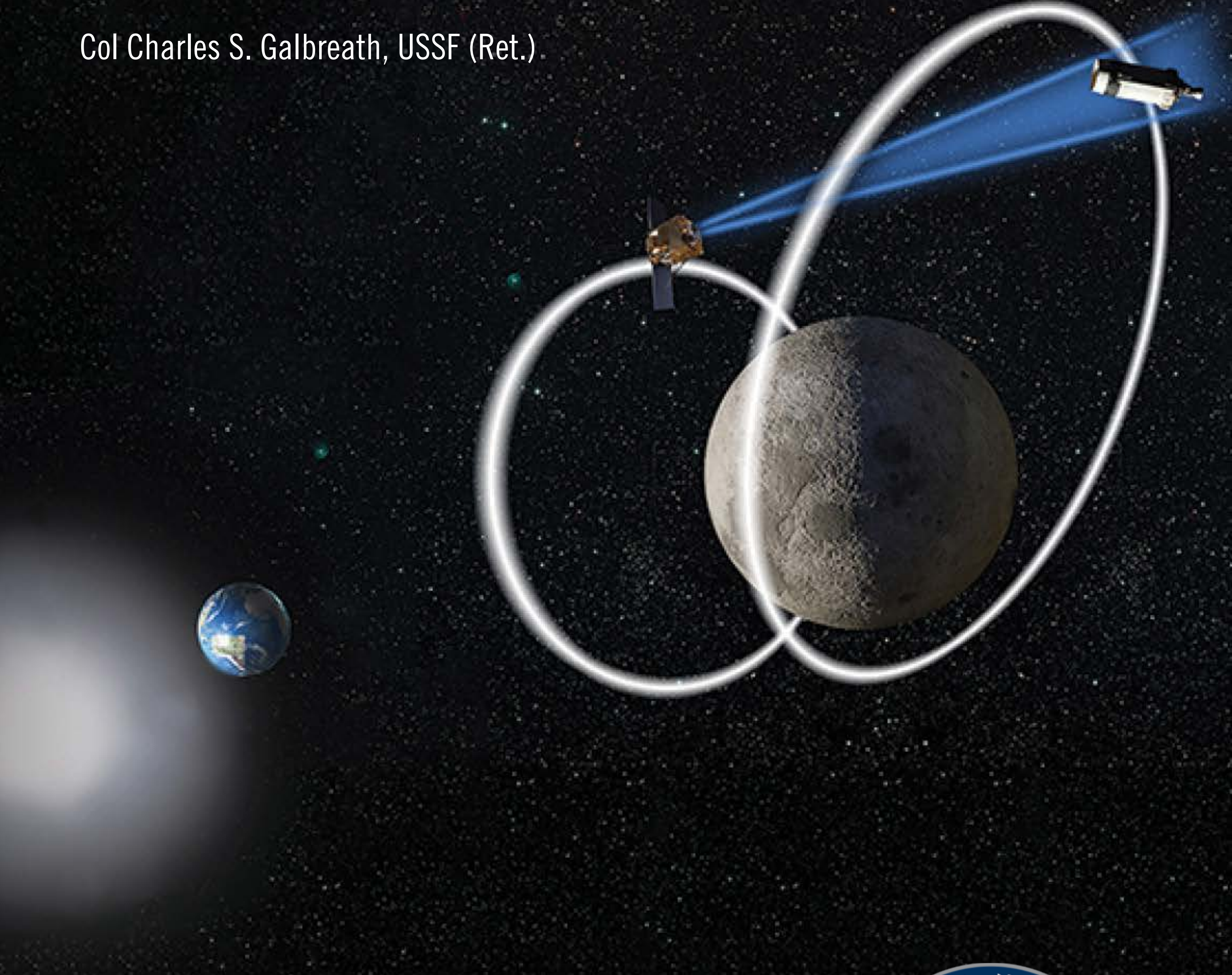
Securing Cislunar Space and the First Island Off the Coast of Earth

Col Charles S. Galbreath, USSF (Ret.)



MITCHELL INSTITUTE FOR AEROSPACE STUDIES

SECURING CISLUNAR SPACE AND THE FIRST ISLAND OFF THE COAST OF EARTH

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The Mitchell Institute for Aerospace Studies

Air & Space Forces Association

Arlington, VA

January 2024

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About the Author

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Cover design by Madeline Portway; graphic: AFRL

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Foreword

The United States and nations around the world are rapidly expanding beyond traditional orbits that focus on enhancing activities inside the atmosphere of the earth. Heading to and exploiting operations on and surrounding the Moon are among them. There are many complex technical, policy, and legal challenges in this new race. To resolve them, the U.S. Space Force must play a pivotal role.

The main rival to the United States in the new race to the Moon and exploitation of cislunar space is a determined China intent on reshaping the world order in its favor. China's zero-sum territorial approach to space starkly contrasts the U.S. approach, which fosters peaceful collaboration in space among dozens of partner nations—an approach now embodied in the U.S. Artemis Accords. The approach that succeeds will have profound security, economic, diplomatic, and technological implications for all nations on Earth.

In this policy paper, Charles Galbreath clearly explains the complex challenges facing the United States, makes a compelling case for increased military activity in the cislunar environment, and describes a path for how the U.S. military can enable continued U.S. leadership in space. It calls on Congress to give Space Force and Space Command sufficient resources to increase space domain awareness, communications, and navigation capabilities. Modest investments today will simultaneously accelerate U.S. efforts throughout cislunar space and reduce future costs to overcome any advantage ceded to China. Delaying action will limit future options, degrade U.S. leadership in space, and allow China to set precedents and norms in cislunar space that will define space development, use, and exploration for decades to come.

This complex undertaking is why the Mitchell Institute created its Spacepower Advantage Center of Excellence (MI-SPACE)—to inform the American public, Congress, and the Department of Defense about the emerging challenges and opportunities that space presents.

Lt Gen David A. Deptula, USAF (Ret.)
Dean, The Mitchell Institute for Aerospace Studies

Gen Kevin Chilton, USAF (Ret.)
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Key Points

The United States and China are locked in a race to harness the scientific, economic, and national security benefits related to the exploration of the Moon and the region of space affected by the gravity of both the Earth and Moon known as the cislunar regime. China views this race as a critical element of its strategy to replace the United States as the world leader.

The Chinese territorial approach to the cislunar regime contrasts starkly with the efforts of the U.S. Artemis Accords—a voluntary multinational agreement to establish norms of cooperation and peaceful collaboration in space.

To win the new race to the Moon, the U.S. military will need to establish an infrastructure that fosters scientific and economic activities, as well as the means to secure those activities from potential threats such as territorial claims and irresponsible or hostile behavior.

The DOD must establish an infrastructure for the cislunar regime, extending the types of services and capabilities currently in operation closer to Earth, such as space domain awareness, high bandwidth communications, and cislunar navigation technologies.

Congress must support and fund additive growth in the Space Force and U.S. Space Command to secure the peaceful advance of U.S. national interests in the cislunar environment before adversaries can deny them and create undesirable norms difficult to change. Modest, early investment will simultaneously accelerate U.S. and allied efforts and reduce the future need for larger investments to overcome an advantage ceded to China.

Abstract

Reaching the Moon was once a powerful statement of America's prowess and global leadership, with huge strategic implications that played out during the Cold War. Today, there is a new race to the Moon and the surrounding region that will establish a precedent for both activities on Earth and further into space. Scientific research and economic opportunities, as well as threats in space and on Earth, are fueling the launch of this new competition. Ongoing U.S. and Chinese activities in the cislunar regime—the region of space where an object's path is affected by the gravity of both the Earth and Moon—are both a race for immediate objectives as well as a facet of an enduring competition between great powers. This race will translate to very real consequences from security, economic, scientific, and diplomatic perspectives. China's comparison of the Moon to the first island chain in the Western Pacific signals that their approach will be based on territorial claims, clandestine weaponization, and regional access denial. In order to establish and protect a more transparent, collaborative, and peaceful cislunar regime, the United States and its partners must "win the race."

The U.S. Space Force and U.S. Space Command must take steps today in the cislunar regime to establish the same freedom of operations it realizes in Earth orbit. These steps will include new capabilities such as space domain awareness, high bandwidth communications, and cislunar navigation technologies. Ultimately, Space Force and Space Command must build an architecture that can simultaneously accelerate scientific and economic activities and enable an ability to monitor and respond to irresponsible or threatening behavior. Failure to act now will limit future options, create an unsustainable precedent in the cislunar environment, or even surrender U.S. leadership in space and weaken U.S. leadership globally.

Introduction

As a scientific, economic, and geopolitical objective, the Moon and surrounding region are now a critical facet of the enduring great power competition between the United States and China. Spurred by national interests in space, renewed scientific interest following the discovery of lunar ice, and economic ambitions surrounding rare-earth minerals, global powers and other space entrants are embarking on a new race to the Moon and the cislunar regime—the region of space where an object's trajectory is affected by the gravity of both the Earth and Moon. While there are many similarities to the Cold War space race between the United States and the Soviet Union, the scope, scale, and stakes of this new contest are even more profound. Characterizing this new, more complex race to the Moon is a lack of established norms to govern an array of multinational players with aims to establish a permanent human presence, extract lunar resources, and posture assets in key positions. One team in the race can generally be categorized as the signatories to the Artemis Accords, a non-binding set of principles to guide civil space exploration. This group includes the United States and dozens of countries pursuing civil and commercial objectives in an aligned fashion.[1] The other team is a territorially minded coalition between China and Russia determined to redefine the world order in their favor.

The United States and our partners must arrive first and establish customary practices of safe and responsible collaboration. Otherwise, we risk relinquishing key interests and governing principles to China and Russia. If we lose, the future of cislunar operations and opportunities further into the solar system will be severely limited. Given a lack of established international norms, this will be just like any other era of territorial exploration and expansion—those who arrive first set the terms. As China, working closely with Russia, plans to supplant the United States as the world leader, losses in the new race to the Moon would hasten a shift in the global balance of power.[2] To win will require Congressional support and funding for the U.S. Space Force and other military entities to work alongside civil, private, and international partners to achieve victory in this new, higher-stakes race in space.

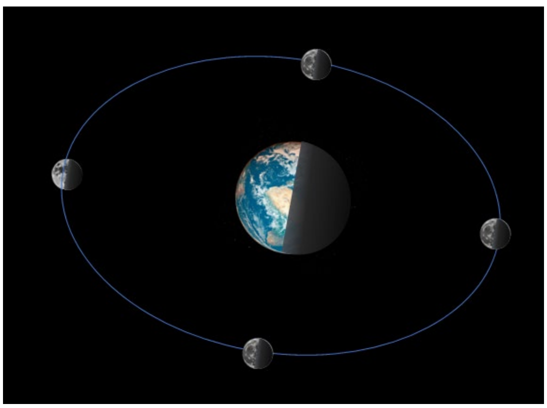


Figure 1: Moon phases and orbit around the Earth. While not to scale, the volume containing the Moon's orbit gives an approximation of cislunar space.

Source: Charles Galbreath/Mitchell Institute

Higher Stakes, Higher Levels of Competition

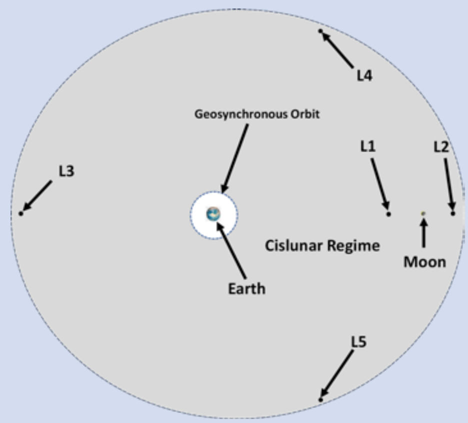
The United States overcame many challenges to successfully land on the Moon and safely return its astronauts over fifty years ago. The significance of that accomplishment can never be understated. However, this new era of competition, which will include maintaining a presence on the Moon and expanding further into the solar system, will present even greater challenges. As the recent failure of Russia's Luna-25 lunar lander illustrates, past performance does not guarantee future success in the incredibly challenging cislunar environment.[3] Compounding the difficulty are the potential actions of China in the cislunar regime. To this point, the head of China's lunar program has referred to the Moon as the Diaoyu Islands, a direct reference to the first island chain in the Western Pacific.[4] This invites comparison to the gray zone tactics demonstrated by China in pursuit of their self-interested goals and actions directed in isolation through their authoritarian regime, such as covert weaponization, territorial claims, coercion, and other aggressive behavior—conduct they have repeatedly and increasingly displayed in the Western Pacific.[5] The United States and free spacefaring nations of the world must prevent China from enacting a similar strategy in the cislunar regime to protect future freedom of operations. That begins by arriving first and establishing the customs and norms of transparent collaboration among nations for the benefit of all.

Orbital Regimes

Space Doctrine Publication 3.0 defines three orbital regimes based on the dominant gravitational force in the region.

Geocentric Regime: The geocentric regime is where Earth's gravity dominates, and objects follow orbital trajectories relative to the Earth.

Cislunar Regime: This regime is characterized by the combined gravitational effects of the Earth and Moon and includes translunar space between these bodies, the Earth-Moon Lagrange points, and orbits around the Moon.



Solar Regime: The Sun's massive gravitational field defines the solar regime, where planets and other objects in the solar system orbit around the Sun.

Source: U.S. Space Force, ***Space Doctrine Publication 3.0: Operations*** (Space Training and Readiness Command [STARCOM]: July 19, 2023).

A Peaceful and Collaborative Way Forward

For the United States, the race to the Moon involves a combination of civil, commercial, and military activities on the lunar surface and the cislunar regime. This includes the pursuit of a diverse array of emerging national interests—everything from research on the formation of the solar system and the extraction of rare-earth minerals to monitoring space activities for potential threats. The still-maturing U.S. Space Force and U.S. Space Command are the entities charged with the protection of national interests in space and must be prepared to secure these interests, especially in the face of demonstrated competition from Russia and China. This is why Congressional support to increase Space Force funding and personnel end strength is critical. This investment is essential to align ends, ways, and means to advance technology and create a foundational architecture with space domain awareness, high bandwidth communications, and cislunar navigation capabilities to secure emerging interests. It also aids in deterring irresponsible or territorial behavior while accelerating advantageous civil and commercial activities in space. Collectively, these lines of effort, if resourced sufficiently, will establish a peaceful and stable environment in the cislunar regime. Given the magnitude of the challenge, this must be executed as a long-term strategy, with regular, sequential advancement yielding smart progress. As we have seen in other areas, like relinquishing the hypersonic technological edge to adversaries, a rush to regain a credible position is both costly and complicated. It is far more effective and efficient to play the long game with an intent to always lead.

An immediate, modest additive investment by Congress to the Space Force over the next five years will have a profound and lasting impact on the stability of new areas of space exploration, starting in the cislunar regime but extending further into the solar system. This is a foundational era, and the U.S. must engage appropriately. By helping to establish cooperative civil and commercial activities on the Moon first, paired with appropriate means of military capability and capacity, the Space Force will advance peaceful, responsible, and cooperative norms in the cislunar regime. These same investments, particularly in domain awareness and communication, will ensure future commanders have the operational picture necessary to identify threats as well as the options to respond when and as appropriate. Executed properly, this will yield a strong deterrent against irresponsible, hostile, and territorial behavior. In defining this strategy, it is crucial to highlight that the U.S. approach to engaging on the Moon and in the cislunar region focuses on civil and exploration activities, with the military in support of those peaceful aims. This stands in contrast to the Chinese space program controlled by the People's Liberation Army (PLA).

The window to make meaningful contributions in the race to the Moon and cislunar region is closing rapidly. It is time to act now. This involves Congress, the Space Force, Space Command, international partners, and civil actors seeking to operate in space. To that end, the following recommendations outline a course of action to secure a peaceful, prosperous set of conditions on the Moon and beyond:

- The DOD must develop a broad strategy for how it will support scientific and economic expansion into the cislunar regime.

- Congress must fund additive growth of about $250M a year to the Space Force budget and increase end strength by approximately 200 personnel for the new responsibilities associated with emerging national interests on the Moon and the cislunar region.

- Space Force must develop a cadre of cislunar experts ready to lead development and operations activities.

- U.S. Space Command and the Space Force must establish doctrine, concepts of operations (CONOPS), and requirements to accelerate the race to the Moon and secure interests there.

- Space Force must work with organizations like AFRL and DARPA to invest in cislunar research and development efforts.

- Space Force must rapidly transition R&D activities into operational capabilities.

If adopted now, these measures will help overcome myriad challenges in the cislunar regime and potential adversary threats over the long term. These crucial, small steps will empower scientific and economic communities to concentrate on the experiments and development efforts necessary to make giant leaps toward an enduring presence on the Moon and the cislunar region. Failure to act will yield the initiative to adversaries with competing interests, limit future options for peaceful engagement in space, and create an unsustainable precedent in the cislunar environment, ultimately ceding U.S. leadership in space and weakening our status globally.

About Cislunar

Defining the Cislunar Regime

Throughout history, battlefield commanders and economic leaders alike required an understanding of the terrain to succeed. This is no less true today, as nations across the globe seek to expand into the unique "terrain" of the cislunar regime. Before the challenges posed by competitors like China are considered, it is crucial to assess what it will take to operate successfully in the cislunar region. This is an incredibly dynamic region involving numerous forces and caustic conditions. Mastering them demands that civil, commercial, and national security leaders collaborate to understand the nature of the cislunar regime and how to devise methods and means for successful mission execution.

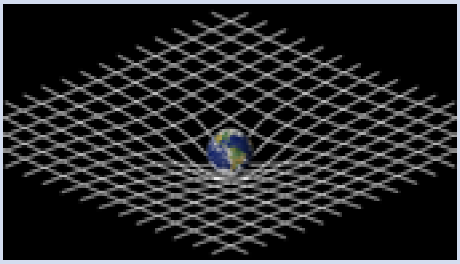
Operating in the cislunar region begins with understanding the forces of gravity from both the Earth and Moon. Operations in Earth's orbit are predictable and follow stable paths because Earth's gravity is the main force affecting those orbits. However, as operations draw near the Moon, that body exerts its own gravitational force, complicating the trajectory of objects. Operations in the cislunar regime must contend with both forces.

In the cislunar regime, there are a few special locations where the gravitational pull of the Earth and the Moon balance, and an equilibrium is attained. These positions are known as Lagrange points. There are five Lagrange points in the cislunar regime: three in line with the Earth and Moon and two angular points off of the line between the Earth. With little fuel use, a spacecraft can remain near one of these points or be on a trajectory around multiple Lagrange points and the Moon. Because of their relative positions to the Earth and Moon, they offer a commanding vantage of the cislunar regime, making these points of great value to future domain awareness, communication, navigation, and scientific activities. As a result, access to and operations in and around these Lagrange points will likely become a significant national interest. Establishing peaceful norms of responsible behavior for these points is crucial. It is not in the U.S. interest to see unilateral efforts to control regions in space like what we see in the South China Sea, with adversaries focused on occupying territory versus peaceful coexistence.

Another important aspect of the cislunar regime is its massive size. The average distance from the Earth to the Moon is 238,900 miles—more than nine times the circumference of the Earth.[6] Since large distances are often difficult to comprehend tangibly, consider a simple analogy. If the Earth were the size of a basketball placed directly under one hoop, the Moon would be the size of a tennis ball placed at the top of the 3-point line. In this comparison, the L4 and L5 Lagrange points would be just beyond the 3-point line, roughly in line with the free-throw line. The large volume of space where most satellites operate today, the geocentric regime, would only reach about two feet past the surface of the basketball-sized Earth.

The challenge of maintaining domain awareness in the much smaller geocentric regime is a fraction of what it will be for the cislunar regime simply based on its sheer volume. The large distances also reduce the effectiveness and utility of ground-based radars. In many cases, cislunar distances render current key space surveillance radars useless for monitoring the regime. We need to innovate an entirely new architecture, set of technologies, and models to depict motion in this region to empower situational awareness. These observations are essential to establishing and enforcing norms and standards.

Cislunar Terms of Reference



Gravity Well: The mass of the Earth can be thought of as warping space around it, in the same way a heavy ball placed on a fabric surface creates an indentation. The resulting "gravity well" has a larger influence on objects closer to the center or "deeper" in the well. As an object moves further away, or "up the gravity well," the force exerted on it by the Earth's mass decreases.

2-Body and 3-Body Problems: For satellites orbiting the Earth in the geocentric regime, the forces influencing their path are well established. Known as a two-body problem, the major factors are the masses of the two bodies, in this case the Earth and satellite, and the distance between them. There are solved equations governing the motion of satellites in this regime. However, in the cislunar regime, the additional gravitational force of the Moon significantly complicates the equations of motion. Known as a three-body problem, the major factors are the masses of the three bodies, now Earth, the satellite, and the Moon, and the distances between the Earth and Moon, Earth and satellite, and Moon and satellite. There is no general solution for the trajectory of an object in a three-body problem.

In addition to the complications of the 3-body problem, there are other factors of the cislunar terrain that make operations and domain awareness truly daunting and the existing Space Surveillance Network (SSN) inadequate. While there are multiple challenges, a select few are especially important to highlight to frame an understanding of the complexity of and impact on future activities in this region. First, the Earth, Moon, and Sun are not on a flat plane like a basketball court. The Moon's orbit around the Earth is slightly inclined, and the Earth's axis is tilted, which adds a third dimension as a planning factor in cislunar domain awareness and operations.

Second, as the Moon rotates around the Earth, it periodically passes between the Earth and Sun—what we know as a New Moon. The light and energy from the Sun create an exclusion zone where Earth-based and Earth-orbiting sensors cannot perform collection of objects near the Moon due to the intense light and energy coming from the Sun. Conversely, during a Full Moon, the reflective brightness of the Moon will obscure optical observations of much dimmer spacecraft.

Third, the pressure from solar wind also impacts the trajectory of some of the objects in the cislunar regime. Known as High Area-to-Mass Ratio (HAMR) objects, their paths are not solely determined by the gravitational pull from the Earth and Moon but also by the pressure from solar wind.

Finally, the existing military space domain awareness orbit determination system is built around an Earth-centered model focusing on objects in geosynchronous orbit and below. Since objects in the cislunar regime are on trajectories influenced by the Earth and Moon, their paths are not consistent with the existing orbital determination models. In fact, the techniques used to track objects in the cislunar regime are closer to astronomy conducted by organizations like NASA than traditional domain awareness of objects following a predictable orbit conducted by the military in the geocentric regime.[7]

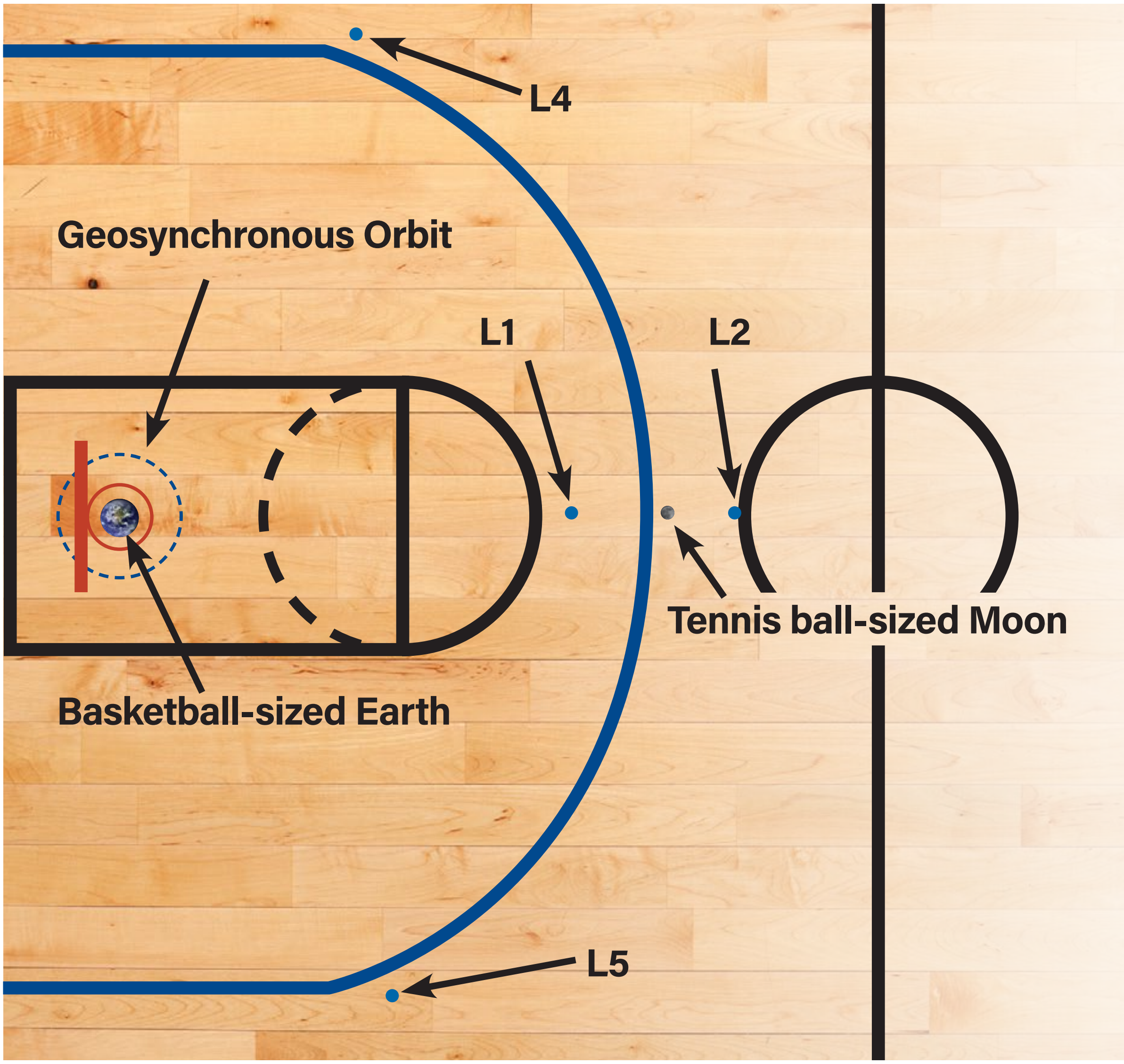


Figure 2: Cislunar regime on a basketball-sized Earth scale. The actual average distance between the Earth and Moon is 238,900 miles. Lagrange points L4 and L5 are approximately 413,800 miles apart. L3 (not shown) would be on the opposite side of the Earth from the Moon.

Source: Dashton Parham and Charles Galbreath/Air & Space Forces Magazine and Mitchell Institute

The challenges do not end at a moon landing because the lunar surface also has unique aspects that complicate all future activities. For example, the extremely thin atmosphere of the Moon is only about one 25-trillionth the density of Earth's, causing three key challenges to future operations.[8] First, the thin atmosphere does not block or absorb radiation. Earth's atmosphere and magnetic field protect us and our equipment from solar and cosmic radiation, but on the Moon, there is no protective barrier.[9] This means activities on the Moon's surface must take active steps to shield personnel and equipment from harmful radiation.

Second is regolith—lunar dust—formed from billions of years of meteor impacts and interaction with charged plasma from the Sun. Unworn by atmospheric or water erosion, regolith consists of fine, jagged, electrostatically charged silica particles that cover the entire surface of the Moon. These particles stuck to spacesuits and equipment during the Apollo program, causing electric, mechanical, and even respiratory issues.[10] As future missions land on and launch from the lunar surface, the possibility of spreading regolith hundreds of miles in the weak gravity and very thin atmosphere of the Moon and contaminating scientific instruments and experiments—or even causing damage to economic or historical sites such as the Apollo landing locations—becomes a very real possibility.[11]

A third major challenge involves extreme temperature fluctuation. Moving from a two-week lunar day to a two-week lunar night can see temperatures change from 250° to -208°. Additionally, in deep craters at the Moon's poles, NASA has recorded temperatures lower than -410°.[12] These temperature ranges can have a significant impact on the lifespan of equipment. The extreme cold can make materials brittle, while the significant change in temperature can cause materials to expand and contract, potentially wearing out connections. The expansion and contraction effect can also generate low-level seismic activity on the Moon's surface, as has been observed originating from equipment like the Apollo 17 lander.[13]

The challenges of the cislunar regime associated with size, complex astrodynamics, solar wind, regolith, and extreme temperatures drive the necessity of working collaboratively, leveraging innovation, and applying steadfast determination to conquer its harsh operational conditions. By applying the best insights from civil, commercial, military, and international partners, the United States can accelerate past China and Russia in the race to the Moon and retain its position in the current world order.

Why Race to the Moon?

"We choose to go to the moon in this decade and do the other things not because they are easy, but because they are hard. *Because that goal will serve to organize and measure the best of our energies and skills*, because that challenge is one that we're willing to accept."

-President John F. Kennedy[71]

For this new space race, the stakes are more than just the prestige of coming in first. It comes down to foundational norms in a new frontier whose implications will have major security, diplomatic, and economic impacts. What nations choose to partner with the United States and those who choose to partner with China hangs in the balance. This will impact not only the race to the Moon but also scientific and economic activities that tie to interests on Earth. The relative success in the race to the Moon could validate or invalidate the underlying political and socioeconomic systems of the United States and China on a global scale, with freedom, transparency, and democracy on one side and authoritarian, state-controlled secrecy on the other.[14] The results of this race also have increasingly pragmatic implications for norms, emerging national interests, and funding.

There are currently few international agreements regarding operations on the Moon or in the cislunar regime. Ongoing discussions in the United Nations Committee On Peaceful Uses of Outer Space (COPUOS) have highlighted a wide range of opinions about the governance of outer space resources but have yet to establish new guidance.[15] This largely means that the first nation or entity to establish lunar operations will also establish a behavioral and legal precedent for the future. The prospect of exploiting this ambiguity is well-suited for China. One only needs to consider their activities in the international waters of the Pacific Ocean to understand what could be at risk.

There are both specific and broad national security interests in the Moon and the cislunar regime. While the Moon's distance to Earth precludes projecting a direct and meaningful military effect on or observation of terrestrial operations, the cislunar environment does offer a means to conduct military operations impacting the space systems and services indispensable to terrestrial operations. It is also possible to leverage the Moon's gravity to maneuver weapons to attack satellites in geosynchronous orbit and below.[16] They could also use the advantageous cislunar "view" to plan, conduct, monitor, and assess the effects of their offensive counterspace operations. While such possibilities might seem farfetched, they are well within the reach of a nation that dedicates sufficient time, talent, and resources to cislunar operations. In many ways, it is comparable to the dawn of early combat aviation in that early operations are highly aspirational but will likely progress to eventually yield very real, fundamentally impactful outcomes that reshape modern warfare.

The scientific national interests in the Moon are also diverse. From understanding the formation of the solar system to human health, the cislunar environment offers an extensive set of scientific opportunities. Some of these opportunities are tied to specific regions on the lunar surface and surrounding space. Maintaining access to and preserving these locations will be increasingly vital national objectives. Consider the far side of the Moon, known as the shielded zone of the Moon (SZM), which offers a region blocked from Earth's radio frequency interference and is, therefore, ideally suited for radio astronomy.[17] Another example of scientific interest is craters, particularly at the South Pole of the Moon, that have never seen sunlight and, as a result, could possess a billion years' worth of history about the formation of the solar system trapped in the rock and ice.[18] This lunar ice could also hold the key for humanity's expansion into the solar system by being a source of oxygen and hydrogen needed to sustain life and propel rockets–which could become a pillar of a future lunar economic ecosystem.[19]

Economic factors also matter. The ability to harvest natural resources from the Moon is one of many proposed business ventures possible in a lunar economy. Beyond the oxygen and hydrogen contained in lunar ice, there are also deposits of Helium-3 and rare-earth minerals (REMs). Helium-3, for example, is more plentiful on the Moon than on Earth and can be a source of rocket fuel or fusion electric power generation.[20] REMs and other elements such as platinum and lithium are also more plentiful on the Moon. The potential to collect these materials from the Moon and return them to Earth in sufficient quantity to generate a profit is currently dubious.[21] However, these elements will be essential components of spacecraft that could be constructed in space and become the enablers of a future lunar economy.

Other economic prospects include creating secure data storage and edge processing.[22] Any examination of specific business cases for a lunar economy today will likely be incomplete because there are possibilities and applications that require further development. They may not even be fully understood or even envisioned. Consider how the internet and smartphones have unlocked whole new markets inconceivable before their creation. Cislunar space will likely follow a similar path.[23] Their eventual realization, even if it takes years and decades, will depend on access, precedents, and infrastructure whose establishment begins today.

At the most pragmatic level, securing funding for space activities in the cislunar regime and beyond depends on winning this current competition and achieving the multiple benefits promised by cislunar exploration and development. Government funding and private investment should support the public good or result in a positive return. This is particularly prescient for military activities. Therefore, achieving U.S. objectives in the cislunar regime is essential to establishing a precedent for future military funding further into space to secure the growing and emerging interests of the future.

Rare Earth Minerals

There are seventeen metallic elements that, due to their scarcity or the difficulty in collecting them, are classified as rare-earth minerals (REM). These materials are necessary components to over 200 high-tech products, from smartphones to components of the F-35 and nuclear submarines. In 2022, China accounted for 63 percent of the world's rare-earth mining, 85 percent of rare-earth processing, and 92 percent of rare-earth magnetic production. The Moon could be a new source for these REMs because in some cases REMs are more plentiful on the Moon than on Earth.

Source: Stephen L. Gillett, **"The Value of the Moon,"** *L5 News*, August 1983; and Lara Seligman, **"China Dominates the Rare Earths Market. This U.S. Mine Is Trying to Change That,"** *Politico Magazine*, December 14, 2022.

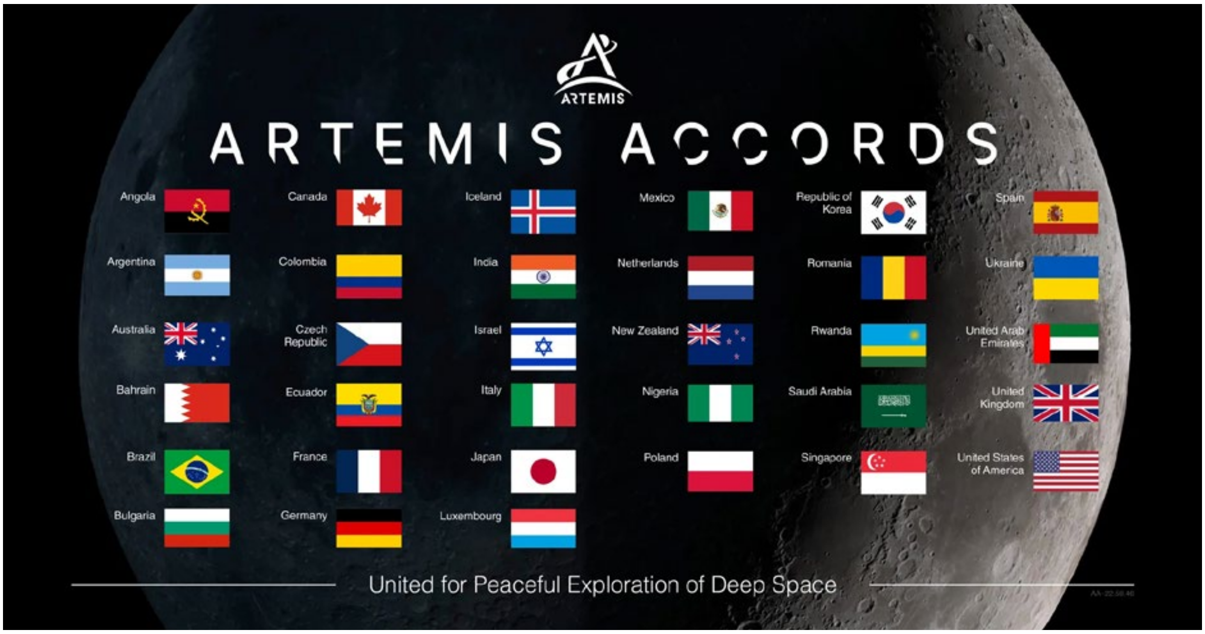


Figure 3: A growing list of countries who have signed the Artemis Accords. Some nations, like India, have extensive space programs of their own. While others, like Ukraine, are not yet independent spacefaring nations.

Source: **NASA**

Sides Are Forming

In a multi-polar world, with a growing list of spacefaring nations and competing national interests on the line, partnering to overcome cislunar operational challenges and win the new race to the Moon is essential. Unlike the first race to the Moon between the United States and the Soviet Union, this new race involves dozens of countries in a dynamic arrangement of geopolitical tensions and technical capabilities. The United States, China, Russia, India, and others are actively conducting robotic missions to the Moon, with some planning a permanent human presence. There are currently 106 planned missions to cislunar space this decade, representing the efforts of nineteen countries and the European Space Agency.[24]

Amidst these various activities, there are now two main teams involved in the current race to the Moon. On one side is the United States and an extensive group of aligned nations who have signed the Artemis Accords. This agreement reaffirms the peaceful intentions of space exploration and contains provisions on transparency, interoperability, emergency assistance, registration of objects, sharing scientific data, preservation of space heritage, extraction and use of space resources, deconfliction of activities, and debris mitigation. These aligned countries enjoy advanced space programs, like India. They are also joined by non-space-faring nations who support the peaceful and transparent approach outlined in the accords.

On the other side of this equation, China and Russia are partnering in the International Lunar Research Station (ILRS). Additional members include Venezuela, Iran, the United Arab Emirates (UAE), and the nations of the Asia-Pacific Space Cooperations Organization (APSCO).[25] Plans call for the ILRS to consist of a facility near the South Pole of the lunar surface and a station in cislunar space used to aid communication and transportation to the lunar facility.[26]

Russia's invasion of Ukraine and resulting sanctions have adversely impacted potential ILRS partnership opportunities. For example, the European Space Agency, a key partner for Russia in its desire to return to the Moon, ceased cooperation after the invasion.[27] In an attempt to prove its relevance and prowess, Russia continued down the path of initiating three more lunar missions, Luna-25, 26, and 27, independently. In 2023, for the first time since 1976, Russia launched a lunar landing mission, placing it in direct competition with India.[28]

During August 2023, both Russia and India vied to be the first to land missions near the Moon's South Pole in what can be characterized as a cislunar tortoise and the hare. India launched Chandrayaan 3 on July 14, 2023. Taking a slow and fuel-efficient path, it entered lunar orbit on August 5. It then spent nearly three weeks surveying for an ideal landing location. Russia launched Luna-25 on August 11, 2023, and entered lunar orbit five days later.[29] Russia's plans to beat India by completing a soft landing on August 21 were cut short when a thruster malfunction caused the destruction of Luna-25 on August 19.[30] On August 23, 2023, India successfully landed Chandrayaan 3, becoming only the fourth nation to safely land on the Moon and the first to land near its south pole.[31]

This is a prime example of how terrestrial geopolitics and space activities are intertwined. Once partners in military and scientific endeavors, India-Russia relations are now strained. Drivers include Russia's increasing partnerships with China, ongoing disputes between India and China, and the Russian invasion of Ukraine. These, along with India's growing desire to expand commercial markets and scientific cooperation, led India to sign the Artemis Accords.[32]

The success of India's lunar landing and the failure of Russia's effort offer two key lessons. First, India's success highlights the key tenet of partnership that underscores multiple provisions of the Artemis Accords. The ability to share both scientific data and lessons learned among partner nations will eliminate the need for each to start from scratch, wasting valuable time and resources. Second, Russia's failure should serve as a reminder of the complexity of cislunar operations and that past performance is not a guarantee of future success. It also serves as a reminder to Congress and others about the need for consistent funding, the imperative for continuous collaborative relationship cultivation, and the need to constantly steward a U.S.-led coalition to outpace Russian and Chinese efforts in the cislunar regime.

"The universe is an ocean, the moon is the Diaoyu Islands, Mars is Huangyan Island. If we don't go there now even though we're capable of doing so, then we will be blamed by our descendants. If others go there, then they will take over, and you won't be able to go even if you want to. This is reason enough."

-Ye Peijian, Lead for the Chinese Lunar Exploration Program, 2015

The Key Threat: China's Approach

Based on expert analysis of PLA programs and doctrine, it is clear that China seeks to be the preeminent global power in space and sees overtaking the United States and "establishing a commanding position in cislunar space" as vital steps toward that objective.[33] China, for its part, claims the United States is misrepresenting its peaceful objectives in space.[34] However, the head of China's lunar exploration program's direct comparison of the Moon to the disputed islands in the Western Pacific heralds a confrontational intent. Their aggressive actions in the Pacific have clear implications for cislunar space, with China viewing national power in terms of territorial control.[35] China has repeatedly signed bilateral agreements regarding disputed territories in the Western Pacific but subsequently engaged in behavior contrary to those agreements in an effort to control more territory.[36] Since the PLA controls China's space program, it is fair to assume these patterns will continue in space.[37]

If China were to establish an infrastructure on the Moon, they could use it as justification to limit other nations' communications or other activities near it.[38] For example, China could establish a "scientific" station in an area rich in lunar ice and require a keep-out zone to not interfere with their scientific research, thus effectively commandeering that region and the resources in it for their use while denying access to other nations.[39] It is worth noting that China is the only country to land on the far side of the Moon, and it intends a sample return mission from there in 2024.[40] If China expands itsinfrastructure on the far side of the Moon, it may adversely impact the SZM and future radio astronomy efforts in that region. From that vantage, they could also conduct offensive operations against U.S. and partner space capabilities in the Earth's orbit.

Figure 4: Screen capture of close approach by Chinese fighter in international airspace indicative of the increasingly aggressive and coercive behavior by China in the Western Pacific over the past 2 years.

Source: Still from Department of Defense video, availalbe via **CNN**

Why the Military is Integral in the Return to the Moon

"Secure our Nation's interests in, from, and to space"

-USSF Mission Statment[72]

As the United States and its allies pursue increased lunar and cislunar activities in the face of stiff competition, statutes and precedents exist for integrating military capabilities as a means to advance civil and commercial ventures. The 2019 National Defense Authorization Act, which established the Space Force, directed the service with the responsibility to "protect the interests of the United States in space." This is reinforced by the newly released Space Force mission statement, "Secure our Nation's interests in, from, and to space."[41] Therefore, where the United States goes in space, the Space Force and U.S. Space Command will need to go. To accomplish this mission, the Space Force must organize, train, and equip forces for U.S. Space Command to employ in monitoring activities, tracking natural and adversary threats, and responding appropriately. The same capabilities needed for this mandate will also follow the long history of military efforts that opened new frontiers and opportunities.

Historically, from the founding of the United States to the modern space age, military efforts paved the way for civil and commercial opportunities. Under the direction of President Thomas Jefferson, U.S. Army Captain Lewis and Lieutenant Clark led the expedition, blazing a trail for the western expansion.[42] The construction of the interstate highway system, championed by President Dwight D. Eisenhower, was in part to provide a means to support national defense requirements during the Cold War.[43] The modern information highway of the internet started as a defense project in what is today DARPA.[44] The space age itself became a reality thanks in part to the efforts of General Bernard Schriever and his work to develop ballistic missiles and infrastructure that became early rockets and launch range capabilities for NASA.[45] This tradition continued with the development of the Global Positioning System (GPS) constellation, providing position, navigation, and timing signals not just for the military but for users all over the world.[46] In all of these cases, military involvement accelerated progress and opened new opportunities for subsequent scientific and economic ventures. It is reasonable to pursue a similar course for the Moon and in the cislunar region.

Maintaining free and peaceful standards in space follows similar existing terrestrial protocols. Today, DOD and especially the U.S. Navy continue to conduct regular Freedom of Navigation Operations (FONOPs) on the surface of the Earth. Per DOD's most recent FONOPs report, "Upholding freedom of navigation as a principle supports unimpeded lawful commerce and the global mobility of U.S. forces. … The United States will uphold the rights, freedoms, and lawful uses of the sea for the benefit of all nations—and will stand with like-minded partners doing the same."[47] Clear parallels exist for DOD's objectives in the cislunar regime.

The role of the military in the cislunar regime will be an extension of the current Space Force and U.S. Space Command missions performed in geosynchronous and lower orbits. In fact, the Space Force's newly designated 19th Space Defense Squadron (19 SDS) is already maintaining an initial level of awareness beyond geosynchronous orbit and into the cislunar regime.[48] The military-provided space domain awareness that is critical to spaceflight safety around Earth will be essential as activity in the cislunar regime increases. Similarly, the aids to navigation and timing currently coming from GPS can be established near the Moon to provide astronauts and robotic missions with a common reference for safer cislunar travel. Satellite communication remains another foundational mission of the military, and a robust communication architecture will be required to transmit scientific data, direct robotic missions, and connect people on Earth with people on the Moon.

In collaboration with NASA, the DOD is taking a few first steps to explore infrastructure opportunities beyond the nascent domain awareness operations currently executed by the 19 SDS. DARPA has kicked off a study examining infrastructure efforts needed in the next ten years to facilitate scientific and economic activities in the cislunar regime. DARPA's LunA-10 study explores 12 key areas necessary to sustain a growing cislunar ecosystem, including construction, mining, transit, energy, communication, and navigation.[49] LunA-10 is the second major cislunar effort coming out of DARPA. The first is the Demonstration Rocket for Agile Cislunar Operations (DRACO), which examines the viability of a nuclear thermal rocket for lunar transportation.[50] Outside of DARPA, the Air Force Research Laboratory's Oracle mission plans to field a space domain awareness spacecraft in the cislunar regime.[51] These are early steps in what must become a larger and more robust enterprise.

A Way Forward for the Military in the Cislunar Regime

"If we've done anything wrong to date ... with regard to sustainability and partnerships, we have the chance to do it right in cislunar. Let's do it right."

-Lt Gen John E. Shaw, Secure World Foundation, NY

The time for USSF to initiate its foray into the cislunar regime is now. Otherwise, the United States will cede the initiative to the Russian and Chinese coalition, requiring much larger and costlier actions later—or potentially leading to a point when even a massive investment cannot fully breach the lead established by adversaries, reverse effects that limit or prohibit others' ability to freely operate within the regime, or undo the precedents they've set.

Before examining specific lines of effort for DOD support in the cislunar regime, it is important to consider elements of relative cost, prioritization, timelines, and limitations on military activities on the Moon. Collectively, these factors will shape the manner and extent of future military support in the cislunar regime.

Cislunar activities are a new mission for the Space Force and Space Command. Successful implementation of a strategy will demand additive resources. Otherwise, cislunar activities risk being an unfunded mandate. Additionally, establishing arbitrary caps on spending will limit the ability to respond rapidly to emerging challenges and could result in tipping the scales in this critical race. Congress increasing the USSF annual budget of ~$30B by an average of $250M each year for the next five years, as a start, would help establish the cislunar infrastructure critical to the race to the Moon in this decade and for decades to come.[52] This initial investment will accelerate the delivery of needed capabilities with sufficient scale and effectiveness to support civil and commercial activities. It will also establish the necessary military means to secure those activities.

Determining priorities in a resource-constrained environment is never easy. Often, the challenges or opportunities arriving soonest garner more attention and resources than those focused on the future. Given the scale of the challenges facing the Space Force and Space Command, this approach is understandable as the notion of space as a contested domain drives a broad range of demands, all of which must be answered rapidly. Certainly, preparing for the "fight tonight" must be the highest priority. However, investing in tomorrow's requirements is also essential to preclude future challenges while they are still manageable. It is about deterring and preventing the fight tomorrow altogether. As Benjamin Franklin put it, "An ounce of prevention is worth a pound of cure." In a similar fashion, Congress must recognize the military role in the cislunar regime as a new, emerging responsibility of the DOD that requires additional funding and support. Just as securing the space domain closer to Earth requires additional resources, the return to the Moon will also require fiscal investment to secure growing interests there.

Initial Space Force and Space Command small investments and efforts made today will create options and opportunities for future decision-makers. Capabilities will not be readily available at a time of immediate need without this downpayment, and time ceded can never be regained. Nor is technology in a vacuum helpful. Effective, prudent use requires a strategy and concepts of operation. Otherwise, efforts risk suboptimization. Given that the United States is competing with adversaries in this domain, failure to act now will result in a capability gap. The initial efforts of AFRL and DARPA are excellent starts, but more needs to be done. This demands additive funding.

Importantly, the DOD's developmental and operational efforts in the cislunar regime will play a supporting yet defining role in the overall set of civil, international, and commercial activities consistent with the Artemis Accords. The mantra of "partnership" is resounding across all sectors of U.S. Space Command and the USSF. This will continue in the cislunar regime. What is different in the cislunar regime is the DOD in a supporting, versus leadership, role typical of today's contested geocentric space regime. While there may be a few efforts, such as domain awareness, where the DOD will lead the development, fielding, and operations of capabilities, the majority of its actions in the cislunar regime will be supporting and gently influencing civil, international, and commercial activities focusing on scientific and economic development to ensure the security of all activities.

Furthermore, there are both legal and philosophical limits to the potential military roles in the cislunar regime. Article IV of the Outer Space Treaty of 1967 states the Moon and other celestial bodies are to be used for peaceful purposes and prohibits the establishment of military bases, installations, and fortifications; the testing of any type of weapon; and the conduct of military maneuvers on the Moon.[53] These restrictions do not preclude military members from transiting to the Moon, as evidenced by the fact that nine of twelve Apollo astronauts who walked on the Moon were active duty military assigned to NASA—and a tenth was in the reserves.[54] However, the prohibition against weapons testing and establishing military bases underpins the accepted ideal of keeping the Moon free of armed conflict and must be upheld.

This does not mean the military is powerless, as there are options short of the use of force the military can take to secure our nation's cislunar interests. For example, through the observation of activities, enabled by cislunar domain awareness capabilities provided by the USSF, U.S. Space Command could identify natural hazards and attribute irresponsible or threatening behavior. Responsible nations can then employ the full range of national power means to respond responsibly to unwanted behavior and impose a cost on nations violating norms. Additionally, the military can be instrumental in developing technologies and establishing practices for safe, responsible operations, thus securing interests for scientific and economic development.

What follows is a guide path to establishing the military support to create the conditions necessary for a peaceful and responsible race for the Moon. These proposals begin with the call for a strategy and then focus on increasingly granular details in specific research areas needed to field key infrastructure elements. Each capability area leverages existing military specialties and will likely be necessary to support future military missions in cislunar space. With minimal DOD initial investment in the near term, the suggested initiatives seek to simultaneously accelerate U.S. and partner civil and commercial endeavors and establish the foundation for the USSF and U.S. Space Command to secure growing national interests in the cislunar regime.

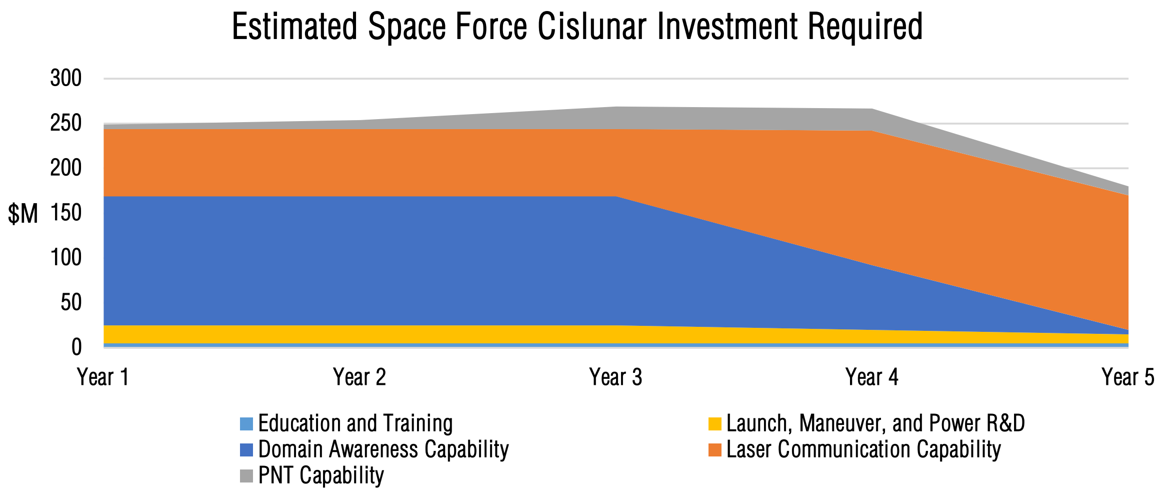


Figure 5: Mitchell Institute ROM estimate of required additive growth the Space Force budget necessary to accelerate and secure civil and commercial activities.

Source: Charles Galbreath/Mitchell Institute

Develop a DOD Cislunar Strategy

Consistent with the existing *National Cislunar Science & Technology Strategy*[55] and the recently released *Space Policy Review and Strategy on Protection of Satellites*,[56] the DOD needs to establish a cislunar strategy to direct and align its efforts. A DOD cislunar strategy, or theory of success, is essential to define the military's role and its relationship to civil and commercial objectives in the cislunar regime.[57] Unlike the *National Cislunar Science & Technology Strategy*, which focuses on science, technology, and exploration, a DOD cislunar strategy would focus on unique military objectives to promote a safe and stable environment as the primary goals, which have secondary benefits to enable or accelerate civil and commercial objectives. Building off the current USSF mission statement, the objective could be as broad as "secure our Nation's interests in, from, and to the cislunar regime." While this may seem a trivial nuance of the USSF mission, the broader DOD application paired with the specificity of cislunar makes such a statement impactful. Advancing from a general vision, the DOD should also detail specific military objectives it intends to achieve. This may include goals like assuring safe operations at Lagrange points or unfettered access to the lunar surface. Furthermore, a DOD strategy should detail how the military will achieve its stated objectives and articulate the roles and relationships of AFRL, DARPA, USSF, and U.S. Space Command in the race to the Moon. Examples could include the USSF fielding a level of space domain awareness necessary for U.S. Space Command to assure astronaut safety or the USSF fielding secure, high-bandwidth communications necessary for NASA's scientific missions. Congress requires this strategy in order to effectively vector resource investment, policy guidance, and oversight efforts. Similarly, the defense industry needs this direction to know where to invest its efforts. Finally, it also signals to our partners what elements of an integrated architecture they can expect the DOD to contribute.

Develop Guardians with Cislunar Expertise

A properly trained and educated workforce is critical to every DOD mission, but it is especially true for a team that will need to overcome the highly technical and complex challenges of securing the cislunar regime. The USSF must develop a cadre of Guardians steeped in the math, science, and expertise required for this mission. This should start with a familiarization of "cislunar basics" for all Guardians, move to an expanded training regimen for a group of Guardians "minoring" in cislunar, and conclude with a small set of Guardians with a deep understanding or "majoring" in cislunar. The Space Force is not starting from a blank slate, thanks to the Air Force Research Lab's *A Primer on Cislunar Space*.[58] Further leveraging NASA and other astronomical support and training materials, the USSF can tap into an array of existing training pipelines. Cislunar-focused Guardians should be equipped with the information and skills necessary to conduct cislunar domain awareness, planning, and strategy development for future operations. It is also important for them to serve as an integral liaison to ongoing civil and commercial efforts. Space Force end strength will need to increase by about 200 personnel over the next five years to develop this cadre. This cadre will facilitate the rapid transition of capabilities from research to operations. These personnel are in four roughly equal lines of effort: supporting ongoing R&D efforts, acquiring and fielding capabilities, conducting operations, and training and staff assignments. The Space Force will need to regularly evaluate personnel requirements to adjust to evolving mission needs and capabilities.

Develop Cislunar Doctrine, CONOPS, and Requirements

With a strategy and trained cadre of cislunar Guardians in place, the DOD must develop new or modify existing doctrine, concepts of operations (CONOPS), and requirements to address the unique challenges of the cislunar regime. Like the DOD cislunar strategy, new or updated doctrine, CONOPS, and requirements will include direct support to civil and commercial activities along with unique military requirements. For example, a current U.S. Space Command requirement to detect, track, and identify objects in the cislunar regime could expand to include the ability to characterize an object's mission type and rapidly determine whether it poses a threat—and if so, how best to nullify that threat through diplomatic, economic, informational, or military means.[59] Additionally, new requirements for precision navigation, maneuverability, and communication data rates will also be necessary to establish the needed cislunar infrastructure. CONOPS for achieving domain awareness or the exchange of information among military, civil, and commercial entities will advance transparency and cooperation. Within this scope of doctrine, CONOPS, and requirements, U.S. Space Command can identify and attribute potentially harmful or threatening behavior as a means to promote stability and preserve interests.

Develop Technology for Mission Success

Parallel to earlier lines of effort, the DOD, and in particular the USSF, should expand ongoing investments in research and development to enable future cislunar operations. To date, DARPA and AFRL have made the most notable DOD investments in this area. Early USSF participation in these efforts and additional attention from the USSF in the key areas of space domain awareness, high bandwidth communications, and cislunar navigation technologies—augmented by enabling R&D efforts in propulsion and maneuverability, power generation and distribution, and lunar surface launch and landing—will increase the probability of successful transition to operational capabilities. Given potential funding and personnel limitations, it may not be feasible for the USSF to pursue all these areas internally, but each of these research fields could leverage the unique military experience and expertise of Guardians to mature the necessary technologies.

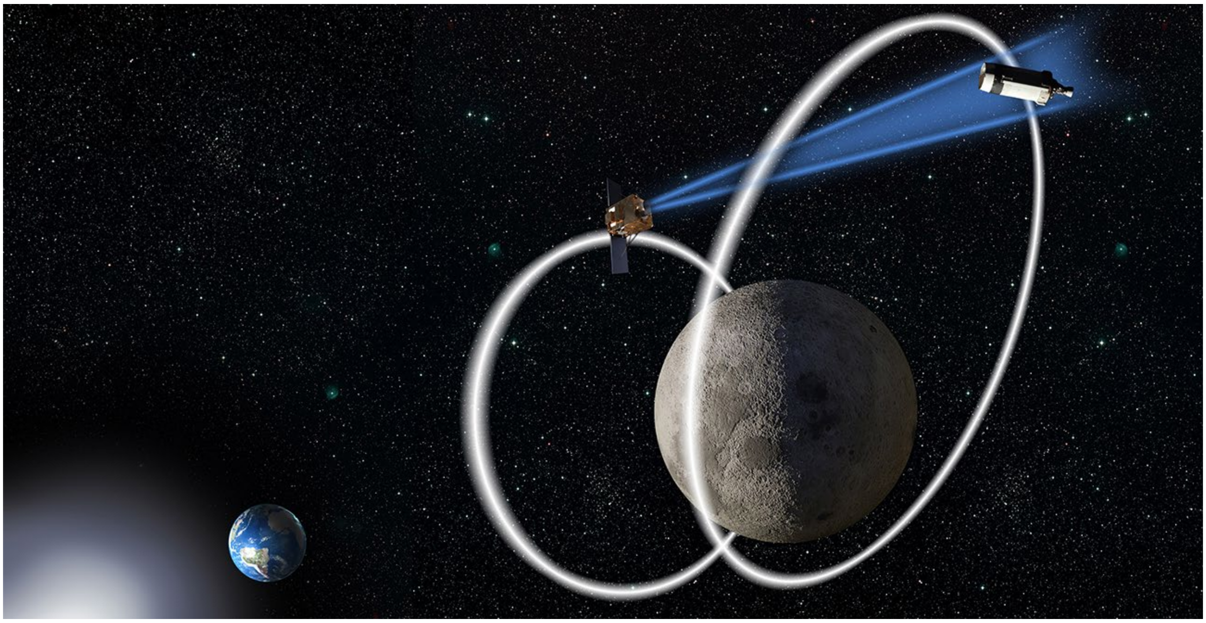


Figure 6: Depiction of Oracle spacecraft performing the domain awareness mission.

Source: AFRL

Cislunar domain awareness

As with any operational endeavor, domain awareness is one of the most critical foundational elements to empower a successful cislunar infrastructure. AFRL's Oracle program will be vital to monitoring the vast cislunar regime and its key areas of interest, such as Lagrange points and transfer orbits. Unfortunately, due to its complexity and funding challenges, AFRL recently announced a delay in the Oracle program from a 2025 to a 2027 launch.[60] This reduces domain awareness of the approximately 100 missions to the Moon in the next seven years and delays the establishment of a robust domain awareness infrastructure for the coming decades. This delay drives imprudent risk at a time when adversary actions in this realm call for enhanced situational awareness. The USSF should support this program and try to re-accelerate the launch. This will likely require additive investment by Congress, given existing USSF funding constraints.

Additionally, the USSF should explore the use of optical and radio frequency (RF) sensors either hosted on upcoming missions or as stand-alone missions. The variations in lighting conditions and the need to preserve the shielded zone of the far side of the Moon will make these capabilities integral to the required domain awareness architecture.

U.S. Space Command and USSF should champion an international standard for the use of beacons and transponders aboard spacecraft and landers. This will further aid in the cislunar domain awareness mission and reduce the need for a purely "search and detect" methodology, making it easier to identify spacecraft and location in an open and transparent manner. An international standard will also have the added benefit that it can be developed to not interfere with radio astronomy or other scientific or commercial ventures. By leveraging optical and RF sensors, beacons, and transponders, as well as the integration of data from commercial and allied partners, U.S. Space Command can establish the requisite level of domain awareness to promote safe operation in and access to and from the cislunar regime.

High speed communication

High bandwidth communication that is assured and secure is major infrastructure challenge that DOD should tackle. Existing communication networks struggle to support the current mission load and will not be able to support the increased capacity required for Artemis Accords purposes.[61] Laser communication seems an ideal choice because it can be used for high-capacity data transfers and, in space, faces no atmospheric challenges like clouds.[62] That is not to say that establishing an interconnected laser communication backbone will be easy. The vast distances of the cislunar regime will require precise pointing accuracy to establish the links. The new network must also overcome challenges related to the relative positions and orientations of the Earth, Moon, and Sun, which will create eclipse periods and solar exclusions that necessitate multiple paths to assure uninterrupted communication. A series of relay satellites at Lagrange points, in lunar orbit, and in geosynchronous orbit will likely be necessary to meet the expected demand. A clear example of the viability of this approach is the recent achievement of a successful test message across a distance of nearly 10 million miles by the Deep Space Optical Communication (DSOC) payload aboard the Psyche spacecraft.[63]

Position, navigation, and timing

Assured position, navigation, and timing for the cislunar regime is another area requiring R&D and the establishment of standards. Leveraging its experience with GPS, the USSF is in an ideal position to lead and shape this area. Ongoing commercial, civil, and international efforts would benefit from the unifying voice of the USSF to establish a cislunar PNT standard. This will require reviewing existing and proposed methods as well as additional research to ensure operational requirements and interoperability among Artemis Accord partner nations meet actual needs.

Propulsion and maneuverability

Given the longer travel distances and challenges required to lift spacecraft higher out of Earth's gravity well into the cislunar regime, it will be necessary to field vehicles with considerable propulsion and maneuverability. Similar to the Navy's transition to nuclear-powered submarines and aircraft carriers, nuclear propulsion will likely be a critical enabler to empower future USSF cislunar operations. DARPA's DRACO is a good example of research into nuclear propulsion for cislunar. Because of the criticality of both rapid and efficient maneuver, an additional research effort into nuclear propulsion may be necessary to assure the delivery of viable nuclear propulsion options for future decision-makers. This will also reduce the risk of being tied to a single vendor or supply chain.

Power generation and distribution

In a similar vein to propulsion, power generation and distribution will be another critical enabler for future cislunar activities. The ability to provide uninterrupted power to scientific, economic, or life-sustaining equipment will be indispensable. The large temperature variations on the lunar surface challenge the thermal regulation of equipment, which complicates power generation and distribution. Options from solar to nuclear power are worth exploring. AFRL's Joint Emergent Technology Supplying On-orbit Nuclear Power (JETSON) is a good example of an ongoing effort to explore alternative spacecraft power generation.[64] The DOD must also consider other novel forms of power distribution. For example, the concept of beaming power to remote users will be instrumental in supporting a variety of cislunar missions. This could come from a solar or nuclear-powered spacecraft that could beam power to a rover operating in the two-week lunar night or from a lunar surface station to a spacecraft in orbit around the Moon.[65] The ongoing AFRL effort named Space Solar Power Incremental Demonstrations and Research (SSPIDR) could help achieve this approach for systems operating in the cislunar regime this decade.[66]

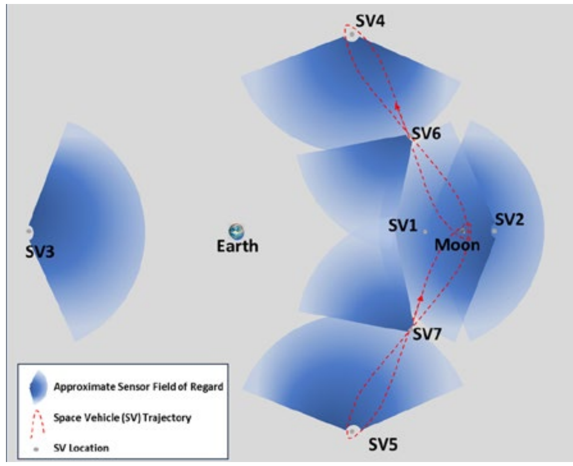


Figure 7: Notional depiction of cislunar domain awareness sensor locations and fields of regard.

Source: Charles Galbreath/Mitchell Institute

Lunar surface launch and landing

Finally, USSF and other DOD entities will need to deliver equipment, supplies, and astronauts to the lunar surface while limiting the spread of harmful regolith. Realizing these goals requires new and responsible methods to land on and launch from the Moon. Because of the extremely thin atmosphere, aerodynamic methods employing wings or parachutes are not possible. One potential option is the creation of launch and landing pads such that rocket thrust is not directed at loose surface rock and dust. Another possibility could employ a tether from the lunar surface as an elevator to move payloads down to and up from the Moon.[67] A third option, specific to launch, could be an electromagnetic rail system. Some previous and ongoing research into using electromagnetic force to propel projectiles has focused on high-velocity weapons.[68] However, because of the Moon's low gravity, a much slower system could be used as a transport from the lunar surface into space. Similar systems are already in use today on aircraft carriers and roller coasters.[69] On the Moon, a system could propel a payload to a predetermined altitude off the lunar surface so that once rocket motors or attitude thrusters engage, they will not dislodge regolith.[70]

Field Operational Capabilities

As technologies mature in the areas described above, the USSF must rapidly transition to the acquisition and fielding of operational capabilities to present to U.S. Space Command for employment and synchronization with civil and commercial efforts. It will be important for the government and industry to maintain the expertise and talent generated during R&D efforts, which will streamline this transition and prevent unnecessary stops and restarts due to workforce loss. A rapid decision on architecture and steady, consistent funding are required to realize this vision. For example, if Oracle or an Oracle-like system is intended to be a main element of the overall cislunar domain awareness architecture, it will likely require seven vehicles—one at each of the five Lagrange points and two transiting between L4 and L5 locations and the Moon. This type of architecture will provide a reasonable baseline to overcome the size and challenging observation geometries unique to the cislunar regime. Making a decision quickly and building it into the USSF planning, programming, and budgeting process early will increase the likelihood of fielding the capability before it becomes late-to-need to support upcoming civil and commercial missions.

As the Space Force fields operational capability to the cislunar regime, it must account for the unique challenges and realities of that region. The long distances and inability to de-orbit failing or retired spacecraft means the USSF will likely need to increase the design life of systems. The current trend of low-cost, short-lived satellites in proliferated Low Earth Orbit (pLEO) is not aligned with cislunar operations. This does not mean cislunar systems cannot take advantage of the rapid technology refresh rate expected with pLEO. By designing for modularity and serviceability, the USSF can enable subsystem replacement and upgrades necessary to meet increasing operational demands and emerging technologies. Further, the ability to service will reduce the potential for the creation of debris in the cislunar regime. As seen in Earth orbit, debris or "space junk" is becoming an increasingly challenging issue. Reducing the creation of this hazard is essential to preserve the cislunar environment for scientific, economic, and national security purposes. Early planning to adopt this mindset and objective is the only way to assure success.

By taking these modest first steps, the USSF will enable civil and commercial activities to focus on other unique challenges, thus accelerating the progress of peaceful nations in the race to the Moon. These same first steps will also establish the needed architecture for U.S. Space Command and USSF to secure the growing cislunar interests against natural hazards, irresponsible behavior, or even outright aggression.

Summary and Recommendations

The second race for the Moon involves dozens of countries, but clearly pits the values of the United States and its allies against the values of the authoritarian Chinese and Russian governments. At the center of the U.S. approach is the Artemis Accords—a multinational agreement fostering cooperation and transparency among nations. In stark contrast, China's comparison of the Moon to the Diaoyu Islands heralds territorial claims, weaponization, and regional access denial. Nations around the globe will evaluate the relative success of these two approaches, which will in turn impact terrestrial geopolitics and establish a precedent for humanity's expansion further into space. For these reasons, the United States and its partners must succeed and establish a more constructive precedent in cislunar space than that of a territorially controlled Chinese and Russian dominated regime.

The United States and its partners must succeed and establish a more constructive precedent in cislunar space than that of a territorially controlled Chinese and Russian dominated regime.

From the exquisite vantages of Lagrange points to natural resources and unique environmental conditions, the cislunar regime and the Moon possess significant scientific, economic, and security opportunities that must be shared peacefully among cooperative nations. At the same time, the vast distances, complex astrodynamics, extreme temperatures, and damaging dust create challenges that also require cooperation and partnership to overcome. More importantly, the prospects of ceding the advantage to an authoritarian and territorially minded Chinese and Russian program would create an even greater disadvantage—one increasingly difficult for the United States to overcome.

As the military has done multiple times throughout the history of the United States, it must now support the advancement of technologies and operations to enable exploration and human progress. In collaboration with NASA, the DOD can help establish an architecture that simultaneously accelerates civil and commercial progress and lays the foundations for the USSF and U.S. Space Command to secure growing national interests in the cislunar regime. Some of these activities will be an extension of existing missions and capabilities, while others will be new efforts to overcome the exceptional challenges of operations on and around the Moon.

Early additive investment by Congress to the Space Force is essential to develop the critical technologies, field the needed capabilities, and establish the desired norms of responsible behavior. Specifically, the following recommendations will appropriately posture the military and avert the need for massive, urgent expenditures to regain a lost advantage:

- **The DOD must develop a broad strategy** of how it can support scientific and economic expansion into the cislunar regime. This will identify and prioritize military objectives and describe how they will secure U.S. interests and support civil, commercial, and partner activities.

- **Congress must fund additive growth** of about $250M/year to the Space Force budget and increase its end strength by 200 personnel in the next five years for the new responsibilities associated with emerging national interests on the Moon.

- **The Space Force must develop a cadre of cislunar experts** ready to lead development and operations activities. This cadre will be equipped with the education and training to solve the complex challenges of operations in the cislunar regime.

- **U.S. Space Command and the Space Force must establish doctrine, CONOPS, and requirements** to foster the race to the Moon. This will align military efforts and provide a framework for future development and operations.

- **The Space Force must invest in cislunar research and development efforts**. Working with organizations like AFRL and DARPA, the Space Force will be able to accelerate R&D activities and streamline their transition to operations.

- **The Space Force must rapidly transition R&D activities into operational capabilities**. A sustained presence on the Moon will require established programs of record and operational capabilities to support continued civil, commercial, and military activities.

The success of a cooperative, transparent, and responsible approach to cislunar operations will result in a more stable and productive opportunity than the coercive and territorial approach consistent with Chinese and Russian activities here on Earth. But to achieve this, the U.S. military must be empowered via Congressional authorization and appropriations to support the ongoing race to the Moon. ✪

Endnotes

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