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The Future of Security in Space: A Thirty-Year US Strategy

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The Future of Security in Space: A Thirty-Year US Strategy

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General James E. Cartwright, USMC (Ret.)
Former Vice Chairman, Joint Chiefs of Staff; *Board Director,* Atlantic Council

General James Cartwright, USMC (Ret.) hails from Rockford, Illinois. He attended the University of Iowa and was commissioned as a second lieutenant in the US Marines in 1971. He was both a naval flight officer and naval aviator who flew the F-4 Phantom, OA-4 Skyhawk, and F/A-18 Hornet. In 1983, he was named Outstanding Carrier Aviator of the Year by the Association of Naval Aviation and went on to command Marine Aviation Logistics Squadron 12, Marine Fighter Attack Squadron 232, Marine Aircraft Group 31, and 1st Marine Aircraft Wing. He also served in a wide range of Marine and joint billets, including assistant program manager for engineering, F/A-18 Naval Air Systems Command; deputy, aviation plans, policy, and budgets, Headquarters, US Marine Corps; and director, force structure, resources, and assessment, J-8, Joint Staff.

General Cartwright graduated with distinction from the Air Command and Staff College, received a master's in national security and strategic studies from the Naval War College, completed a fellowship with the Massachusetts Institute of Technology (MIT), and was honored with a Naval War College Distinguished Graduate Leadership Award. Unique among Marines, General Cartwright served as commander, US Strategic Command, before being nominated and appointed as the eighth vice chairman of the Joint Chiefs of Staff, the nation's second-highest military officer. During his four-year tenure as vice chairman across two presidential administrations and constant military operations against diverse and evolving enemies, General Cartwright became widely recognized for his technical acumen, vision of future national security concepts, and keen ability to integrate systems, organizations, and people in ways that encourage creativity and spark innovation in the areas of strategic deterrence, nuclear proliferation, missile defense, cybersecurity, and adaptive acquisition processes.

General Cartwright is also an adviser for several corporate entities involved in global management consulting; technology services and program solutions; predictive and big-data analytics; and advanced systems engineering, integration, and decision-support services. He serves as an adviser to Beyond

Aerospace, Enlightenment Capital, IxReveal, HSH Analytics, ForcePoint, and the Potomac Institute. In addition, he was a member of SpaceX National Security Space Strategic Advisory Committee, as well as a consultant for AT&T Government Solutions and Logos Technologies. General Cartwright is also affiliated with a number of professional organizations to include the Aspen Strategy Group, Council on Foreign Relations, Global Zero, and Nuclear Threat Initiative.

Secretary Deborah Lee James

Former Secretary, US Department of the Air Force; *Board Director*, Atlantic Council

Deborah Lee James served as the twenty-third secretary of the Air Force and was responsible for the affairs of the Department of the Air Force, including the organizing, training, equipping, and providing for the welfare of its nearly 660,000 active-duty, National Guard, reserve, and civilian airmen and their families. She also oversaw the Air Force's annual budget of more than $139 billion.

Secretary James has thirty years of senior homeland and national security experience in the federal government and the private sector. Prior to her Air Force position, James served as president of Science Applications International Corporation's Technical and Engineering Sector, where she was responsible for 8,700 employees and more than $2 billion in revenue.

For nearly a decade, James held a variety of positions with SAIC, including senior vice president and director of homeland security. From 2000 to 2001, she was executive vice president and chief operating officer at Business Executives for National Security, and from 1998 to 2000 she was vice president of international operations and marketing at United Technologies. During the Bill Clinton administration, from 1993 to 1998, James served in the Pentagon as the assistant secretary of defense for reserve affairs. In that position, she was the Secretary of Defense's senior advisor on all matters pertaining to the 1.8 million National Guard and Reserve personnel worldwide. In addition to working extensively with Congress, state governors, the business community, military associations, and international officials on National Guard and Reserve component issues, she oversaw a $10-billion budget and supervised a one-hundred-plus-person staff. Prior to her Senate confirmation in 1993, she served as an assistant to the assistant secretary of defense for legislative affairs.

From 1983 to 1993, she worked as a professional staff member on the House Armed Services Committee, where she served as a senior advisor to the Military Personnel and Compensation Subcommittee, the NATO Burden Sharing Panel, and the Chairman's Member Services team.

Secretary James earned a bachelor of arts degree in comparative area studies from Duke University and a master's degree in international affairs from Columbia University School of International and Public Affairs.

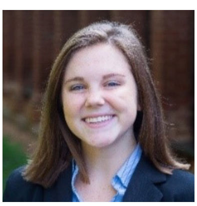
Lead Authors

Clementine G. Starling is the deputy director of *Forward* Defense and resident fellow of the Transatlantic Security Initiative at the Atlantic Council. In her role, she oversees the Initiative's programming and research, and leads on the defense policy and European security practice areas. Her own research focuses on great-power competition with China and Russia, deterrence and US force posture, and transatlantic security. During her time at the Council, Starling has produced and contributed to reports on Russia's nuclear strategy, military mobility, political warfare, Europe-China relations, and the US-UK relationship. Starling's analysis has been featured in a range of publications, and she has provided commentary for National Public Radio, the BBC, and ABC News, among others. Within the Transatlantic Security team, she played a leading role in managing NATO's official public-diplomacy efforts ("NATO Engages") around the Alliance's 2019 London Leaders' Meeting and other summits. Starling was the 2020 Security and Defense fellow at Young Professionals in Foreign Policy (YPFP). Prior to joining the Atlantic Council, Starling worked in the UK Parliament with the House of Commons Defence Select Committee, providing analysis on UK defense, Middle East security, and technology. Originally from the United Kingdom, she also worked for the Britain Stronger in Europe (BREMAIN) campaign. She graduated with honors from the London School of Economics with a bachelor's of science in international relations and history.

Mark J. Massa is an assistant director in *Forward* Defense (*F*D) within the Scowcroft Center for Strategy and Security at the Atlantic Council. Massa contributes to *F*D research on nuclear security and arms control, the Future of DHS Project, the Commanders Series, and other endeavors. Having supported the launch of *Forward* Defense as the Scowcroft Center's newest practice area, he continues to carry out program administration in strategy, budgeting, business development, and event planning. He is a second-year master's student in the Security Studies Program at the Georgetown University School of Foreign Service. His research focuses on nuclear weapons, space security, homeland security, and the Arctic. Massa graduated magna cum laude from Georgetown University with a degree in science, technology, and international affairs. He was awarded honors in his major for a senior thesis on a theory of nuclear ballistic-missile submarine strategy. He was elected to several honors societies, including Phi Beta Kappa (national), Pi Sigma Alpha (political science), and Pi Delta Phi (French). His writing has appeared in the *Hill*, RealClearDefense, and Defense News.

Lieutenant Colonel Christopher P. Mulder is a senior US Air Force fellow in *Forward* Defense within the Scowcroft Center for Strategy and Security at the Atlantic Council. Prior to his fellowship, Lt Col Mulder served as the 80th Operations Group deputy commander at Sheppard AFB, Texas, responsible for assisting the Operations Group commander in leading operations for the Euro-NATO Joint Jet Pilot Training Program. In addition, Lt Col Mulder instructed and trained new pilots from fourteen nations, including Germany, Belgium, and the Netherlands. Lt Col Mulder previously served as the 80th Operations Support squadron commander, leading a diverse squadron of 530 personnel that maintained the airfield and navigation equipment, controlled aircraft, produced weather reports, taught aerospace physiology concepts, and also included all student pilots.

Lt Col Mulder graduated from the US Air Force Academy in 2001. He instructed in the T-6 as a first assignment instructor pilot and served as a mission commander, evaluator, and instructor in the F-16. He has held various squadron positions at Moody AFB, Osan AB, Shaw AFB, and Spangdahlem AB. During his time as the current operations flight commander, 20th Operational Support Squadron, he was responsible for executing a multi-million-dollar flying-hour program, managing the Ready Aircrew and SERE programs, and maintaining Shaw AFB's F-16 simulator complex. As part of the 480th Fighter Squadron, Lt Col Mulder led missions in both Operation Odyssey Dawn and Operation New Dawn in support of national security objectives. He also served as aide-de-camp to the United States Air Forces in Europe-Africa commander. He planned and executed more than two hundred strategic events, traveling to twenty-nine countries in Europe, Africa, and the Middle East, entailing high-level meetings, academic and think tank roundtables, and industry engagements. Prior to moving to Sheppard AFB, he served on the Joint Staff in various roles. Lt Col Mulder is a command pilot with more than 2,600 hours in the F-16 and T-6, including two hundred and seventy combat hours.



Julia T. Siegel is a member of the Young Global Professionals program with *Forward* Defense at the Atlantic Council's Scowcroft Center for Strategy and Security. She graduated with highest distinction from the University of Virginia's Batten School of Leadership and Public Policy with a bachelor of arts in public policy and leadership and a second major in Spanish. Prior to interning with the Atlantic Council, she worked at the University of Virginia's National Security Policy Center, where she conducted research on the US Space Force and Chinese naval diplomacy. Siegel's research interests include global governance, space development, and the intersections of military and diplomacy.

Collaborators

This paper was written with the support of a research team that contributed to the primary outline and extensive research of this strategy. The individuals listed below contributed their views and expertise and are supportive of the general thrust and major elements of this strategy but may not agree with every aspect of the paper.

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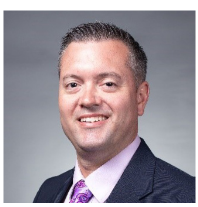

Dor W. Brown IV is a graduate student at Georgetown University pursuing a master of arts in international business and policy and holds a bachelor of arts in political science from the University of Texas at Austin. He is a former tactical aviator in the United States Marine Corps with operational experience in the Middle East, Africa, and Asia. His technical expertise covers a wide range of military technology and weapons systems, and he currently works in the aerospace defense industry in Dallas, Texas.

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- **Mr. Paul Saffo**, *nonresident senior fellow, Foresight, Strategy, and Risks Initiative, Scowcroft Center for Strategy and Security,* Atlantic Council

There will come an age in the far-off years when Ocean shall unloose the bonds of things, when the whole broad earth shall be revealed, when Tethys shall disclose new worlds and Thule not be the limit of the lands.

— Seneca's "Medea"[1]

I have always found that plans are useless, but planning is indispensable.

— President Dwight D. Eisenhower[2]

FOREWORD

Some national strategies are designed to endure for a few years, a single administration at most—but such an approach will not suffice for outer space.

Security and prosperity in space are too important to life on Earth, and too sensitive to long-term trends, to address with short-term strategies. The security of assets in space will have a defining impact on future terrestrial conflicts. Economic prosperity on Earth increasingly depends on data transmitted through space. Even more so than many domains on Earth, security and prosperity in space depend on long-term technology developments. That is why the authors of this strategy paper call for the United States, in concert with its allies and partners, to implement a thirty-year strategy for space.

The ambitions of this strategy paper are bold enough to merit such a timeframe. The authors call for an overhaul of the body of international law governing space. They make a compelling case to replace the 1967 Outer Space Treaty with a new, foundational space treaty that addresses the security and commercial realities of space in the twenty-first century. The authors call for a new coalition of the willing to push back on recent destabilizing Russian and Chinese activities in space. New alliances—and existing ones—need to step up their commitments to security in outer space. An attack in outer space could have devastating consequences on Earth, and no ally should be left without support because existing treaties do not yet fully recognize the consequences of space attacks. Finally, the legal, security, and physical architectures that the United States develops over the coming decades must explore opportunities for the commercial sector to plug in, or even take over, elements. Not only will commercial firms be crucial to developing the technologies that will define space activity, but there will also, by 2050, be a range of profit-making activities in space that one can only begin to imagine today. The United States can develop plans for space now in a way that enables it to benefit later.

Crucially, the authors of this strategy paper take on two developments in space that require deep thinking now because of their impact in coming decades. First, this paper considers point-to-point transportation around the Earth transiting space. As space-launch costs continue to plummet, the military is already conceiving the use of space ports for thirty-minute

> "Will [Lagrange points] become chokepoints over which spacefaring nations battle, or oases of future space commerce? This strategy suggests that the United States must work for the latter, while being prepared for the former."

transportation to any point on Earth.[3] Clever commercial applications will be only a few years behind. Work must begin on legal and diplomatic frameworks now. Second, this strategy explores the development of the Lagrange points—orbits in the Earth-Sun and Earth-Moon systems with advantageous, stable gravitational attraction. Space agencies already understand the benefits of placing satellites at these points. Will these become chokepoints over which spacefaring nations battle, or oases of future space commerce? This strategy suggests that the United States must work for the latter, while being prepared for the former.

The bold, forward-looking recommendations of this strategy call for the kind of long-term thinking and practical actions that the United States needs today if it is to secure the commanding heights of security and prosperity a generation hence. Our hope is that space, foreign policy, and national security policy makers are inspired to act based on this landmark strategy paper. We are.

General James E. Cartwright, USMC (ret.)
Eighth Vice Chairman, Joint Chiefs of Staff
Board Director, Atlantic Council

Secretary Deborah Lee James
Twenty-Third Secretary, United States Air Force
Board Director, Atlantic Council

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EXECUTIVE SUMMARY

Across cultures, centuries, and continents, exploration has been core to the human experience—exploring and developing space will continue to inspire and be one of humankind's great accomplishments extending to future generations.[4] For the United States, where crucial advances in astronomy, rocketry, and space exploration took place, its identity as a spacefaring nation is ingrained in its history, society, and self-image.[5] As Ed Weiler, the Hubble Space Telescope's first chief scientist, said some thirty years ago, "The universe is even more complex than we dream. Almost everywhere we look, we find something bizarre."[6]

Today, space seems an unremarkable part of daily life, but the possibility for human activity in space to further transform and inspire society is as great as it was during the headiest days of the 1960s space race. While there is vast uncertainty about the future of space development, space will surely become even more important for global security and prosperity in the decades and centuries to come. Developed over the course of a year, this *Atlantic Council Strategy Paper* provides an ambitious thirty-year strategy for the United States, alongside its allies and partners, to harness today's innovation, shape the future trajectory of space activity and discovery, and secure this evolving domain to ensure future prosperity so that humankind can exponentially reap its benefits.

FOUR DEVELOPMENTS DEFINING THE FUTURE OF SPACE

Four major developments together provide both an opportunity and a requirement for the United States and its allies and partners to define the future of space activity and adopt a long-term space strategy.

1. Space Holds Boundless Potential for Humankind.

Increased Reliance on Space for Human Activity. For the United States, its allies and partners, spacefaring nations, and humanity at large, space holds the potential to revolutionize Earth's economy, security, and, potentially, the nature of human civilization itself. Outer space has, for decades, been a vital resource—one that both enables security and prosperity on Earth and is rapidly becoming the locus of an increasingly large share of humankind's economy. Space enables critical economic and security activities on Earth. The global economy depends on communications, navigation, timing, and remote sensing that occur in space—the US economy more so than any other. For the United States, space is also essential for national security missions, including the transit of intercontinental ballistic missiles, detecting and tracking missile launches, communicating securely with forces deployed across the globe, and observing otherwise-denied areas.

"[S]pace holds the potential to revolutionize Earth's economy, security, and, potentially, the nature of human civilization itself."

"[E]nabling further exploration will uncover resources integral to the resilient existence of life on Earth."

A Promise of Radical Abundance and Resilience. Recognizing the known and unknown values of space to humankind means that this relatively new domain will increase in importance in the coming decades and centuries. Humankind still has much to discover in this vastly unknown frontier, and enabling further exploration will uncover resources integral to the resilient existence of life on Earth. Space holds virtually unlimited sources of energy, vast amounts of useful materials, and untapped potential to provide a "radical abundance" of resources for humankind in the future. These developments could lead to "radical resilience" for societies in their responses to challenges on Earth, like climate change.[7] Space has been invaluable for producing wealth, spurring commerce, and winning wars for decades—but a qualitatively different aspect to space is emerging today and may be primary in thirty years' time. This new paradigm for space prioritizes the security and economic activities that occur within space itself, not just those they enable on Earth.

2. Space is on the Cusp of a Major Transition from Exploration to Security and Commerce.

The Phased Development of Space. Space is no longer the exclusive domain of scientific exploration and discovery. Just as the land, air, and sea domains transformed from unfamiliar realms to commonplace, so too is human advancement in space changing. This development raises new questions about the ways activity in space will be defined in the future and who will define it. The purpose of human space activity is transitioning from a phase of "discovery" to phases of "security" and "commerce." These next phases will be defined by an explosion of commercial activity and security operations necessary to protect that activity, safeguard access and maneuverability, prevent malign actions, and pave the way for more routinized space activity. The time is rapidly approaching when space's value to security on Earth will be matched by the need to secure the economic activity occurring within Earth orbit. Even as commercial concerns begin to dominate Earth orbit in the short term, over the next thirty years, the frontier of economic activity in space will likely expand to encompass cislunar space, the spherical area formed by the radius

"[H]uman advancement in space is changing. This development raises new questions about the ways activity in space will be defined in the future and who will define it."

between the Earth and the Moon.[A] To bridge this phased transition in space, the United States, in concert with its allies and partners, must set forth a framework to protect sovereignty and property in space.

An Explosion of Space Actors. Unlike during the 1960s space race, space today is no longer a domain in which few nation-states operate. Over the past several decades, there has been an explosion of actors with activities and interests in space. While the United States still leads in space by many measures, including its share of global space investments and numbers of satellites in orbit, there are a far greater number of countries operating in space today. For example, Russia, China, the European Union, Japan, and India all have deployed their own global or regional satellite-navigation networks comparable to the US Global Positioning System (GPS). A legion of smaller nations—from Luxembourg to New Zealand to the United Arab Emirates—are playing in the arenas of space commerce, exploration, and security. Multipolarity in space presents a range of challenges and opportunities for the United States to achieve security and prosperity in space.

Commerce as a Driver of Activity. Nation-states are far from the only entities operating in space. Corporations have been making money in Earth orbit for half a century and will continue to lead innovation in space, creating opportunities and challenges for governments. New technology and business revolutions—in microelectronics, telecommunications, and space launch—have made a compelling business case for commercial firms to conduct missions in low Earth orbit (LEO) that had traditionally been situated in geosynchronous Earth orbit (GEO). The result of this trend—massive constellations of small satellites—will upend commercial space business and transform the global communication industry. Indeed, while traditional advances in defense technologies (like ballistic missiles) have driven space commerce and exploration in the past, it is increasingly commercial developments (like on-orbit satellite servicing) that are driving defense capabilities and concerns going forward.

3. Security in Space is at Risk, and the United States Must Act Urgently.

The Security (Ad)Vantage Point of Space. From a security perspective, there is an urgent need for the United States and its allies and partners to shape the future trajectory of space. In many ways, space is the ultimate "high ground," as it contains key "terrain" that is very advantageous for surveillance, warfighting, and rapidly expanding commercial uses. This high ground is becoming more and more useful for nations—including the United States and its allies and partners, as well as competitors like China and Russia. Securing this high ground over the coming decades is imperative for spacefaring nations to gain and maintain an advantageous position.

The Return of Great-Power Competition. Increased competition among the United States, China, and Russia on Earth further complicates the security picture in space. Great-power competitors may find themselves in a struggle for space resources and this high ground. The winners of this

A For the purposes of this *Atlantic Council Strategy Paper*, cislunar space is further distinguished as the area beyond geosynchronous Earth orbit (GEO) but closer than lunar apogee.

> "The United States should lead now to pave the way for space governance and to ensure favorable regulations and norms are developed and adhered to—otherwise, these rules will be written for it."

struggle will likely be those nations that successfully seek consensus on an order for space; the United States must move first or risk an adversary taking the podium. If great-power competitors are unable to agree on rules of the road for space, a long-term struggle for space superiority may escalate into tension and potentially even boil over into warfare. The authors of this report lay out a strategic plan that not only seeks to prevent a space catastrophe from occurring, but also to encourage dialogue and planning to unlock new opportunities and innovation. A promising avenue for such cooperation may be human or robotic exploration of the solar system, a common interest of humankind. The United States should lead now to pave the way for space governance and to ensure favorable regulations and norms are developed and adhered to—otherwise, these rules will be written for it. To realize this potential, it is imperative that policymakers act now and in accordance with a long-term strategy.

Risk of Disruption and Denial of Space Activity and Access. Since the 1990s, the United States' expeditionary model of warfare has relied on space capabilities for both tactical and strategic intelligence, missile-launch warning, and communication. Meanwhile, China and Russia are fielding increasingly sophisticated counterspace weapons capable of disrupting, denying, or destroying US and allied space assets in conflict or crisis. The saliency of denying space access is likely to increase in great-power competition. The vulnerability of space systems to lower-cost cyberattack means that other, smaller competitors could also achieve counterspace effects. The creation of the Russian Aerospace Forces (2015), the Chinese People's Liberation Army Strategic Support Force (2015), and the US Space Force (2019) all point to key players perceiving space as a warfighting domain.

4. New Frontiers of Exploration Require Shaping.

The edge of humanity's routine activity in space is moving beyond GEO to encompass cislunar space, the sphere formed by the Earth-Moon radius.[B] This development opens new opportunities and risks with which any future strategy must come to grips. As the United States continues to plan a crewed lunar landing in the 2020s, commercial firms are racing to support exploration efforts (and even resource extraction) on the Moon—present-day developments which could drastically change the paradigm for

B Some satellites in highly elliptical orbit (HEO) have a higher apogee than GEO, but the latter is a better definition of routine activity. For the purposes of this *Atlantic Council Strategy Paper*, cislunar space will refer to the area between GEO and lunar apogee.

"[A] short-term strategy for space is insufficient."

future space activity. At the Lagrange points[C]—areas of particular orbital stability in the Earth-Moon system—nation-states are deploying satellites for research and, increasingly, military reconnaissance. The Lagrange points (and other advantageous orbital regions) may become contested as nations seek to observe and operate in cislunar space, and activity there will become all the more important in the coming decades.

STRATEGIC APPROACH

These developments—today and through 2050—demand a new US approach to space. This *Atlantic Council Strategy Paper* offers space, foreign policy, and national security policymakers a roadmap for navigating this new space age.

The United States and its Allies Need a Long-Term Strategy for Space. Given the pace of major trends, a short-term strategy for space is insufficient. While the 2020 US National Space Policy and 2018 US National Space Strategy helpfully identified principles, goals, and guidelines for US space activity, a longer-term lens is needed.[8] This strategy does not profess to predict or anticipate all changes that may occur in space over the next three decades, but its ambitious timeframe is deliberate to raise questions and encourage the necessary long-term strategic vision. It is imperative for the United States and its allies to get out ahead and shape the future of space in ways favorable to them. This paper proposes the United States takes a phased approach to implementing a long-term strategy, including milestones in the short, medium, and long term to achieve security and prosperity in space and on Earth (enabled by space). Thinking strategically will help shape the context in which novel technologies and activities are introduced, even if specific technological advancements are largely unpredictable in the thirty-year time horizon. Any strategy that is implemented should be updated over time and will require regular reevaluation of goals

C Lagrange points are regions in space where the gravitational forces of two celestial bodies (such as the Sun and the Earth or the Moon and the Earth) produce regions of enhanced orbital stability.

"The United States, in concert with its allies and partners, has the opportunity to shape the future of space over the next thirty years if it takes action today."

and policies. The United States, in concert with its allies and partners, has the opportunity to shape the future of space over the next thirty years if it takes action today.

The Importance of Allies and Partners

Realizing the full potential of space requires that the United States work with many spacefaring nations, including existing allies and new partners—and, in some instances, with competitors. This strategy seeks to set forth a future for space that is free, secure, and prosperous. But, this strategy prepares for the eventuality that some nation-states may harbor malignant intent. It will be critical to monitor the space strategy and policy of US competitors—which are sure to evolve in the timeframe of this strategy—to determine where cooperation is possible and where competition is necessary.

THE STRATEGY

Vision and Strategic Goals

The vision of this strategy is to ensure the space domain remains harmonious, fully accessible, organized, and regulated. This will allow humankind to reap the benefits of space resources in perpetuity. The key goals of this strategy are to:

- Promote stability, harmony, and freedoms among space actors by establishing a rules-based order for space;
- Deter hostile action and secure US and allied space access to, and freedom of navigation within, the global commons of space; and
- Foster US and global prosperity through the continued expansion of space commerce.

A BLUEPRINT FOR SECURING SPACE BY 2050

This *Atlantic Council Strategy Paper* provides a blueprint for the United States and its allies and partners to secure space in the long term. The four key elements of the strategy are:

- Provide guidelines for space governance, laying out "rules of the road" for safe and secure operations in space;
- Defend space access from those nation-states—particularly great-power competitors—who would seek to deny it;
- Accelerate space commerce critical for space development through clear regulation and targeted investments; and
- Intentionally push the envelope of security and commercial activity to embrace cislunar space—the area between the Earth and the Moon.

PRINCIPAL RECOMMENDATIONS

To accomplish these goals, the strategy recommends graduated actions to be taken in the short (2021–2025), medium (2025–2040), and long (2040–2050) term. Over the three-decade time period, this strategy calls for the United States to do the following.

1. Update and refine the legal and regulatory frameworks governing space. The international law of space, centered on the 1967 Outer Space Treaty, is outdated and insufficient for a future of space in which economic activity is primary.[D] The international community needs a new foundational space treaty, and the United States should precipitate its negotiation. Moreover, the United States needs to update its domestic governance of space, such as ensuring that each administration uses the National Space Council, an executive body to coordinate government-wide space activity, as well as empowering the council to deliver a thirty-year strategy for space.

- In the short term, the US president should appoint, and the State Department should staff, the office of a special presidential envoy for space. The US special presidential envoy for space should then energize the United Nations Office for Outer Space Affairs to socialize norms for responsible space behavior, which should include US allies, competitors, and industry in laying a foundation for a comprehensive space order.
- In the short term, the United States should also reform space administration. The Joe Biden administration should form a National Space Council immediately, ideally chaired by the vice president, which should be charged with developing and overseeing the implementation and regular reevaluation of a thirty-year space strategy. The administration and Congress should collaborate on legislation to ensure each administration utilizes and staffs the National Space Council. The Congress should monitor the newly formed US Space Force and, in due time, mandate a study of whether an independent Department of the Space Force is warranted. The National Space Council should champion international cooperation in space, including potentially with China and Russia when possible.
- In the medium term, the United States should lead the international community in either extending the International Civil Aviation Organization (ICAO) area of responsibility to space or creating an ICAO-like organization for space activity. Doing so can begin laying the foundations for customary international law favorable to security and prosperity in space prior to replacing the 1967 accord. Even in the long term, international space governance must remain flexible to an evolving space domain in which development will be ever changing.

D See Appendix A.

- In the long term, spacefaring nations should construct a modern, internationally agreed-upon order and "rules of the road" for behavior in space, including a new foundational treaty.

2. Establish a collective security alliance for space. To deter aggression in space, the United States should form a new space security alliance, including likeminded spacefaring nations, to establish collective security in space.

- In the short term, the United States should engage its existing allies in discussions to gain common understandings of space security and take part in coordinated allied activities in space and space-adjacent capabilities to enhance allied credibility on space security.
- In the medium term, the United States can activate existing alliances to build international consensus on the protection of space-related assets and develop a shared understanding of the importance of defending key resources and access, and the need for an alliance to establish collective security in space.
- In the long term, the United States should lead the establishment of a space security alliance.

3. Accelerate space commerce through clear regulation and targeted investment. The United States should identify and invest in keystone space technologies—those capabilities with positive externalities for the entire space industrial base. In doing so, the United States and likeminded governments can accelerate private-sector use of Earth orbit in the short term, while developing cislunar space toward the end of the thirty-year period.

- In the short term, through public-private partnerships and by leveraging its considerable research-and-development budget, the US government should promote the development of keystone space technologies. Those technologies enable a range of missions in space at affordable cost in the short term, including technologies for launch, communications, and in-situ resource utilization (ISRU).
- In the medium term, the United States should involve allied and US subnational governments and leadership in space organization and infrastructure. At a federal level, the government should provide grants and other incentives to encourage state, local, tribal, and territorial governments to participate in the space economy through research grants for state universities, the lease of state public lands for space ports, and building infrastructure for space launch. This may be a valuable way to increase revenue streams for remote localities, leading to increased local prosperity. Further, the United States should work to negotiate access to space ports in foreign countries.
- In the medium term, an appropriately utilized and staffed National Space Council at the Cabinet level can avoid redundant commercial regulation across executive agencies. The National Space Council

should incorporate industry perspectives in a structural fashion.[E]

- In the long term, enhancing private-public partnerships in space will enable the United States to maintain and expand its technological edge in space, including in the crucial area of diversifying space launch platforms and employing ISRU on the Moon and beyond.

4. Take a cislunar approach to space development. This strategy seeks to expand nations' access first to Earth's orbit and eventually to cislunar space, which together will host an increasingly large fraction of the global economy over the next thirty years. This cislunar approach to space will involve the routinization of space activity in cislunar space over the next thirty years, to an extent similar to how activity in LEO is unremarkable today.

- In the short term, US exploration of the Moon and Mars via the Artemis program provides a number of avenues for increasing security uses of cislunar space.
- In the medium term, as commercial activity in Earth orbit becomes ever more routine, US civil and military entities should push the envelope of regular space activity into cislunar space, the area between the edge of where most current satellites orbit and the Moon, and similarly advantageous areas identified in the solar system.
- In the long term, the United States should seek to build infrastructure at the Lagrange points, critical strategic geography within cislunar space, in service of a "Cislunar Economy" that will eventually rival today's "LEO Economy." Given China's planned activities on the Moon—including the planned establishment of a permanent base on the water-rich lunar south pole—increased attention in this region of space is crucial.[9]

E The National Space Council Users' Advisory Group is one model for this body.

NASA

Space development has been monumental to twenty-first century advancements here on Earth and will remain as such in the thirty-year context of this strategy.

CHAPTER 1

STRATEGIC CONTEXT

Space in 2050 will look vastly different from space today. Over the next decade alone, the number of satellites could quintuple as government and industry entities launch various missions.[10] While such proliferation of activity will enhance space-based capabilities, enabling universal Internet access and enhancing Earth-observation and data-collection capabilities, it also risks further space debris triggering an unstoppable chain of collisions. Space is currently undergoing a paradigm shift, as commercial entities are developing and fielding the technologies that are the key drivers of space utilization. Indeed, inventive space companies are expanding the concept of what is possible in space, eyeing space tourism in the near future, and simultaneously growing the space economy to what could be a trillion-dollar enterprise by 2040.[11] In the long term, commercial and state entities will see novel levels of cislunar activity, requiring ISRU and onsite, three-dimensional (3D) manufacturing to keep pace with space activity.[12] Indeed, spaceflight could underpin resiliency on Earth, opening access to space-based energy and material resources.[13] Yet, with the realization of such value in the space domain, the future may see an increased use of space by militaries, including great-power competitors China and Russia.[14] China is racing to develop capacity for its own permanent space station, cislunar supremacy, and deep-space exploration within the next thirty years.[15] Despite the expansive future of space, the current space framework is rooted in the past. The future is just around the corner, and protecting space will cultivate innovation, wealth, and security to the

"However, with the regulation and security of space not yet well established, the world risks a new 'Wild West' or 'Scramble for Space.'"

benefit of all humanity.

To achieve security and prosperity in space—just as in any domain—national efforts must progress through three phases. The first phase, scientific, requires civil agencies (like the National Aeronautics and Space Agency [NASA]) to engage in missions of exploration, setting the parameters for the new domain and establishing sources of value. The second phase, security, requires administrative and defense bodies (like the Federal Aviation Administration [FAA] and US Space Force) to provide the public goods of security and freedom of navigation in the domain. Finally, the third phase is commercial, where private-sector entities (like the many commercial space firms operating today) build an economy around the new domain, justifying the national investments made in the first two phases. Today, space, and Earth's orbit specifically, is on the cusp of transitioning from phase two to phase three, with commercial entities eager to leverage space for private business ends. Within thirty years, the frontier of space commercialization will likely expand from the edge of GEO to cislunar space. However, with the regulation and security of space not yet well established, the world risks a new "Wild West" or "Scramble for Space."[16] In the former, commercial activity risks outpacing the development of space law, hazarding negative externalities and prohibitive uncertainty. In the latter, nation-states could seek to dominate orbital space and exclude others, running contrary to US and allied values of freedom of navigation and commerce.

The 2017 National Security Strategy recognized the return of great-power competition among the United States, China, and Russia.[17] A feature of this competition to date includes Chinese and Russian revisionism against US allies and partners and consistent undermining of international law and norms by both China and Russia. Indeed, strategic competitors China and Russia have enhanced their militaries' focus on space, reorganizing their military services for space in 2015.[18] China's 2015 space strategy emphasized China's attention to reusable rocketry for low-Earth orbit, space exploration, and development of a space station.[19] As such, the 2020 US Defense Space Strategy (DSS) called for maintaining the US and allied strategic advantage in space in the face of the return of great-power competition.[20] Activity in space has broader implications for Earth-based activity and security, and thus the space-related ambitions of US competitors, such as China and Russia, will need to be couched in the broader context of US and allied national security. As more activity on Earth becomes reliant on space, the interrelation of the two realms is likely to increase over the next thirty years; as a result, space may both be impacted by and directly shape the future of great-power competition.

However, space has never been the exclusive domain of competition, and some cooperation in space remains between the United States, Russia, and China. Between 2011 and 2020, US astronauts flew to the International Space Station (ISS) aboard Russian rockets.[21] The ISS, of course, remains a joint venture with nations including Russia. Under the terms of the 2013 Wolf Amendment, which generally prohibits bilateral NASA ties with the Chinese space program, there is markedly less US cooperation in space with China.[22]

Generally, this bold strategy for space assumes that the future strategic environment will be distinct, and in ways unpredictably so, from the present strategic environment. Specifically, this strategy assumes that the primary driver for space security will be space commerce, that strong alliances will prove just as relevant (or even more relevant) to space activity as to Earth-based activity, and that the strategic geography of space—key access points and orbits—will be become even more critical and contested. This strategy paper attempts to identify primary areas that need improved norms, regulation, and laws. It is impossible to identify all issues in space that will emerge over the next three decades. However, the positions, offices, and bodies that this strategy paper proposes will be well positioned to take on these challenges in due time.

This strategy proceeds by reviewing the current and projected strategic space environment and providing policy recommendations for US and allied decision-makers in the short, medium, and long terms, with recognition that the timeline of such achievements is subject to change.

Routinization of Earth Orbit

Earth orbit is now a routine part of military and strategic competition, a standard part of national policy for a great number of smaller states, and so well-trod as to raise concerns about sustainability. Space commerce is routine in the major orbital bands around Earth: GEO, medium Earth orbit (MEO), and LEO. Space commerce began in GEO, an orbit with an altitude of 22,236 miles. GEO hosts many larger communication satellites. Unlike in other orbits, satellites in GEO can appear stationary to viewers on the ground (when they orbit around Earth's equator). Further, the high altitude of satellites in this orbit gives them greater coverage of the Earth. Located between GEO and LEO, MEO hosts the fewest number of satellites, but many of them—including the satellites of the GPS—are of utmost importance to prosperity and security on Earth. Below 1,200 miles in altitude, LEO hosts an increasing share of space commerce. Placing satellites in LEO requires less launch energy and is therefore

> "Spacefaring nations, along with non-state space entities, are partaking in the competition to seize upon vast opportunities ranging from commercial wealth to military dominance."

cheaper. The tradeoff for satellites in LEO is the disadvantage of a smaller view of Earth. LEO hosts the majority of the world's approximately 2,700 satellites.[23] However, even GEO will cease to be the outer edge of humankind's routine economic activity; within thirty years, that frontier will reach the edge of cislunar space.[F]

Rather than being exceptional, it is becoming routine that major countries find that their national security and economic interests extend to space. Indeed, the days are numbered that Earth orbit will be considered more a part of outer space than an integral part of Earth's economic, political, and social structures. Because activity in Earth orbit is becoming so routine, and is proceeding at an increasing pace, questions of space sustainability and the consequences of debris in Earth orbit are coming to the fore.

Small- and medium-sized countries are fielding research, intelligence, and communications assets in Earth orbit. Major powers are gearing up their militaries to increase space situational awareness, defend their space assets, and exercise space control. Smaller countries are betting the future of their economies on space commerce. Commercial entities are preparing to develop entirely new lines of business in orbit. The simultaneous increase in the space economy and the degrading space security environment may touch off a "space rush."

The space rush of the 2020s differs from the space race of the 1950s and 1960s, when the United States and the Soviet Union dominated space exploration and development. Today, more than eighty national space programs around the globe have entered the space rush, contributing to space advancements while increasing space congestion.[24] Spacefaring nations, along with non-state space entities, are partaking in the competition to seize upon vast opportunities ranging from commercial wealth to military dominance.

The urgency with which governments are pursuing influence in space is matched by national budgets, with national spending totaling nearly $93.5 billion globally in 2019. The United States leads in global space-related investment, with $20.8 billion allocated to NASA for space in 2019 alone, and the new US Space Force requesting $15.4 billion for fiscal year 2021.[25] Great-power competitors China and Russia also maintain substantial budgets for their space programs. In 2019, the China National Space Agency received $11 billion in funding, and Russia allocated $4.1 billion to its space programs.[26]

F While the apogee of some standard highly elliptical orbits (HEOs) has a higher altitude than GEO (such as the Molniya orbit), GEO is the best way to understand the limits of typical activity in space.

US AIR FORCE/ UNITED LAUNCH ALLIANCE

An increasing number of nations are launching an increasing number of space missions. In this picture, the United Launch Alliance Atlas V rocket carries Cygnus cargo vessel OA-6 for resupply services supporting the International Space Station.

GREAT-POWER COMPETITION

Competition among the great powers—the United States, China, and Russia—is the defining feature of international security on Earth as it is in space. The peaceful use of space by governments and the private sector will undoubtedly continue. However, the United States, China, and Russia see space as an essential battlefield in future wars and as a means to project great-power status.

The United States relies on space to enable its expeditionary way of war and perceives growing threats to its ability to rely on space in high-end conflict. Since the 1991 Gulf War, the United States has depended on space-based support—such as Global Positioning System (GPS) navigation, secure communications to deployed forces, battlefield mapping and intelligence, tactical missile launch warning, and precision-guided munitions—in its operational warfighting concepts. Space also plays an enduring strategic role for the United States in national intelligence satellites and missile launch and nuclear detonation detection satellites. However, US intelligence agencies note with grave concern the growing antisatellite threat—including destruction of satellites and denial of their services to the warfighter.[27] China and Russia, according to the US 2020 Defense Space Strategy, "present the greatest strategic threat due to their development, testing, and deployment of counter space capabilities and their associated military doctrine for employment in conflict extending to space."[28]

Perceiving that its competitors have made space into a warfighting domain, the United States is committed to preparing to deter and prevail in conflicts in space. Furthering this objective, the United States established the US Space Force (USSF) in 2019 as its first new military service since 1947. In this way, space is becoming no different from the land, air, and sea domains, with some military theorists arguing that control of space will be determinative in future conflicts. In the words of US Air Force (USAF) military strategist Everett Dolman, echoing Halford Mackinder's heartland theory, "Who controls low-earth orbit controls near-Earth space. Who controls near-Earth space dominates Terra. Who dominates Terra determines the destiny of humankind."[29] While this long-term vision informs US military space planning, short-term goals are more grounded: The US Space Force recently had one of its components designated a part of the US intelligence community, underscoring that the primary military use of space is, and will continue to be for some time, the support of operations on Earth.[30]

The People's Republic of China sees space as a commanding height in modern warfare, one which is an asymmetric vulnerability for the United States, and one which is thoroughly integrated with the cyber and electromagnetic domains. Chinese observers noted with great interest the US campaigns in the first and second Gulf Wars and the ways in which those operations were undergirded by space capabilities. In response, Chinese civilian and military leaders elaborated the concept of the "assassin's mace," weapons which could exploit asymmetric vulnerabilities, and stressed preparing for local wars under high-technology conditions.[31] Under this rubric, the People's Liberation Army (PLA) developed and tested direct-ascent antisatellite weapons. In 2015, a major reorganization of the PLA regrouped various elements of the PLA into a service-like Strategic Support Force (SSF), which included cyber, electromagnetic, and space warfare branches. This reorganization coincided with the PLA's adoption of "winning informationized local wars" as its military strategy, highlighting the importance of controlling space, with its dominant position in the acquisition and dissemination of information.[32] Much remains unclear about the SSF even six years later, and it is a further unknown as to the extent to which China's own developments in space—including Earth-observation, secure communications, and potential strategic missile launch detection—may temper its willingness to employ counterspace weapons in conflict. What is clear, however, is that China's military regards Earth orbit as central to current and future military competition.

The Russian Federation regards control of aerospace as essential to its national security and strategic deterrence. After the collapse of the Soviet Union, Russian space assets were severely hollowed out during the 1990s, leaving gaps in important early warning networks.[33] While Russian early warning has largely recovered, Russia continues to express grave concerns about its vulnerability from space, including to potential space-based weapons and space-based missile-defense interceptors.[34] If fielded, either of these weapons could undermine Russia's nuclear deterrent, upon which it has increasingly relied as it faces conventional weaknesses. In response, Russia has revived from its Soviet past perhaps the world's most sophisticated arsenal of anti-satellite weapons, including direct-ascent, co-orbital, and directed energy modes. Russia's space doctrine—defending from space threats by holding space assets at risk—is reflected in its military organization and diplomacy. Russia reorganized its military forces in 2015 to place its air forces, space forces, and air and missile defense forces under one service, the Aerospace Forces. Further, the joint Russian–Chinese draft treaty on prohibiting the placement of weapons in space has been roundly rejected by the United States because it would limit missile defenses without addressing ground-based anti-satellite weapons.[35] This treaty aligns well with Russia's space security interests of preventing aerospace attack, particularly on its strategic deterrent.

For great-power competitors, space security is now a routine military concern.

MORE STATES IN SPACE

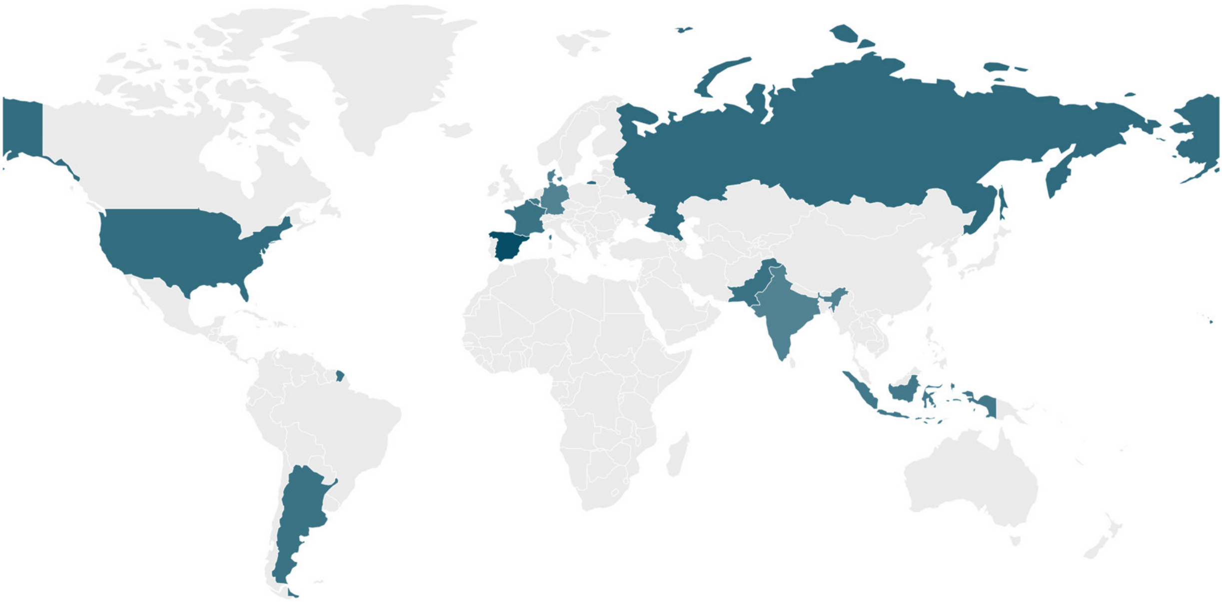
Paraguay, New Zealand, Luxembourg, and the United Arab Emirates offer four examples of how more governments are seizing upon emerging opportunities in space.[36] The Paraguay Space Agency, established in 2014, pursues strategic partnerships for both capacity building and technology transfer, such as collaborating with India for resource mapping, remote sensing for agriculture, and satellite manufacture and launch.[37] The Paraguay Space Agency's partnership with India is notable, given the prevalence of Chinese investment in Latin American space programs, including in nearby Argentina, where China has constructed a military-run space facility. According to a US National Security Council official, the station serves as "another example of opaque and predatory Chinese dealings that undermine the sovereignty of host nations."[38] With the establishment of the New Zealand Space Agency in 2016, New Zealand opened its "front door" for space activity.[39] New Zealand's first foray into space is a methane-emission satellite mission.[40] New Zealand's membership in Five Eyes (an intelligence-sharing group that also includes the United States, United Kingdom, Australia, and Canada) means that the United States may be able to work with this ally in space security missions in the future. Also, consider the example of Luxembourg. The smallest and least-populated state in the European Union, it transformed its economy from a steel hub to a financial powerhouse in the twentieth century. In the twenty-first century, Luxembourg has reinvented itself again as a hub of an emerging space economy, creating a positive regulatory, legal, research, and business environment. Indeed, Luxembourg was the first country in Europe to adopt domestic legislation that regulated property rights for resources returned from space, which may serve as a precursor for similar legislation in other nations.[41] In February 2021, the United Arab Emirates inserted the Hope probe into Martian orbit for an exploratory mission—an accomplishment, as the UAE's space program is only the seventh to ever do so.[42] From developing to highly developed nations that have not previously participated, countries recognize the positive impact of space investments for commercial, research, and educational purposes.[43]

An explosion of nations in space

Space has seen a proliferation of actors since nations first began launching space-related agencies and programs in the mid-1950s.

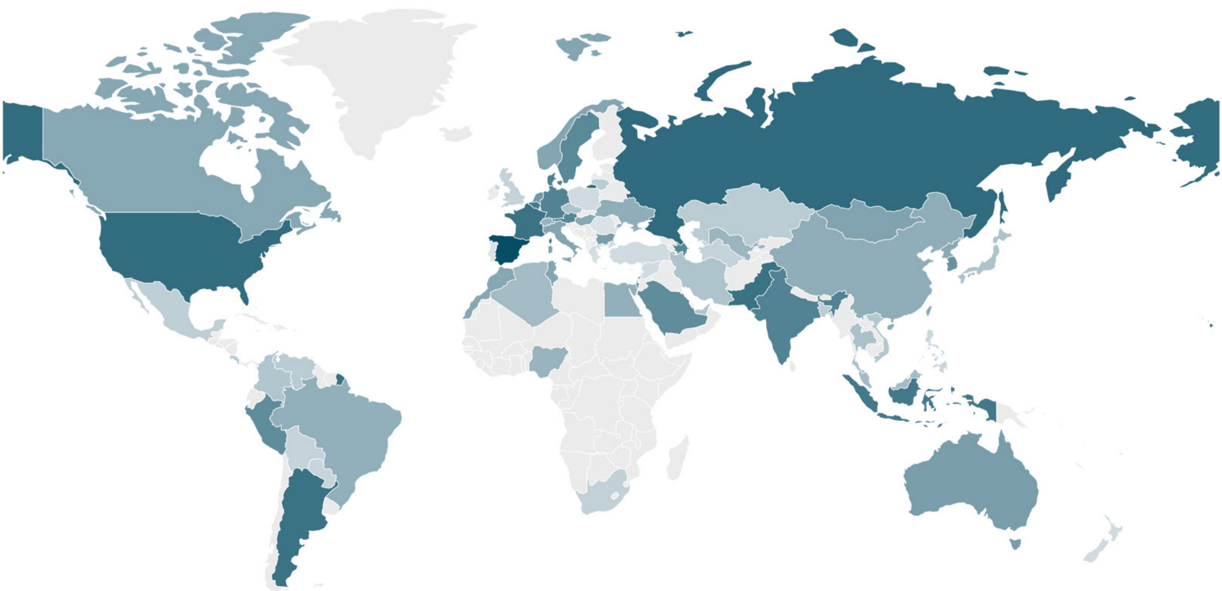
In the early years of the Space Race, few nations had established agencies managing space development...

Number of years active 2 80



...whereas, today, small and large nations alike are exploring outer space.

Number of years active 2 80



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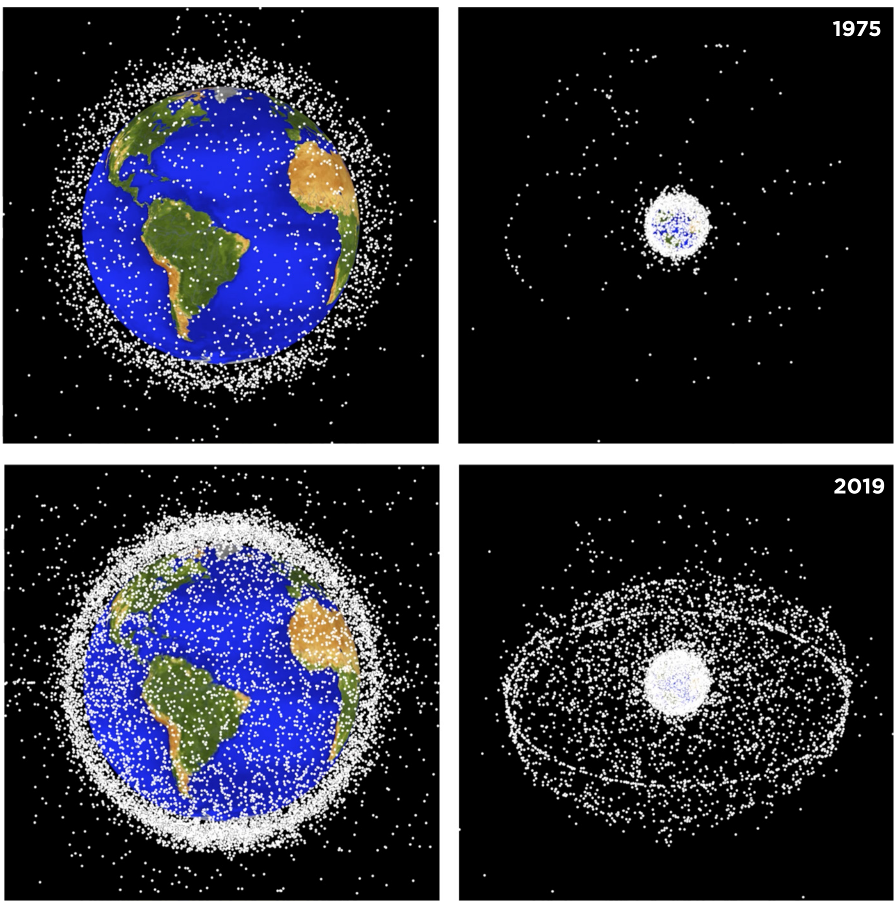
Space has seen a proliferation of actors since nations first began launching space-related agencies and programs in the mid-1950s. In the early years of the Space Race, few nations had established agencies managing space development, whereas, today, small and large nations alike are exploring outer space.

SPACE SUSTAINABILITY

Satellites are critical for security and prosperity, but they are also delicate, expensive hardware subject to damage in the harsh environment of space by small pieces of debris. Because objects in space travel so fast, a bus-sized satellite can be destroyed by an object the size of a marble and critically damaged by a fleck of paint. This vulnerability makes space debris of vital importance. Due to a range of factors—the proliferation of smaller satellites in LEO, counterspace weapons tests, and collisions in space—the amount of space debris has become extensive. Space-surveillance networks regularly track and catalogue more than twenty-eight thousand debris objects.[44] Notably, these objects vary in size. While an estimated thirty-four thousand objects are greater than ten centimeters, there are nine hundred thousand that range from one to ten centimeters, and 128 million that are between one millimeter and one centimeter.[45] While millimeter-scale debris can cause serious damage to a satellite, they are generally not possible to track.



NASA

Since the launch of the first satellite in 1957, space has grown congested with more and smaller satellites being launched into Earth orbits. Limited space situational awareness and insufficient space traffic management risk satellite collisions, which could generate space debris endangering the use of these orbits.

There exists a tipping point where the quantity of debris is great enough that entire orbital bands become unusable. In 1978, NASA scientist Donald J. Kessler proposed a theory that debris-driven collisions can become self-perpetuating, making space access impossible. This runaway effect is known as the "Kessler Syndrome." As the density of objects in LEO increases, so does the number of collisions, producing more debris fragments. The larger number of debris fragments subsequently increases the number of collisions, producing yet more debris in a vicious cycle.[46]

To protect operating satellites and preserve space sustainability, space situational awareness (SSA) and space traffic management (STM) are vital missions. While these two areas have some overlap, they have notable differences, and should be addressed separately. According to one set of definitions, SSA is "comprehensive knowledge and understanding of the space and terrestrial environment…that enables timely, relevant, decision-quality and accurate assessments, in order to successfully protect space assets."[47] Meanwhile, STM is "the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space, and return from outer space to Earth."[48] Put simply, SSA is often taken to refer to the collection and dissemination of data that characterize the space environment, while STM refers to a regime that regulates the behavior of satellites in orbit (loosely analogous to air-traffic control). The United States has positioned itself as a leader in SSA, developing a high-fidelity understanding of where objects in space are located and providing warnings of impending collisions to all satellite operators globally. The USAF defines SSA as the following tasks: detect, track, and identify; characterization; tactical warning and attack assessment; data integration and exploitation; spacecraft protection and resiliency.[49] The US Department of Defense has worked to create a catalogue of space objects, actively tracking the location of objects and sharing this information with partners globally.[50] The United States since 2010 has worked to provide SSA services to other entities and, as of 2017, had data-sharing arrangements with twelve nations and fifty-eight international companies.[51]

To carry out the demanding requirements of SSA, the United States has a wide network of SSA capabilities. Operating more than thirty ground-based radars and optical telescopes alongside six satellites in orbit, the United States has the strongest SSA capabilities in the world, benefitting from sensors on the territories of its allies and partners.[52] A number of specific programs comprise these capabilities. The Space-Based Space Surveillance (SBSS) system is a satellite that monitors surrounding objects, while the Ground-Based Electro-Optical Deep Space Surveillance (GEODSS) system tracks small objects as far as GEO.[53] Alongside some smaller, more niche capabilities such as the Geosynchronous Space Situational Awareness Program (GSSAP), these comprise the US Space Surveillance Network

"There exists a tipping point where the quantity of debris is great enough that entire orbital bands become unusable."

(SSN). Recently, to cover gaps in small-object sensing, the United States inaugurated the Space Fence; while many existing capabilities cannot see objects smaller than a basketball, the Space Fence can observe objects as small as a marble.[54]

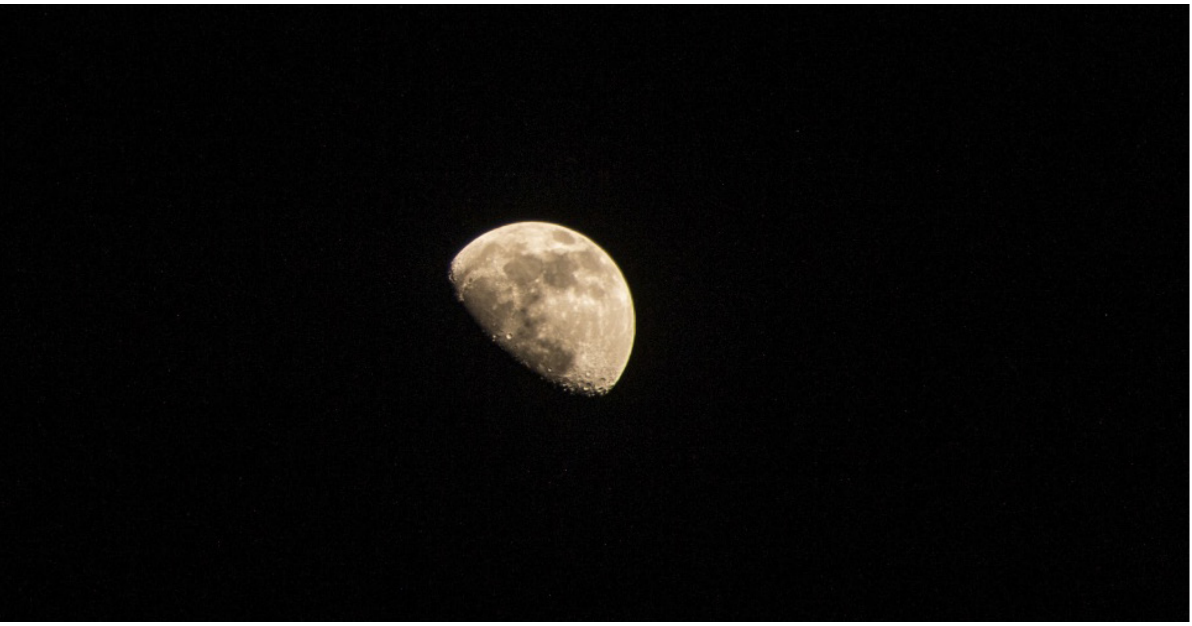
However, the current US catalog of SSA data is secretive by nature, hindering international collaboration and, thus, improved data collection. Operated under the auspices of the Department of Defense (through US Space Command), the US catalogue treats collected data as a national security resource, subject to substantial classification. Orbital data for large swaths of government satellites (and, in many cases, nongovernmental satellites) remain classified, reducing trust in the data generated by the United States.[55] Some have claimed that the publicly available database has more than six thousand fewer objects than the classified internal one, resulting in incomplete information for non-US-government users.[56] This compromises the effectiveness of SSA sharing. When conjunction warnings are issued, they cease to be actionable if parties not privy to the US database lack sufficient information to decide if the warnings are reliable.[57]

In sum, commerce and security activity in Earth's orbit are an unexceptional part of the global economy and international relations. This routinization has consequences for the space environment and greater congestion threatens to significantly interfere with satellite operations in the coming decades. Plenty of pressing issues remain in Earth orbit, among them the evolution of commercial and defense technology, the role of the private sector, and access to critical materials for space systems. But, beyond Earth orbit, a thirty-year strategy needs to consider the next frontier—cislunar space.

The Promise of Cislunar Space

Human economic and security activity in the space domain is already beginning to extend beyond Earth orbit and will, within the timeframe of this strategy, encompass cislunar space. The sphere created by the Earth-Moon radius, cislunar space offers the chance to extend activities beyond GEO, with the possibility of scientific and military observation, military sensing and communication, and resource extraction. Cislunar space is particularly attractive, as it offers three elements essential to human space activity: energy, materials, and integrated intelligence. Without these three convergent streams, space-mission success is obstructed. Cislunar space provides all three of these assets simultaneously and is positioned relatively close to the Earth.[58] With Earth approximately 1.35 light seconds away from the Moon, cislunar space offers a platform wherein Earth-based communications can control missions in near real time. Additionally, because the Moon sits in a shallow gravity well compared to Earth, space vehicles can more easily propel from points in cislunar space.[59] Thus, cislunar space offers a viable point for kickstarting exploration beyond Earth orbit.

As noted by the US Space Force in its recent capstone document,



US NAVY PHOTO BY PETTY OFFICER 3RD CLASS DOMINICK A. CREMEANS

Cislunar space is the sphere created by the Earth-Moon radius. It could provide energy, materials, and intelligence, which are all required for space activity. Positioned relatively close to Earth, cislunar space provides a zone for near-real-time communications from Earth, making it a valuable avenue for further space exploration.

"[t]oday, the entirety of economic and military space activities is confined to the geocentric regime; however, commercial investments and new technologies have the potential to expand the reach of vital National space interests to the cislunar regime and beyond in the near future."[60] However, the United States is not alone in recognizing the strategic advantages of cislunar space for communication, resource extraction, and space domain awareness.[61] China shares a similar interest in information dominance and understands the strategic importance of cislunar space for high-level domain awareness.[62] Within the vast expanse of cislunar space, there is important strategic geography that could become areas of tension, including the Earth-Moon Lagrange points.

The Earth-Moon Lagrange points are the gateways of cislunar space. Lagrange points are regions in space where the gravitational forces of two celestial bodies (such as the Sun and the Earth or the Moon and the Earth) produce regions of enhanced orbital stability. These points are already attracting scientific missions and will likely host security and economic activity as phases of space development evolve. Even as initial deployments to the Lagrange points take place, spacefaring entities are building

"The Lagrange points are unregulated and present the risk of a tragedy of the commons should government or commercial activity accelerate before a regulatory framework is established."

on an unstable scaffolding. The Lagrange points are unregulated and present the risk of a tragedy of the commons should government or commercial activity accelerate before a regulatory framework is established.

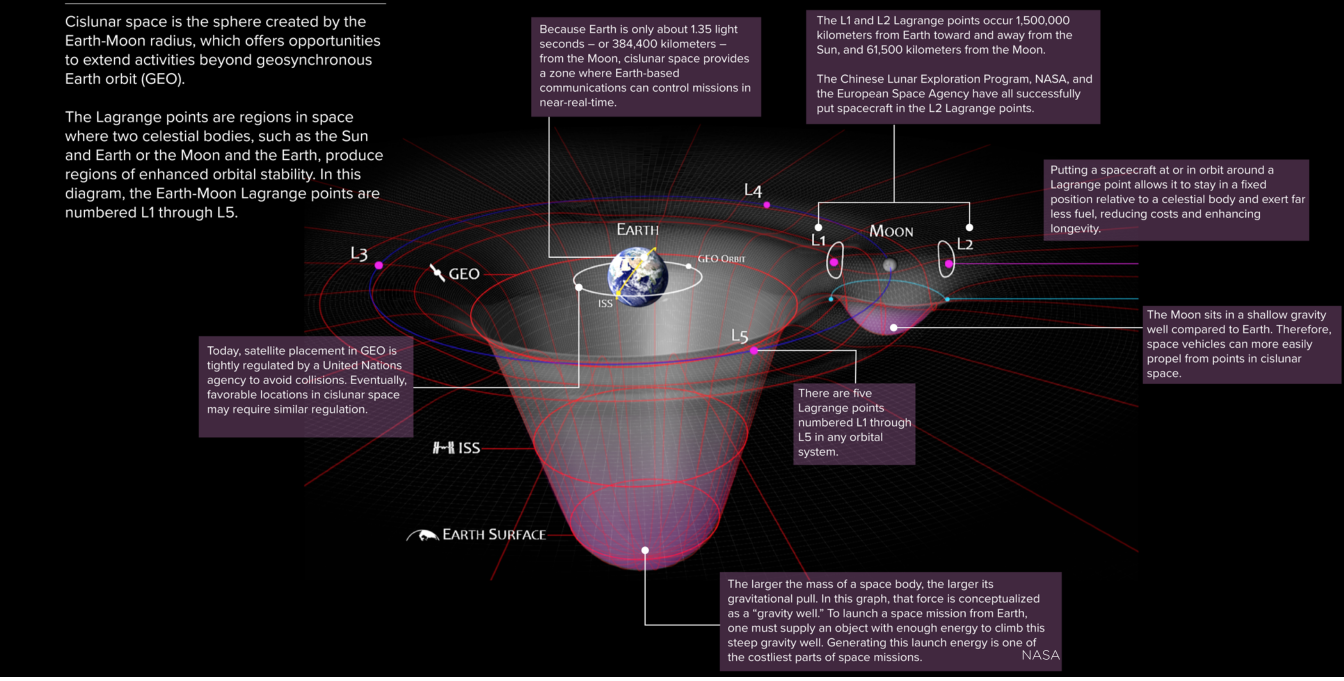
The security of Lagrange points will be essential to maintaining and expanding US and allied interests in space. Putting a spacecraft at (or in a "halo" orbit around) a Lagrange point allows it to stay in a fixed position relative to a celestial body. Thus, spacecraft placed at Lagrange points consume far less station-keeping fuel, reducing costs and enhancing longevity. There are five Lagrange points numbered L1 through L5 in any orbital system, and, while there are plenty of uses of the Earth-Sun system, this paper concerns itself with the Earth-Moon Lagrange points.[63] The Chinese Lunar Exploration Program, NASA, and the European Space Agency have all successfully put spacecraft in the L2 Lagrange point.[64] In September 2020, the US Air Force Research Lab revealed plans to build a Cislunar Highway Patrol Satellite for space domain awareness, an important military mission that enables space operators to characterize the space operational environment.[65] Importantly, this satellite could possibly orbit at the L1 or L2 points within the Earth-Moon system.[66] Russia, India, and Japan all aspire to place orbital assets at the Lagrange points.[67] Lagrange points are a vital piece of space "real estate"; although space is large, a hostile power could dominate a Lagrange point and exclude other nations from accessing it.

The Lagrange points are a known challenge in cislunar space, but there are other advantageous orbits that may be contested as well. For instance, the so-called "pole-sitter" orbit would allow a satellite, using a solar sail or a small engine, to stay in orbit directly over one of Earth's poles, a valuable

Map of Cislunar Space

Cislunar space is the sphere created by the Earth-Moon radius, which offers opportunities to extend activities beyond geosynchronous Earth orbit (GEO).

The Lagrange points are regions in space where two celestial bodies, such as the Sun and Earth or the Moon and the Earth, produce regions of enhanced orbital stability. In this diagram, the Earth-Moon Lagrange points are numbered L1 through L5.



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location from which to observe Earth's Arctic and Antarctic regions, or potentially an entire hemisphere.[68] Today, exotic orbits like these are consigned to the pages of astrophysics journals and conferences. But, in decades' time, they could be the front-page concern of defense analysts and national security policymakers. Currently, satellite placement in GEO is tightly regulated by the International Telecommunications Union (ITU), a United Nations (UN) specialized agency, so that satellites in GEO do not interfere with each other.[69] Without future regulation, specialized orbits in cislunar space may suffer from a tragedy of the commons where individual satellite operators have no incentive to deconflict with each other.

While Earth orbit and cislunar space will be the critical theaters of space strategy, two cross-cutting issues will impact the development of these space domains: the employment of emerging technology in space applications and the increasing role of the private sector in space activity.

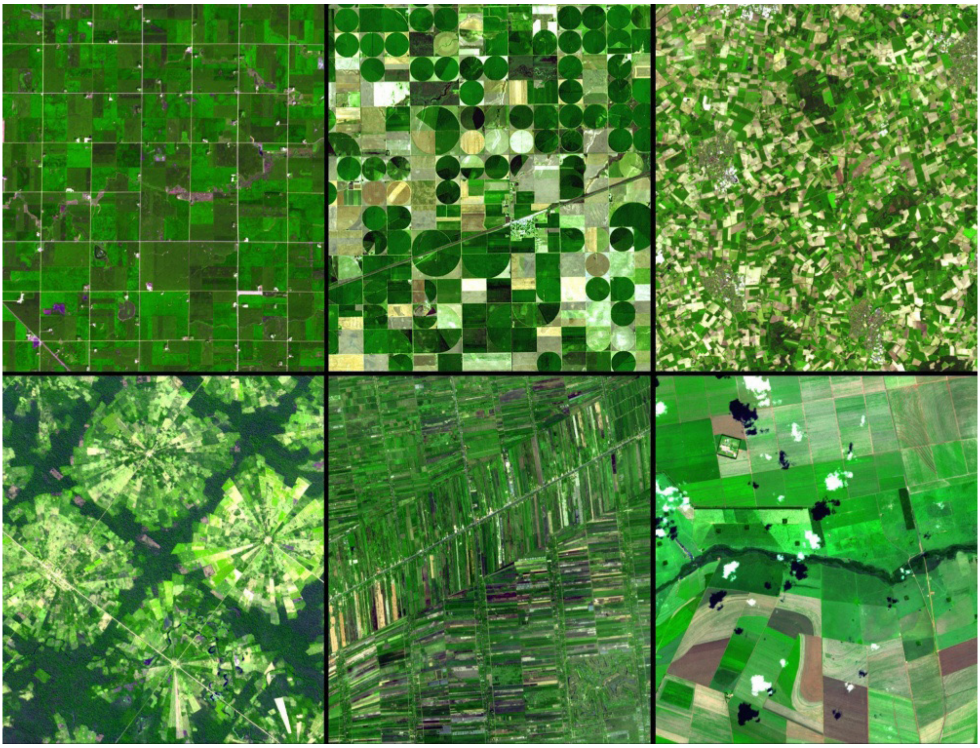
Commercial and Defense Technology

In contrast to the twentieth century—when defense technologies like ballistic missiles drove advances in space commerce and exploration—the twenty-first century space strategic environment is largely driven by advances in commercial technology. This trend is likely to hold through 2050, as advances in commercial space technologies enable space exploration and defense applications which, if unregulated, could threaten the enduring use of space. Rapidly growing LEO satellite constellations, faster satellite communications, and improving sensor capabilities on Earth-observation assets all heighten the promise of future missions.[70] Simultaneously, space advancements hasten the need for enhanced space security in the context of major powers fielding an increasingly sophisticated arsenal of weapons designed to degrade or destroy satellites. While commercial firms lead space technology developments in the United States and many other free-market democracies, this is not the case in Russia and China. Russia's commercial space sector is moribund, riven with corruption, and generally does not make major contributions to Russia's space efforts.[71] Moreover, China's program of military-civil fusion and the dominance of state-owned firms in the Chinese space industry further blur the lines between military and commercial space technology in China.[72]

COMMERCIAL AND DUAL-USE TECHNOLOGY

The strategic space environment will be shaped by emerging technology developments, which enable more sophisticated satellite networks, enhance Earth observation, and reduce costs while effectively broadening access to space. These technologies will enable a range of new commercial and military space missions and applications.

Communication is a core mission of space systems, with new communications technology facilitating more sophisticated satellite constellations. Communications satellites provide broadband connectivity to users



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Satellites benefit activities on Earth such as agriculture, communications, and navigation. For example, NASA's Advanced Spaceborne Thermal Emission and Reflection Radiometer provides high-resolution imaging data to create detailed maps of Earth's surface in hope of better predicting and responding to climate trends.

worldwide; this connectivity is especially essential to remote ground users, vehicles, and other satellites in locations where cable communications are otherwise physically and financially impractical.[73] Broadband from space reduces reliance on foreign-subsidized 5G providers like Huawei and ZTE. Internet from space may even help undermine censorship in autocratic countries during the timeframe of this strategy if the signal is resilient to jamming or interception. Among other benefits, communications satellites in GEO are responsible for television broadcasting, meteorology, radio, and military satellite communication.

While satellites in GEO are enormously useful, space commerce is shifting to LEO. LEO has two key advantages: proximity to Earth and revisit frequency. Satellites close to Earth can produce sharper images and communicate with less latency than their peers in GEO. Further, orbital mechanics dictates that satellites in LEO orbit Earth more rapidly than those in GEO, allowing LEO satellites to pass over the same spot on Earth more

"While the ITU regulates satellite positioning in GEO, there is no parallel in LEO, where now, in a major paradigm shift for space commerce, most satellites reside."

frequently. The smallsat revolution (the continued miniaturization of satellites), decreased launch costs, and compelling new business cases have combined to make massive constellations in LEO possible that take advantage of LEO benefits. Large constellation operators like SpaceX's Starlink and OneWeb promise to launch thousands to tens of thousands of satellites to LEO to provide persistent Internet connectivity for hard-to-reach locations and for new uses. The introduction and proliferation of cubesat satellite constellations (those composed of small, standardized, cheap satellites) may further increase the number of objects on orbit in LEO. Given this rapid growth, concerns have emerged about overcrowding of satellites in LEO. While the ITU regulates satellite positioning in GEO, there is no parallel in LEO, where now, in a major paradigm shift for space commerce, most satellites reside. Absent a strong STM regime, many fear that collisions between satellites and debris (or other satellites) could be destabilizing.

Laser technology is on the cusp of enhancing satellite communications through higher data-transfer rates and enhanced security. Currently, data transmitted using radio waves carry a number of disadvantages. As radio waves propagate, the signal transmitted "grows weaker due to noise, disruption, or the sheer volume of space."[74] As activities move farther into space, latency issues will create unacceptable delays for some applications. Lasers, by contrast, maintain signal strength over longer distances and employ shorter wavelengths, allowing exponentially faster data transfer. While the radio spectrum is tightly controlled in space, limiting room for innovation, there is more regulatory freedom to experiment with communication lasers. Laser technology can advance LEO satellite connectivity as well as deep-space communications, as NASA demonstrated.[75] Beyond NASA, the US Defense Advanced Research Projects Agency (DARPA) has tested optical lasers for crosslink (i.e., communications between satellites). The Department of Defense's (DoD's) interest comes in part because, compared to radio communications, lasers do not propagate nearly as much and therefore are vastly more difficult to intercept.[76] The continued development of laser communication will allow for satellite constellation growth, increased data throughput, and greater security.

Another important development concerns radar. For years, defense and commercial satellites have employed electro-optical and infrared (EO/IR) cameras, which aim to image targets by creating a contrast between the desired target and its background.[77] While defense and commercial satellites have employed EO/IR cameras, such systems encounter limitations in tracking objects at a distance, especially under adverse conditions. While modern EO/IR sensors are degraded by cloud cover, heavy moisture, and low light, synthetic aperture radar (SAR) is always available, regardless of conditions.[78] SAR can produce either two-dimensional (2D) or elevation maps, which are useful for defense and civilian applications.[79] As such, SAR imagery improves orbital detection. Through 2050, SAR resolutions and applications are expected to expand and proliferate.[80]

Finally, reusable space launch has revolutionized the space industry by reducing cost to orbit, a longtime limiting factor for military and commercial space applications.[81] While previously capsules or other components

"The space environment is characterized by increasingly capable kinetic and non-kinetic anti-satellite weapons. With the expanding value of space, these weapons will become increasingly salient as the threat of space conflict grows."

would be used only a single time, innovations have allowed rocketry firms to retrieve and reuse launch components, substantially reducing cost. Reusable launch vehicles have transported commercial satellites, national security payloads, and even human astronauts in just the past year.[82] While SpaceX has led in reusable rocketry, other "new space" firms and aerospace incumbents are not far behind. Over the next thirty years, this strategy assumes that fully reusable launch and other promising technologies—like space launch from airborne platforms—will become more widespread, flexible, and operationally responsive. These technological developments will further drive down space launch costs and steadily lower the barriers to space access, enabling new missions and reaffirming the urgency of space security.

SPACE WEAPONS TECHNOLOGY

The space environment is characterized by increasingly capable kinetic and non-kinetic anti-satellite weapons. With the expanding value of space, these weapons will become increasingly salient as the threat of space conflict grows.

The United States began testing direct-ascent anti-satellite weapons (DA-ASATs) in 1959, eventually destroying a solar observation satellite in 1985 with the ASM-135 missile.[83] DA-ASATs have ground-to-space capabilities, that is, a terrestrial launch that targets space-based infrastructure. Currently, the United States possesses several ballistic-missile-defense (BMD) interceptors, which function as latent kinetic ASATs. These BMD systems include the Ground-Based Midcourse Defense (GMD), the Aegis-based SM-3, and the Terminal High Altitude Area Defense (THAAD).[84] While these systems are designed as BMD, any exoatmospheric BMD has an inherent, latent ASAT capability. Indeed, the technical requirements for hitting a satellite are no more challenging than hitting a missile, so a nation with strong missile-defense prowess can be said to have an ASAT capability.[G]

G University of North Carolina physicist Mark A. Gubrud has argued that BMD is "so closely related to kinetic energy antisatellite (KE-ASAT) weapons that the two are in many cases indistinguishable. Although tests against satellites and against missile targets are distinguishable by definition, this distinction has little or no technical significance for the weapons involved, and testing against one type of target can fully satisfy requirements for development and validation of weapons for use against either type of target." An SM-3 anti-ballistic missile was used for Operation Burnt Frost, which shot down USA-193, a satellite. The SM-3 in question had only light modifications. GMD interceptors have burnout speed in the range of 5.5-6 kilometers per second (km/s), which would allow them to reach an altitude sufficiently high to threaten most satellites in LEO. Mark A. Gubrud, "Chinese and US Kinetic Energy Space Weapons and Arms Control," *Asian Perspective* 35, 4, October–December 2011, 619, 624–626, http://www.jstor.org/stable/42704774.

US AIR FORCE, COURTESY OF LOCKHEED MARTIN

As adversarial nations obtain new capabilities to disrupt US and allied satellites, the United States must ensure resilient space systems. In this picture, workers prepare the US Air Force Advanced Extremely High Frequency satellite, which provides survivable, near worldwide, secure, protected, and jam-resistant communications for high-priority national military operations.

However, as of now, the United States has prioritized DA-ASATs to a lesser extent than China or Russia, and arms-control proposals by those nations reflect that. Proposals such as the Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects (PPWT), pushed by China and Russia, focus on space-to-space or space-to-ground weapons placed in space; this notably excludes ground-to-space weapons like DA-ASAT capabilities.

In 1968, the Soviet Union successfully demonstrated an anti-satellite weapon. With the fall of the Soviet Union, Russian counterspace advancements slowed, but have picked back up within the last decade, potentially capitalizing on previous Soviet research. In 2018, a Russian MiG-31 fighter jet was photographed with a possible air-launched ASAT. Russia's S-400 surface-to-air missile system can range to LEO satellites but may not be accurate enough to target them.[85]

In 2007, China conducted its first successful kinetic ASAT test, destroying an aging Chinese meteorological satellite with an SC-19 missile.[86] This test, which came with no warning and produced a dangerous quantity of debris, violated international norms and brought China widespread criticism. China has not conducted any additional debris-producing ASAT testing since, but intelligence analysts believe that China has conducted several non-impact kinetic trajectory tests, which could reach GEO satellites, with its DN-2 and DN-3 interceptors.[87] The United States uses GEO satellites, such as the Defense Support Program (DSP) and the Space-Based Infrared System (SBIRS), for ballistic-missile early warning.[88] Given their high strategic value, damage or destruction to even one of these systems would have enormous consequences for US national security and the security of allied and partner nations that rely on the US nuclear umbrella.[89]

In 2019, India became the fourth country to successfully test a kinetic ASAT weapon, which was employed against a small target satellite in LEO over the Bay of Bengal.[90] While India is a promising partner of the United States, US officials condemned this test for potentially endangering the ISS. At least a dozen debris fragments reaching altitudes of more than one thousand kilometers, making it likely that the debris will remain in orbit.[91]

Other nations such as North Korea and Iran have continued to expand their ballistic-missile programs. Iran has achieved a handful of successful payload deliveries into LEO. The technologies for launching satellites to LEO are fundamentally the same as those needed for a kinetic ASAT, which makes it likely that North Korea or Iran will eventually possess a latent ASAT capability.

While direct-ascent kinetic ASATs are of concern, both Russia and China are experimenting with co-orbital ASATs and non-kinetic orbital assets to compromise or destroy US and allied satellites. A co-orbital ASAT is an object that, stationed in orbit, can change its orbit rapidly and collide with or otherwise disable (e.g., with a robotic arm) another satellite.[92] Unlike ground-to-space DA-ASAT technologies, co-orbital ASATs are space to space, with satellites targeting other objects in orbit. Known alternately as "rendezvous and proximity operations" (RPO), or colloquially as "space-stalking" satellites, co-orbital satellites pre-position themselves within close

Directed-energy weapons (DEWs) pose an increasingly viable threat to space-based assets. Directed-energy weapons primarily operate by blinding, jamming, or damaging sensors or circuits, rendering a satellite inoperable."

proximity to other satellites to collide during a conflict. In 2019, a Russian satellite maneuvered near a US satellite, in separate and apparently deliberate moves, even after the US satellite attempted to avoid it.[93] General John Raymond, the commander of US Space Command, confirmed the close approach and added that he believed it was intentional.

In addition to kinetic ASATs, various countries have developed counterspace cyber capabilities. The cyber threat to space assets ranges from theft or alteration of information to destruction of satellites or their supporting components.[94] Cyberattacks directly target data and data systems, exploiting links between satellites and from satellites to ground stations. Since cyberattacks are less likely to produce debris when rendering a satellite inoperable, they may function as a "soft-kill" capability. As such, nations may perceive cyberattacks on space assets as less escalatory and therefore view cyberweapons as more usable than debris-producing hard-kill alternatives. According to the Secure World Foundation, one former senior military official identified cyber vulnerabilities as the "No. 1 counter-space threat."[95] Of particular concern to the United States are cyber threats posed by Russia, which has demonstrated cyberattacks on space assets, in one case frying the optics of a satellite by rotating it toward the sun.[96] The barrier to entry for a state to hack a satellite or ground station is lower than that required to develop a DA-ASAT.

Directed-energy weapons (DEWs) pose an increasingly viable threat to space-based assets. Directed-energy weapons primarily operate by blinding, jamming, or damaging sensors or circuits, rendering a satellite inoperable. DEWs operate at different thresholds—they can dazzle (temporarily blinding the optical sensor of a satellite), disable (rendering the satellite itself temporarily inoperable), or destroy (permanently destroying the satellite itself), with varying energy requirements across that spectrum.[97] Directed-energy threats include lasers, high-power microwaves, and other types of radiofrequency weapons. Through fake transmissions or spoofing, radiofrequency weapons can interrupt satellite connections and, thus, achieve similar ends as do cyber means.[98] Unlike kinetic systems, these directed-energy weapons are comparatively small, both in size and signature. It is often difficult to trace the source of the emission. Russian scientists have an impressive record with laser technologies, and China has made impressive advances in directed energy as well.[99]

Electronic warfare (EW) will present a major and evolving threat to space-based positioning, navigation, and timing (PNT) assets and the Global Navigation Satellite Systems (GNSS) in the timeframe of this strategy. EW includes radiofrequency (RF) jamming and GPS spoofing. These techniques have been used in terrestrial warfare for decades, so it is no surprise that this practice is expanding to space. One space-distinct EW application is uplink and downlink jamming. Although usually temporary, jamming technology has the ability to seriously inhibit or block various space-based technologies on which modern economies and global militaries rely, such as GPS, satellite communications (SATCOM), and SAR imaging. Currently, the USSF operates several Counter Communications Systems (CCS), which are categorized as defensive weapons intended to temporarily inhibit an enemy's communication-satellite signals.[100] Both China and Russia have jamming technology that will need to be addressed by developing anti-jamming capabilities.

Private-Sector Engagement

While private firms have been making money in space for more than fifty years, the lion's share of commercial activity in space has been about enabling activity on Earth—including transmission of radio and television signals and Earth observation. These activities remain important and have enormous potential for growth in the coming decades. Yet, there is a new wave of space commerce coming that implicates activity within space—mining, manufacturing, and tourism. This new category of space commerce has the potential to move the space domain into a commercial phase distinct from the scientific and security concerns that have previously dominated. As this transition occurs, the United States will have to interact with the private sector—already a crucial element of space strategy—in a different manner to foster discovery and innovation, while guarding against exploitation that could prove detrimental to sustainable space development.

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Satellite in orbit. Emerging and incumbent space companies have been launching large numbers of smaller satellites, known as satellite constellations, into Earth orbit. While these developments provide benefits to Earth, they also crowd already congested orbits and risk further satellite collisions.

The private sector is, and will remain, a key element in the success of US and allied space programs. Especially since NASA ended the Space Shuttle, space programs have relied less on governments and more on private industry, as evidenced by the burgeoning US commercial space sector. A decade after the first commercial launch of a satellite to LEO in 2009, the space industry has accelerated, with more than $25.7 billion of private investment globally.[101] Despite this important development, private-sector space entities sometimes face challenges in interacting with the US government. These obstacles include a complex regulatory and compliance environment that can be slow moving, risk averse, and process based, rather than outcome oriented.[102]

The success of the US space-industrial base will depend, in part, on the availability, resiliency, and security of the supply chains upon which it relies. Like many other advanced manufacturers, the space industry relies on materials like rare-Earth elements. Chinese restriction on rare-Earth exports in 2010 brought concerns about strategic minerals to the fore in Washington.[103] While this particular rare-Earth supply issue has seen improvements, other supply-chain issues could emerge in areas such as radiation-hardened microprocessors and space-class photovoltaic cells during the timeframe of this strategy.[104] In addition, space supplies that do not make the news regularly but are critical for resilient rocket launch propellant, like liquid hydrogen and liquid oxygen, need to be properly secured for continued space security. The US government and its allies and partners, along with industry, need to actively monitor and support applicable supply chains. Ensuring access to those supply chains will be critical for space security in the next thirty years.

CHAPTER 2

KEY GOALS FOR US SECURITY STRATEGY IN SPACE

Currently, given the widespread reliance on space for a variety of civilian and military applications, space is increasingly "congested, contested, and competitive."[105] In the coming thirty years, the United States and likeminded nations should nurture a thriving, self-sustaining economy in space.[H] Further, as the space domain transitions away from a phase of development primarily characterized by exploration, the United States must lead in establishing a security order that enables this space economy and pushes the envelope of human economic activity beyond GEO and into cislunar space. To do so, the United States, in concert with its allies and partners, should work to provide the common goods of sovereignty and property rights in space. Accordingly, this long-term space strategy prioritizes the following three goals: promote stability, harmony, and freedoms by establishing a rules-based order for space; deter hostile action and secure space assets and access; and foster US and global prosperity through the continued expansion of space commerce.

Promote Stability, Harmony, and Freedoms by Establishing a Rules-based Order for Space

The rules-based order has enabled unprecedented stability, freedoms, and security on Earth, and the United States should strive to extend that order to space. Security on Earth is becoming more interlinked with activity in space, which offers the potential for disorder as more entities operate there. Thus, in the long term, it is imperative for spacefaring nations to construct an internationally agreed-upon order and "rules of the road" for behavior in space.

The establishment of a rules-based international order following World War II stands as one of the most prominent and enduring US foreign policy successes. Leveraging the United Nations, the World Bank, the International Monetary Fund, and a network of allies and partners, US and allied policymakers constructed a new world order that deterred great-power war,

H A self-sustaining space economy does not mean an autarkic one. Rather, this future economy will produce goods and services that are valuable to Earth without being propped up by governments.

"The rules-based order has enabled unprecedented security and prosperity on Earth, and the United States should strive to extend that order to space."

NASA

The space domain is much more congested and contested than it was when humans first began launching into orbit. Novel developments call for an update to the framework governing space activity. Pictured here is Space Shuttle Columbia launching from Kennedy Space Center in 1982, when many of the existing challenges to space security and prosperity were not yet imagined.

increased global gross domestic product, and encouraged democratic governance.[106] While competitors continue to challenge this system today, post-World War II negotiations lay the foundation for a viable, albeit imperfect, solution to the constant instability wrought by an anarchic world system and revolving cycles of great-power competition.

Unfortunately, that primarily terrestrial rules-based order will not suffice for an increasingly complicated space domain that demands tailored treatment under international law. The rapid advancement of space technology is outpacing existing rules of the road, especially as competitors seek to weaponize the domain and private-sector innovations reveal unimagined possibilities for space development. The absence of exhaustive space law invites uncertainty and instability.[I] Competition in space will inevitably lead to conflict and, without clear guidelines for space activity, the risk-reward calculus for humanity-improving endeavors may become too great for many private entities and too costly and inefficient for governments alone.

In this eroded environment, it is imperative for the United States to lead a comprehensive campaign toward establishing and cementing a rules-based international order in space.

Deter Hostile Action and Secure Space Assets and Access

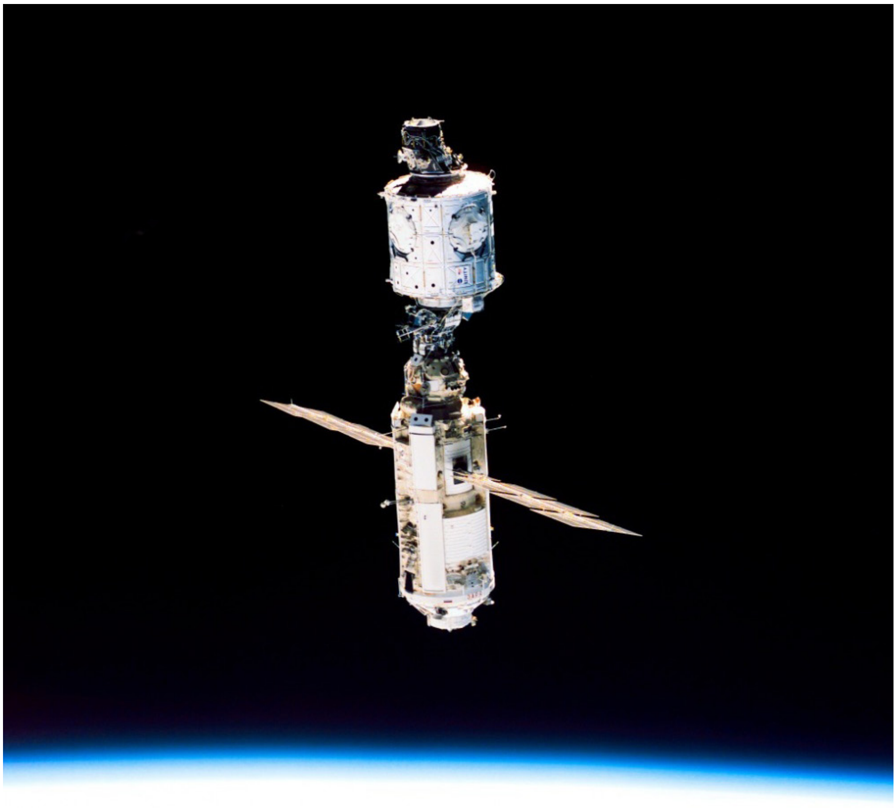
Cooperation under a rules-based system is paramount to success in space, but it is not possible without the leadership of like-minded nations willing to commit to a collective security architecture and develop the technologies to protect space assets. In this domain, the United States is well positioned to continue fostering "Peace through Strength" if it coordinates effectively with allies and partners.[107] Not all threats can be deterred, and the United States should seek to collaborate with its allies and partners in reducing the natural danger from a degrading space environment.

Deterring conflict in space is essential to enabling commerce and preserving the ability to navigate in Earth's orbit. After World War II, the terrestrial rules-based international order was founded on the premise that interconnectivity and interdependence incentivize peace and reduce the likelihood of conflict. In fact, it is even more important to deter aggression in space because the implications of even a limited conflict are amplified, given the world's widespread reliance on satellites and other space-based systems. An attack on a satellite, for example, could generate debris that would cause third-party military or commercial systems to fail, thereby inflicting catastrophic damage on various platforms used on Earth, including civilian and military communication, aviation, maritime navigation, cell phones, traffic-management systems, and railway operations.[108] At an extreme, all-out war in space, including the use of space-based nuclear weapons, could even prompt nuclear war on Earth.

US and allied leadership of a collective security regime would be essential to preventing such a breakdown of the current tenuous order in space, while serving as a security "backbone" for the eventual rules-based order in space that this paper advances. The United States and its allies and partners must be willing to punish transgressions to any rules-based international order in space, thereby establishing a deterrence-by-retaliation paradigm that has worked well for the rules-based order on land.

The United States and its allies and partners can also formulate a

I While the United States has traditionally supported ambiguity in defining, and thus constricting, space, the time is fast approaching wherein such ambiguity will be more restrictive than permissive. Therefore, the United States must act proactively or risk adversarial actors taking advantage of the current state of vagueness.



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Cooperation is paramount to furthering human advancement while securing the space domain. The International Space Station, pictured here, provides an example of international cooperation in space development.

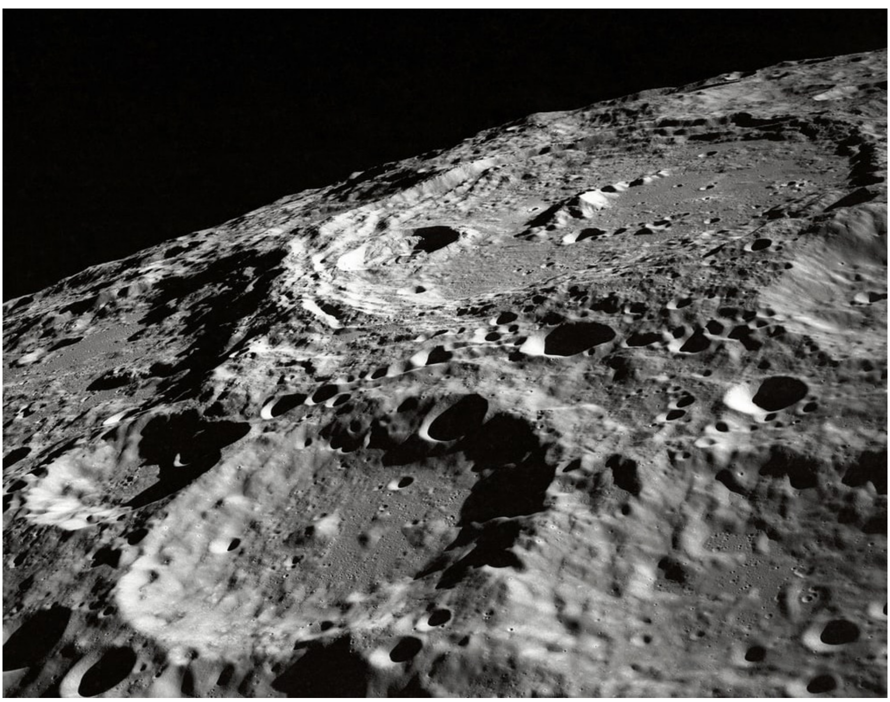
deterrence-by-denial strategy to protect their space assets, investing in technology that makes attacks in space undesirable. Presently, the most important national assets in space cost $1 billion or more and are easy to track and destroy. Thus, attacking one of these exquisite satellites with a relatively cheap ASAT is a very attractive proposition to competitors in conflict or crisis. Moreover, security measures have not kept pace with the cyber threat to space assets, which entices competitors with the potential for high impact relative to cost, targeting multiple missions and potentially reducing reaction time.[109] To deter hostile action and secure space assets and access, it is crucial for the United States and its allies and partners to reimagine orbital architectures and operations such that they are much less vulnerable to attack and disruptions.

Threats to US security and prosperity in space do not proceed only from hostile nations. In addition, the hostile and degrading space environment can be fatal to US space assets. Space has become increasingly congested, with debris posing a major challenge to the space operations of the United States and other spacefaring nations.

Foster US and Global Prosperity Through the Continued Expansion of Space Commerce

US and global prosperity should continue to be fostered through the expansion of space commerce, with investments in keystone space technology as a central focus. Keystone technologies are those that enhance a wide range of space missions, be it through less expensive development, longer mission life, greater flexibility, or other metrics of mission efficiency. From today's perspective, keystone technologies include the categories of space launch, satellite-constellation operations, new power and propellant systems, orbital servicing, and ISRU (including the extraction of material from the lunar or asteroid surface for fuel or water processing). Many of these technologies are dual use and can benefit from Defense Department investment.

To maintain its strategic advantage in space, the United States should promote stability for supply chains essential to the space industrial base. Where appropriate, the US government and industry partners will need to assure access to key materials; one such example is rare-Earth elements. As new components become clear as potential vulnerabilities to the national space enterprise— potentially including radiation-hardened microchips and space-grade photovoltaics—government and industry will need to collaborate to prevent potential disruptions.



NASA

The US and likeminded government and industry must mature keystone technologies, such as those uncovering lunar resources like ISRU, to keep pace with rapid space development.

CHAPTER 3

MAJOR ELEMENTS OF THE STRATEGY

Earth orbit is on the edge of a transition from being primarily the remit of exploration and security to being the locus of a thriving economy. In the next thirty years, human economic and security activity is likely to push this envelope further, embracing cislunar space. This transition must be built upon a solid regulatory, security, technological framework, and human capital base.

In order to achieve a rules-based order in space, preserve the US and allied space security advantage, and advance technology for space development, the United States—in coordination with its allies and partners—should prioritize new space law, a new space security alliance, advanced space technology, and a cislunar approach to space as the major elements of US national strategy for space over the next thirty years. First, the United States must update and refine the legal and regulatory framework that governs the use of space at home and abroad. Second, the United States should establish an alliance of likeminded nations to act in concert to enhance security in space. Third, the United States ought to maintain its technological advantage in space by facilitating public-private partnerships. Fourth, the United States should take a cislunar approach to space, focusing on the known potential of the Lagrange points, while remaining flexible enough to react to future developments.

Update and Refine the Legal and Regulatory Framework Governing Space

Major spacefaring entities are increasingly disregarding the existing space treaties or interpreting them in ever-more expansive ways to justify their activities in space. (See Appendix A for more details on pertinent international agreements regarding space.) In the long term (2040–2050), the United States should seek to develop a new, foundational space treaty. Because international agreements of this sort can take years, if not decades, to negotiate, in the short term (2021–2025), the United States should seek to develop customary international law that matches US and allied norms for space and to forge consensus among likeminded nations about the need to develop a new treaty on the international law of space.

UPDATE AND REFINE THE LEGAL AND REGULATORY FRAMEWORK GOVERNING SPACE

SHORT TERM (2021-2025)	The United States begins socializing key elements of a new space treaty to set the scene for diplomatic negotiations. US government negotiates bilateral and multilateral agreements similar to the 2015 SPACE Act to influence the development of international space law.
MEDIUM TERM (2025-2040)	The United States achieves buy-in from likeminded nations on core principles of space exploration, security, and commerce. US and allied governments decide to extend the ICAO area of responsibility or create an ICAO-like organization to monitor space activity. US and likeminded governments align orbital-debris mitigation standards. The United States works to create a formalized system to exchange SSA within the international community.
LONG TERM (2040-2050)	The United States seeks widespread accession to a new, foundational treaty for outer space activity.

IN THE SHORT TERM (2021 – 2025)

To rewrite the foundational space treaty governing space will take time, as well as prolonged dialogue with allies and partners. Socializing key elements of, and the need for, a new treaty will require the United States to start diplomatic negotiation early. The United States should begin the process now, outlining key pillars of the international space treaty and ensuring that the treaty accounts for long-term changes in the strategic environment in decades' time. By acting first, the United States and its allies and partners can seek to guarantee that the coming legal reconstitution shapes the space domain for prosperity and security in space and does so in a way consistent with democratic, open-market values. Unshackling industry to innovate and explore under the greatest of incentives, within a clearly defined legal structure, will secure industry interests and the interests of humankind by protecting commercial ventures from malign actors both public and private.

In the short term, the United States should seek to influence the development of international space law by negotiating bilateral and multilateral agreements. For instance, in 2015, then-President Barack Obama signed the Commercial Space Launch Competitiveness Act (SPACE Act), which, *inter alia*, granted US firms the right to extract resources from celestial bodies. While the SPACE Act stated that this extraction did not amount to appropriation prohibited under the 1967 treaty, not all legal interpretations of the treaty concur. Yet, the adoption of a similar law by space-resource-extraction powerhouse Luxembourg may begin to create international customary law.[110] The principle of international customary law is that the standard, broadly accepted practices of nations, over time, gain the status of international law.[111] Another potential source of international customary law is the legally binding mutual understandings of space set forth by the Artemis Accords. The Artemis Accords, which nations must sign if they wish to participate in NASA's Artemis program, restate some of the core principles of international space law: mutual assistance, publication of research findings, and the common benefit of humankind. However, Section 11 of the accords sets forth a rather sophisticated set of "safety zones" for satellites and stations on celestial bodies, which approximates needed protections for property and sovereignty.[112] By incorporating this interpretation of the 1967 treaty in the Artemis Accords—and then using the peerless soft-power tool of human spaceflight to convince likeminded nations to sign on—the United States is beginning the process of pushing its expansive interpretation into international customary law. Unless other nations challenge this interpretation—raising the fascinating prospect of freedom-of-navigation operations in space—then it may gain widespread acceptance.

The United States should approach the negotiation of the new treaty by working first with likeminded nations. It is likely to be significantly easier to come to agreement with traditional US partners and important space-faring entities like the European Union and Japan. Combined, nations with a view of space security similar to that of the United States constitute a large fraction of activity in space.[113] Once the United States and likeminded nations set forth an approach, other nations and commercial entities will have incentives to adhere to these rules, eventually incentivizing Russia and China to follow what will become an international standard. Moreover, this approach is more likely to generate some results in the short term, which would allow the United States to see immediate benefits from its investment in space diplomacy.

Working with likeminded nations first may risk alienating near-peer competitors Russia and China. While this approach is justified, the United States can take action to avoid complete estrangement from these important actors in space. As such, it is important to keep channels of communication open through limited cooperation in space, such as in space exploration. US-Soviet and US-Russian cooperation in space, whether through Apollo-Soyuz, the Space Shuttle docking with Mir, or the International Space Station, were more a symptom of warming bilateral relations than a cause of them.[114] The United States can also build common understanding with great-power competitors through technical and scientific information exchange on issues such as space-debris mitigation. The Inter-Agency Debris Coordination Committee (IADC) is a forum in which NASA and allied space agencies, such as the European Space Agency, collaborate with the China National Space Administration and Russia's Roscosmos State Space Corporation. It increases the visibility of shared space security concerns, offering a platform to bolster awareness of the threat posed by growing space debris and to create international guidelines for debris mitigation.[115] Participation in ad hoc bodies like the IADC that address specific areas of agreement in space policy could prove a viable mechanism to strengthen mutual understanding between the United States, China, and Russia in space.

Keeping a basic level of cooperation when possible can help build understanding, including forging ties at a technical level between individuals in each nation's space program. This level of technical cooperation is not currently possible with China, due to a law known as the Wolf Amendment. The Biden administration should consider whether cooperation in space with China is a worthwhile diplomatic endeavor, and its legal and congressional-relations teams should evaluate whether these initiatives are possible within the confines of the Wolf Amendment, or if the provision should be repealed.

IN THE MEDIUM TERM (2025 – 2040)

Because negotiating this treaty will likely take years, if not decades, the United States should aim to achieve buy-in from likeminded nations on core principles of space exploration, security, and commerce in the medium term to set the ground for a full treaty. This widespread consensus and mutually accepted practice in space will undergird the development of international customary law that reflects the interests of the United States, its allies, and its partners.

In the medium term, the United States may consider leading the international community in either extending the International Civil Aviation Organization (ICAO) area of responsibility to space or creating an ICAO-like organization for space activity. Doing so may help lay the foundations for customary international law favorable to security and prosperity in space prior to replacing the 1967 accord.

Orbital-debris mitigation is another area in which the United States can seek to synchronize its space policies with those of likeminded nations. The US federal government regulates debris from its nation's space operations by requiring deorbiting plans with a certain timeframe and level of surety and requiring safety plans that mitigate the risk of a debris-generating explosion.[116] By aligning these rules with other major satellite regulators, the United States can forge a common international standard on debris mitigation that could eventually be incorporated into international law. While the United States currently gives conjunction warnings to satellite operators who are coming close enough to risk collision, this system is ad hoc and fragmented, with operators facing an overload of information and false positives.[117] Part of the problem stems from the nature of the US data; SSA data, housed within the Department of Defense, is secretive, undermining transparency and openness surrounding the data.

Instead, the United States should work to create a formalized system that exchanges SSA data with members of the international community. Data-sharing arrangements with existing partners are a good start, and these agreements must be extended, with greater transparency surrounding US SSA data. Due to geographic limitations, the United States cannot glean nearly as much SSA data alone as it can with partners. The fact that the United States has had data-sharing arrangements with twelve nations and fifty-eight international companies in recent years is a promising development, and such arrangements should continue to be fostered.[118] Consistent with a do-no-harm paradigm of space sustainability, doing so would allow the United States to work to keep critical orbital bands free from collisions. Space security is a collective challenge, and the United States stands to benefit from having all hands on deck for data collection and dissemination to satellite operators. Building upon enhanced SSA, the United States can then consult with relevant commercial entities on a set of "best practice" guidelines for effective STM.

By coordinating domestic legislation with likeminded nations in space, leveraging the soft-power appeal of human spaceflight to promote the

50TH SPACE WING PUBLIC AFFAIRS

Coordinating space situational awareness with allies and partners is critical as space becomes increasingly congested with new operators and satellites. Pictured here, 1st Space Operations Squadron Geosynchronous Space Situational Awareness and Space Based Space Surveillance crews operate satellite vehicles in the combined ops floor at Schriever Air Force Base, Colorado.

Artemis Accords, and normalizing the exchange of space-object data, the United States can promote its vision for space through customary international law. Doing so will socialize the ideas behind a new space treaty—when it comes time to put the norms into writing, their inclusion will seem obvious.

IN THE LONG TERM (2040 – 2050)

By 2050, the United States should seek widespread accession to a new, foundational treaty that sets global standards for national security and economic activity in space.[J] Spacefaring nations should construct a modern, internationally agreed-upon order and "rules of the road" for behavior in space. Legal ambiguity, technological advancements that rapidly outpace today's legal architecture, and the increasing value proposition of space commerce that make established rules of the road a necessity to ensure space access and management of behavior and to avoid conflict. International space law must be refined to reflect the transformation space has undergone in the last five decades and to anticipate similarly accelerated change in the coming decades, while remaining cautious not to constrain needed strides in space development. By updating current domestic and international legal and regulatory frameworks, the United States can create order for currently unregulated commercial and defense competition in space.

The 1967 Outer Space Treaty is outdated, fostering uncertainty as businesses and governments rapidly redefine space through novel discoveries and technological breakthroughs.[K] Provisions within the treaty are either too broad, overly specific, or dangerously vague, creating an ambiguous operating environment as spacefaring entities explore commercial resource extraction, launch increasing numbers of satellites into orbit, and deploy destructive space-based military capabilities. Notably absent from any

J Some of the space industry experts with whom the authors spoke asserted that some developments in space will challenge the current international space order within the coming five years. Particularly, these experts note that space resource extraction—at odds with some interpretations of the 1967 treaty—will likely significantly expand well before the thirty-year time period that the authors believe is necessary for a foundational new treaty. While the authors believe that the steps identified in the "In the medium term (2025-2040)" section will address these concerns, the new administration should consider an expedited track for space resource-extraction negotiations.

K See summary of Outer Space Treaty and other pertinent space law in Appendix A.

"By coordinating domestic legislation with like minded nations, leveraging the soft-power appeal of human spaceflight to promote the Artemis Accords, and normalizing the exchange of space-object data, the United States can promote its vision for space through customary international law."

international space-related treaties is language regarding cislunar space, which has since been recognized to contain critical security chokepoints. These legal uncertainties create fertile ground for dispute and conflict in the long term.

To achieve this goal, the United States should work with likeminded nations to reshape the legal governance of space through comprehensive multilateral treaties, reforming the 1967 Outer Space Treaty or replacing it with an agreement that reflects the reality of today's and tomorrow's strategic environment. These accords should shape national security and commercial use of space and celestial bodies, and establish delineated, internationally agreed-upon legal structures for mineral rights, tort law, private-property ownership, claims of right to resources (as well as their extraction and exclusivity), and strategic celestial real-estate law. The primary goal of an updated agreement should be to alleviate ambiguity or conflict that could arise from activities in space, all while operating under a do-no-harm principle promoting space sustainability.

This foundational new space treaty should aim to:

- Guarantee freedom of navigation and exploration in space. Freedom of navigation can be accomplished only through expeditionary space security; limited weaponization in space and the extension of military intelligence, surveillance, and reconnaissance (ISR); and civilian and military communications infrastructure and capabilities throughout outer space, in planetary orbits, and on celestial bodies.
- Continue the Outer Space Treaty's provisions that prohibit the placement or use of nuclear weapons or other weapons of mass destruction in space. As such, even a future international legal framework that loosens restrictions on conventional weapons in space should preserve nonproliferation of nuclear weapons and weapons of mass destruction (WMD). The objective from the 1967 treaty of preserving inclusivity and peaceful uses of space should be cemented as well. However, this legal framework must remain pragmatic to the requirement of space security and defense of peaceful use and access from malign actors.
- Address space sustainability. To do so, the treaty should contain provisions that account for orbital-debris mitigation and removal. Indeed, the need for this provision is likely to increase dramatically by 2050 as the pace of space launch only increases.
- Contain the same ideal of non-appropriation of entire celestial bodies as in the 1967 treaty (that prohibits the establishment of sovereignty over the Moon or any other celestial bodies), but it ought to be clarified so as not to interfere with the placement of peaceful installations on these bodies or prohibit resource extraction. Moreover, the 1967 treaty was correct to rule out appropriation of celestial bodies, but

this new treaty must go further by prohibiting the seizure and exclusion of important orbital zones, such as the Lagrange points, while allowing for legitimate safety zones.

Accountability for this new treaty should be sustained by identifying clear goals, norms, and ideals for inclusion in the new treaty. An accountability or enforcement mechanism that extends beyond customary international law should be included in the treaty to provide a framework for grievance and issue resolution in a timely manner. For instance, similar to the dispute-resolution mechanisms laid out in Part XV of the United Nations Convention on the Law of the Sea, the foundational space treaty should either set forth an international tribunal for space law or identify existing competent bodies, like the Permanent Court of Arbitration, to resolve treaty disputes between nations.[119]

ESTABLISH A SPACE SECURITY ALLIANCE

SHORT TERM (2021-2025)	The United States prioritizes a common understanding of the space security environment and builds capacity. The United States comes to common understandings with allies and partners about mutual interests in space.
MEDIUM TERM (2025-2040)	The United States works with NATO and likeminded partners to develop an ambitious set of aligned activities for cooperation in space. The United States undertakes multilateral and bilateral diplomatic efforts with European and Indo-Pacific allies and partners to socialize the need for a space alliance in the long term.
LONG TERM (2040-2050)	The United States, its existing allies, and new partners commit themselves to a space security alliance which pledges collective security and mutual defense from attacks in the space domain.

Establish a Space Security Alliance

The United States and its allies must create a framework for cooperation and mutual security in space by forming an international space security alliance and extending the reach of existing alliances like NATO—appropriate for the twenty-first century and beyond—to ensure collective security and deter aggression in space. As described earlier in the paper, over the next thirty years, great-power competition is likely to impact activity in space, and space may well be used by the United States' strategic competitors to achieve broader security goals on Earth. As space activity increases, Earth-based activities enabled by space will multiply over time, and space-based activities will have greater potential impact on security on Earth itself. As a result, the securitization of space will become an increasingly important focus, and the establishment and maintenance of collective security among likeminded nations will be important in the long term (2040-2050). To reach this, in the short (2021-2025) and

DOD PHOTO BY GLENN FAWCETT

NATO is a natural starting point for building collective defense in space.

medium terms (2025-2040), the United States should focus on arriving at common understandings of space security with allies and partners and on engaging in coordinated activities in space.

Recent steps by NATO have laid the groundwork. In 2019, NATO allies approved a space strategy that emphasized the need for the Alliance to be "vigilant and resilient—also in space."[120] Designed with input from then- Commander of the US Space Command John Raymond, the strategy emphasizes the need to "work with foreign allies…with commercial companies…to deter conflict."[121] NATO's first-ever space policy is a strong beginning, and this strategy paper proposes using NATO as a framework for the development of a broader space security alliance. In the long term, a new space alliance is needed because existing alliance frameworks, current membership, and remits are unlikely to suffice as activity within space becomes more prevalent. The explosion of activity and actors in space requires a security architecture that is *global* in constituency and focuses not only on space-enabled security on Earth, but on security *within* space itself, especially as more nations develop space forces. No existing alliance structure currently suits those needs; thus, a space security alliance is required in the long term.

IN THE SHORT TERM (2021 – 2025)

Negotiating a space security alliance could take years, if not decades. The United States, however, does not need to start the process from a blank slate; rather, it can, and should, leverage its worldwide network of allies and partners. Existing allies can eventually form the nucleus of a new space security alliance. But, in the short term, the United States should prioritize a common understanding of the space security environment and build capacity.

The United States must leverage existing allies to protect its interests in space and contribute to global space security. One way forward is to come to common understandings with allies about mutual interests in space. NATO provides an encouraging example of this approach. NATO declared space as its fifth domain of operations in 2019 and has since developed the beginnings of a NATO Space Policy.[122]

Further, the United States can activate existing alliances to build international consensus on the protection of space-related assets and develop a shared understanding of the importance of defending key resources and access. Establishing a space alliance will take time and political buy-in, so in the short to medium term, the United States should communicate with existing allies and new partners on the eventual need for an alliance to establish collective security in space.

IN THE MEDIUM TERM (2025 – 2040)

The United States should work with NATO allies and partners to develop an ambitious set of aligned activities, including shared intelligence, situational awareness and understanding of developing threats, and aligned rules of the road for space governance and activity. The space security alliance should establish a shared understanding of collective security in space, to deter and repel aggressive behavior and ensure shared security. Publicized, coordinated activities in space—even if of an entirely nonmilitary or defensive nature (for example, a drill that exercises the Alliance's response to an accidental satellite collision)—would increase NATO's credibility in the domain. Expanding NATO's Space Policy over the next five years will be critical to paving the way for a credible space security alliance that includes additional allies and partners and that is prepared to adapt to a more active and congested space domain.

While NATO is a natural starting point, the United States also has a variety of bilateral allies in the Indo-Pacific with a history of collaborating in space with the United States. Australia, for instance, cooperates with the United States on satellite communications.[123] Japan and South Korea also have sophisticated space programs. The United States should undertake multilateral and bilateral diplomatic efforts with European and Indo-Pacific allies and partners to engage in activity in space and socialize the need for a space security alliance in the long term.

> "Enhanced cooperation in space—whether it be research, dealing with space debris, or deconflicting satellite orbits—may be one avenue to improving overall relations [among great-power competitors]."

IN THE LONG TERM (2040 – 2050)

By 2050, the United States, its existing allies, and new partners should commit themselves to a space alliance that pledges collective security in space and defense from attacks in the space domain.

To help stabilize key regions and domains in a way that multiplies US security and permits sustainable expenditures, the United States traditionally relies on allies and partners. A space security alliance will extend collective security on Earth to space, protecting access to space for all, and assuring agreed rules of the road.

This space security alliance should promote cooperation among allies and partners and establish and guarantee collective security. A key first task for the alliance will be to devise a tailored strategy, building on this thirty-year strategy for space, to counter hostile action and guarantee safe access and passage, free from malign interference, in space. A space security alliance should deter countries known to be undermining collective access and security in space—or those nations that have actions in, and goals for, space that are not entirely known. This strategy must be flexible enough to keep up with rapidly advancing technology and establish rules of the road for conduct and cooperation in space, deterring adversarial action that jeopardizes the space commons. While the United States and its allies will always reserve the right to defend themselves, they must identify ways to extend their long history of working with competitors when appropriate. Even competitors of the United States recognize that the space domain is so dynamic, diverse, critical to advancing humanity, and interconnected that one entity could not possibly act alone to secure space.

In the years ahead, the United States and its allies and partners will need to walk a difficult line between all-out competition with near-peers like China and Russia and cooperation on issues including addressing the climate crisis, reforming the world health system in the wake of COVID-19, and realigning international trade. Enhanced cooperation in space—whether it be research, dealing with space debris, or deconflicting satellite orbits—may be one avenue to improving overall relations. While it is foolish to think of space exclusively as a domain of peaceful cooperation, it is equally unhelpful to emphasize only competition in space.

Accelerate Space Commerce through Clear Regulation and Targeted Investment

To facilitate the transition to an orbital economy in the long term (2040-2050) and maximize space-based services to Earth in the short term (2021-2025), the US government should invest in space launch, satellite-constellation operations, upgraded space power and propellants, on-orbit services, and ISRU; prepare for rocket transportation; develop innovative ways of harnessing the private sector; and secure supply chains critical to the manufacture of space components. It is difficult, if not impossible, to predict which technologies will be critical in thirty years' time. To account for the nonlinear nature of technological development, this strategy recommends investing in some specific technologies to push the envelope of space development in the short term and engaging in reforms to government practices that will encourage the development of space technology throughout the thirty-year timeframe of this strategy.

ACCELERATE SPACE COMMERCE THROUGH CLEAR REGULATION AND TARGETED INVESTMENT

SHORT TERM (2021-2025)	The United States increases national investment in research and development, specifically to ensure emerging space developments are leveraged for US and allied interests. US government reviews existing acquisition policies and regulations that hinder public-private cooperation and space technology advancement. US officials carefully monitor critical supply chains for critical space components.
MEDIUM TERM (2025-2040)	US government undertakes efforts to regulate rocket launch and build landing infrastructure. The United States works with key allies and partners, notably in Europe and Asia, to build space ports.
LONG TERM (2040-2050)	The national security space community reevaluates which technologies should be prioritized for investment in coordination with industry and academia. The United States and its allies develop disaggregated, multidomain, and mobile launch platforms.

"To remain competitive in the twenty-first century, civilian policymakers and Pentagon officials should invest in emerging technologies, support a talent pipeline of space experts, and more effectively harness ingenuity from the private sector."

HARNESS THE PRIVATE SECTOR

US space policy must be formulated with the end goal of further expanding routine human economic activity beyond Earth in the short term that can be sustained in the long term. US space policies have historically focused on civil exploration and national security intelligence gathering. However, the scope of space policy is changing, driven by the continued expansion of space-faring activities and the growing commercial use of space.[124] To remain competitive in the twenty-first century, civilian policymakers and Pentagon officials should invest in emerging technologies, support a talent pipeline of space experts, and more effectively harness ingenuity from the private sector.

IN THE SHORT TERM (2021 – 2025)

To nurture a private sector that best supports US policy, national investment in research and development (R&D) must increase. In 1960, US government defense-related research and development accounted for 36 percent of global R&D, but by 2016, it fell to less than 4 percent.[125] While this decline can be attributed to rapid increases in the R&D of other nations and the private sector, the Pentagon's leading role in global R&D has waned. By another measure, while US R&D expenditures since 1960 grew by a factor of thirty-seven, in current dollars the US share of global R&D has dropped from 69 percent to 28 percent.[126] This decline leaves critical gaps in the development of breakthrough technologies compared to potential adversaries. To secure US interests in space, this R&D in space should be increased to ensure that this burgeoning domain of operations is used to support broader US and allied goals.

This imperative also requires a review of existing government acquisition policies and regulations that, while designed to be fair and avoid waste and abuse, can be slow moving, risk averse, and process based rather than outcome oriented. Public-private-sector cooperation in space can be better harnessed, and the technology required for the United States to maintain its leading edge requires the government agencies to harness and encourage the innovations of small and large businesses.

For the private sector to be leveraged effectively to help the United States achieve its goals and exploration in space, the US government should ensure that the space industrial base has access to the supplies that it needs. Throughout this thirty-year strategy, US officials working on space policy should carefully monitor critical supply chains for critical space components, such that vulnerabilities (like those introduced by the rare-Earth-element crisis of 2010) do not reemerge.

ROCKET TRANSPORTATION

IN THE MEDIUM TERM (2025 – 2040)

The use of rockets to transport time-sensitive goods across the globe—including for humanitarian assistance and disaster relief in response to crises—will come to fruition for military, and potentially commercial, use in the period from 2025 to 2040. While rocket transportation will likely attract military customers at first, use of rocket transportation by the US government may eventually create economies of scale that attract private entities. Perhaps unused payload mass on US military rocket transportation should be offered on a fixed-price, space-available basis to commercial entities. Where feasible, US government rocket-transportation infrastructure should be made available to private entities as well.

For military rocket transportation and potential commercial applications to thrive, the US government should undertake efforts to regulate rocket flight and build landing infrastructure. International regulations should cover launch notification, so that cargo rockets are not mistaken by early-warning sensors as intercontinental ballistic missiles.

Point-to-point transportation involves sending a rocket with a cargo payload into low-Earth orbit and then deorbiting the rocket to safely land its

NASA

To foster an expansive space economy, US and allied space agencies will need to invest in keystone technologies and space-related research and development. Pictured here, the Hubble Space Telescope has been operating for over twenty-five years and, at its inception, was considered a significant research advancement.

Rocket launch sites worldwide, 1940 – 2021

The addition of new rocket launch sites points to enhanced space activity today, while promising opportunities for coordination of international rocket launch and transportation tomorrow.

Country has launch capabilities ● Rocket launch sites throughout the space age

Data drawn from Wikipedia, "List of rocket launch sites," excluding solely missiles test sites, sites with fewer than ten launches, and sites with only suborbital launches.

A proliferation of countries with rocket launch sites—including in Latin America, Europe, and the Indo-Pacific—indicates an increase in space activity today. This trend also indicates promising opportunities for countries to coordinate on international rocket launch and transportation in the future.

payload in another place on Earth. Like a ballistic missile, a cargo rocket could cross intercontinental distances in a matter of minutes, compared to the hours or days that it might take a cargo plane to reach the same distance.

However, point-to-point transportation around the Earth transiting space is only as useful as the number of points that can support cargo rockets. While the US military is already considering rockets for prompt global transportation, it must bring allies and partners into the conversation for maximum efficacy, as it is largely their territory that would receive cargo rockets; space ports are of little use to the United States unless other nations agree to host them as well. The next step is for the United States to work with key allies and partners—notably in Europe—to build these space ports. Earth-based activity and transportation, enabled by space, are coming in the next few decades, and allies will want a stake. The United States should prioritize collaboration with existing allies and partners in Europe and Asia to enable cooperation building out space ports on the European and Asian continents in parallel to those in the United States.

INVEST IN KEYSTONE TECHNOLOGIES

The US government has an important role to play in technology investment, and it should prioritize the development of keystone technologies for space.

IN THE LONG TERM (2040 – 2050)

Throughout the timeframe of this strategy, the national security space community will need to evaluate and reevaluate which technologies should be prioritized for investment to meet the goal laid out above.

Today's critical keystone technologies include satellite-constellation operations and smallsat technology. The dominant paradigm of orbital-asset operation relies on a handful of bus-sized, exquisite, billion-dollar satellites. But, a new generation of satellite operators is seeking to distribute that functionality across dozens, hundreds, or even thousands of much smaller satellites that can cooperate. The loss of any one satellite is not destructive for the entire constellation, and the architecture can be upgraded in blocks. Satellite miniaturization, communication within satellite networks (including laser communication), and mitigation of environmental impact (e.g., interference with terrestrial astronomy, debris generation) are areas within this keystone technology area worthy of investment. Small-satellite constellations, when used for national security missions, could deter counterspace attack by direct-ascent ASATs, because the cost of building and launching a missile into space exceeds the tactical value of destroying only one node in a large and self-healing network.

Large satellite-constellation operations contribute to another keystone technology: operationally responsive space (ORS). The cost of sending a payload to space has been steadily decreasing over time, but new space-launch technologies promise to further revolutionize this key mission enabler. For instance, reusable launch vehicles are able to launch to space, return to Earth, and then be reconfigured for additional missions, saving a great deal of money compared to expendable launch vehicles, which are destroyed on reentry. Future space architectures will be built around inexpensive and flexible space assets and space launch.

The ORS paradigm differs from traditional space programs, which produce exquisite, very expensive satellites for small and limited production runs with years of lead time. By contrast, ORS emphasizes rapid design and fabrication of satellites with "good enough" capabilities. These satellites can be prepositioned near launch sites in order to surge capacity to a conflict zone or reconstitute a satellite constellation that comes under attack.[127] ORS demands a new concept of space launch, which currently takes place

"The cost of sending a payload to space has been steadily decreasing over time, but new space-launch technologies promise to further revolutionize this key mission enabler."

almost exclusively from a handful of fixed, coastal sites that are eminently vulnerable to attack in the event of major conflict. In addition to these fixed launch sites, the United States and its allies need to develop disaggregated, multidomain, and mobile launch platforms. The ability to launch from land, sea, air, and space from mobile platforms would frustrate a hostile effort to deny US access to space in a conflict. Because launching from these platforms can be more expensive and less reliable than doing so from traditional fixed sites (and, thus, is mostly unattractive to commercial users), the US government has a unique role in creating a market for these technologies. US government investment in these technologies might eventually yield positive externalities for commercial users as well. Consider air launch, which allows space users to customize the geographic location of their space launch, potentially reducing fuel consumption. Launching from mobile platforms, such as air launch, allows satellite operators to launch from closer to the equator, giving a boost to space launch due to Earth's orbit.

All space missions rely on power and propellent systems, meriting their inclusion on the list of keystone technologies. All satellites in Earth orbit and beyond need to generate electrical power to drive their station-keeping engines and operate their payloads. Space officials should carefully monitor the supply chain for solar cells (which are used to power most missions in Earth orbit) and plutonium (which heats and powers deep-space probes) and invest in technologies to generate power more efficiently using these means.[128] Critical to the success of sustainable missions to the Moon and beyond is ISRU, or the extraction of material from the lunar or asteroid surface and processing it into rocket fuel or an important resource like water.

Reliable ISRU on the moon, Mars, and other planetary bodies would allow for missions to launch with less fuel mass and eventually permit missions to originate on the Moon, with its advantageous lower gravity, and facilitate permanent lunar settlement. Already, spacefaring nations and companies recognize the lucrative potential of asteroid mining of rare metal elements—a football-field-sized asteroid could produce $50 billion in platinum—and are pressing for matured ISRU technology in the short term.[129] The European Space Agency anticipates the first ISRU technology in space will consist of oxygen production on the Moon by 2030.[130] Conversely, launch technology has rapidly become more economically feasible over the years, enabling ISRU prospects. SpaceX's Falcon Heavy recent payloads cost approximately $1,500 per kilogram, down from the Space Shuttle cost of $65,400 per kilogram between the 1980s and 2000s.[131] However, many future space-based missions, such as returning humans or rare metal elements from space back to Earth, will heavily depend on fuel. Eventually, the practice of collecting and processing materials on and from astronomical bodies may replace the current constraints of carrying this same material from Earth. The potential exists to reduce payload costs for expendable resources by producing, harvesting, or collecting them in space with ISRU technology. ISRU not only provides materials for propellants—the chemical substances that generate vehicle propulsion, supporting launches from elevations outside of Earth's gravity well—but has the potential to harvest

"While cislunar space is vast, the Lagrange points of the Earth-Moon system deserve special attention."

Helium-3, a clean and efficient form of energy brought to the Moon by solar wind.[132] This could enable clean fusion energy.

A final keystone technology worth consideration is on-orbit servicing. For many satellites, the limiting factor on their lifespan is not their payload, but their quantity of fuel. On-orbit servicing encompasses inspecting, refueling, and repairing satellites to expand their lifespans. Moreover, the technologies for service satellites to rendezvous and interact with other satellites could be used for deorbiting expired satellites.[133] Extending the life of satellites would be a further paradigm shift in satellite operations, which could reduce orbital debris and make space launch more profitable.

The risk of government promotion of certain keystone technologies is that government agencies may not be able to "pick winners and losers" as efficiently as the free market. To avoid this pitfall, government analysts should take two approaches. First, they should consult as closely as possible with experts from industry and academia in identifying key technologies. Second, to the extent possible, government agencies should set requirements and invest in multiple technologies that meet that requirement (e.g., the ability to transmit data with low latency) rather than specifying a technology (e.g., laser communications) that is only one solution to a requirement.

Take a Cislunar Approach to Space

To achieve long-term security and prosperity in space, the United States should emphasize the development of cislunar space, the sphere formed by the Earth-Moon radius. Doing so will require steps in the short (2021-2025), medium (2025-2040), and long (2040-2050) term. In the short term, the new administration should evaluate the Artemis program to determine if its present goals and timeline are realistic. In the medium term, the United States should field a full suite of sensors and communications assets in cislunar space for national security and intelligence purposes. Finally, the United States, in cooperation with international partners, should seek international management of the Lagrange points and work to build physical infrastructure at these points in the long term.

TAKE A CISLUNAR APPROACH TO SPACE

SHORT TERM (2021-2025)	NASA evaluates the Artemis program and adjusts benchmarks for its space exploration program if needed, prioritizing a deep-space exploration program.
MEDIUM TERM (2025-2040)	The United States considers the implications of military satellites and SSA for the routinization of cislunar space.
LONG TERM (2040-2050)	NASA develops infrastructure at the Lagrange points while US diplomats negotiate an international framework to regulate the use of cislunar space. The United States and likeminded nations build out a presence at the Lagrange points to eventually transition to commercial operators.

IN THE SHORT TERM (2021 – 2025)

The United States plans to return to the Moon under the aegis of the Artemis program, planning to land the first woman and next man on the lunar surface by 2024. As part of this effort, NASA and its international partners plan to construct the Gateway, a miniature space station in lunar orbit. The use of commercial components in the Gateway, commercial rocketry to reach the Moon, and commercial payloads for Moon science seek to create a market for private firms to develop technology relevant to operating in cislunar space.[134] Indeed, NASA is already contracting with private firms to mine small samples of lunar material.[135] However, many have criticized the Artemis plan for its unrealistic timeline, expensive approach, and technical risks.[136] The new administration should take these criticisms under advisement, balancing the need to adjust a program to address these criticisms and meet more achievable timelines with the commitments previously made to other nations and the American people. Over the next four years, regardless of the name or framework of the program, the US government should prioritize a deep-space exploration program with positive externalities for security and economic development of cislunar space.

IN THE MEDIUM TERM (2025 – 2040)

In this context, there are several potential medium-term applications of cislunar space. While most Earth observation use cases benefit from proximity to Earth, several missions are more feasible if the observing satellite is at a distance. SSA is the process of observing and categorizing objects in space, particularly those in Earth orbit that may impact the operations of other assets. A satellite in a distant cislunar orbit would be able to see a broader array of space objects than any one sensor on Earth or in Earth orbit. That is the purpose of the Cislunar Highway Patrol Satellite mentioned earlier.[137] Similarly, the United States might consider placing satellites capable of detecting terrestrial nuclear launches or detonations in cislunar orbit. The advantages of doing so could include observing a larger fraction of the planet and being less vulnerable to direct-ascent ASATs and the effects of nuclear detonations in Earth orbit. In fact, the United States formerly deployed such a satellite in cislunar space: the 1960s–1970s Vela nuclear-detonation-detection satellite series was placed at an altitude of approximately sixty thousand miles, roughly triple the altitude of GEO and a quarter of the way to the Moon.[138] Given recent concerns that high-end conventional conflict in space could generate nuclear escalatory pressures, offloading strategic satellites from LEO and GEO to cislunar space could be stabilizing.[139] In the same vein, there may well be cislunar applications for military satellite communications.[140]

Moreover, as more nations place important assets in cislunar space, the United States must expand its SSA to that region. According to one space expert, the United States had more ability to observe Sputnik in 1957 than it does now to observe objects above GEO.[141] As such, an important mission in the medium term is improving the United States' ability to characterize the cislunar space environment.

In sum, the US government should leverage the marketplace for cislunar launch that it is creating as part of the Artemis program to avail itself of the many opportunities to use cislunar space for national security purposes.

IN THE LONG TERM (2040 – 2050)

In the long term, NASA should develop infrastructure at the Lagrange points, while US diplomats seek to negotiate an international framework to regulate use of these points and other valuable cislunar real estate. To open up cislunar space in the long term, the United States must address the security of, and access to, the Lagrange points. While cislunar space is vast, the Lagrange points of the Earth-Moon system deserve special attention. Lagrange points are one-dimensional. However, in practice, spacecraft in the L1 and L2 points, useful for observation, are placed in a so-called halo orbit around a Lagrange point. Such an orbit—like geosynchronous Earth orbit—can support only a limited number of spacecraft. Just as the ITU regulates satellite positioning in GEO, so too must a future legal framework devise a means of allocating access to the Lagrange points in a manner that prevents any one state from dominating these regions or excluding other nations from accessing them. Moreover, future defense agreements in space should eventually expand to cover the Lagrange points. International law and thoughtful regulation can prevent a tragedy of the commons at the Lagrange points.

The Lagrange points will be useful for government space agencies but could also prove lucrative for commercial entities in ways that current strategists cannot anticipate. The International Space Station currently hosts (or will soon host) non-governmental science, industrial, and tourist payloads; NASA promotes these commercial opportunities as part of its "LEO economy."[142] US space strategists, working with allies and partners, must build out US presence at the Lagrange points in such a manner that these facilities can co-host commercial modules and, eventually, be transitioned to private-sector operators. Doing so will lend the United States and its partners an advantage in the future "cislunar economy."

While the Lagrange points offer one attractive orbit in cislunar space that is obvious to strategists today, there is a potential for other orbital "real estate" in cislunar space to become contested over the next thirty years. Furthermore, similarly advantageous zones of the solar system may be reached, and their potential realized, in the coming decades. For example, the moons of planets like Mars, Jupiter, and Saturn, and other bodies in space, such as the planetoid Ceres and asteroids, provide fertile ground for mining operations. Securing cislunar space will provide a critical trial in protecting these valuable zones for sustainable space exploration.[143] By working to wisely and proactively manage the Lagrange points, the United States can set the international standard for constructive resolution of future debates in cislunar space and beyond.

CHAPTER 4

GUIDELINES FOR IMPLEMENTATION

In pursuit of the goals of this strategy, US policymakers should coordinate with allies and partners to execute the major elements of this strategy using the following guidelines for implementation. Policymakers must weigh these recommendations with potential drawbacks and alternatives.

1. Space Law and Policy

To facilitate space commerce and sustainability by guaranteeing sovereignty and property rights in space, the United States must work to implement new treaties, laws, frameworks, and organizations governing space from the international to the subnational levels.

ESTABLISH A NEW COMPREHENSIVE SPACE TREATY

The United States and its allies must lead an effort to draft a new, foundational space treaty. This process will require consistent buy-in from US national leadership to commit the US diplomatic corps to consensus-building discussions, bilateral and multilateral negotiation rounds, and early input from the international legal community. While negotiations to rewrite a new treaty will be a longer-term process, existing treaties such as the Liability Convention must be revisited to ensure that they reflect modern conceptions of space commerce and security.

Content of the Treaty

The content of a foundational new space treaty will likely take many years to coordinate, negotiate, and come to agreement on. However, the groundwork for the treaty should begin sooner rather than later. In the next five years, the United States and likeminded nations should spend considerable time discussing and working through areas that will require socialization of key issues and clear language that can be used in a new treaty.

In developing a new foundational space treaty, historical legal frameworks should be used as a reference point, but modern and emerging legal frameworks may be more appropriate analogies for the space domain. The key for policymakers is to, over time, make incremental improvements by collaborating with key stakeholders, which will eventually lead to a new foundational space treaty. This treaty should develop the framework to govern ownership and delineate access, limitations, and rights for commercial activities and infrastructure in space, to include the Lagrange points.

"The United States and its allies must lead an effort to draft a new, foundational space treaty."

Considerations for the treaty may also include: terrestrial precedents, statutes, and case law as a guide; preserving the prohibition on the national appropriation of entire planets and planetary bodies while balancing modifications to spur commercial growth; addressing the security of, and consensus-based special protections for, Lagrange points as critical for future access to space; and prohibitions of landmines on celestial bodies, among other issues.

Negotiating the Treaty

Negotiations for this new, foundational treaty should begin now, build on best practices of past comprehensive multilateral negotiations, and avoid those negotiations' mistakes. While the treaty may take some time to finalize and materialize, negotiations must begin early in order to determine the framework. The new treaty could start as a "working" treaty that is adhered to in principle as it evolves, but will be signed and ratified no later than 2050. Negotiators should consider legal regimes of comparable complexity, such as the UN Convention on the Law of the Sea (UNCLOS), which governs access to and activity within the high seas (although, ironically, the United States has never signed on to UNCLOS because it disagrees with a resource-extraction provision).[144] Numerous exploratory negotiations will need to be conducted, and these bilateral negotiations must begin early this decade. New US presidential administrations are an opportune time to implement such negotiations and legal exploration, marshaling diplomats from the Department of State, particularly the Offices of Space and Treaty Affairs and the Bureau of International Security and Nonproliferation, among others, to make necessary overtures to allied nations. It is imperative that the United States appoint a special presidential envoy for space security at the Department of State. Further, the US State Department should create a space-centric office within the Bureau of International Security and Nonproliferation that would focus on multilateral efforts in creation, implementation, and maintenance of the treaty.

Implementing this treaty will require outreach to existing allies, new partners, and international organizations. The United States should start by engaging its closest spacefaring allies, like those in NATO, while making concurrent overtures to other allies and partners with developed space industries. Buy-in to the new legal framework must be broad based to be effective. Once a substantial number of allies and partners become engaged, the US ambassador to the UN should consult the UN Committee on the Peaceful Uses of Outer Space and its legal subcommittee for insight and support in the exploration, drafting, and implementation of the new treaty. Concessions, arguments, incentives, and soft power will be required to encourage nations to join in this process of crafting a wide-ranging, agreed-upon treaty, and the treaty should become a focus of subsequent strategy research and focus by policymakers.

This foundational space treaty should replace the 1967 Outer Space Treaty and other outdated accords on space. US negotiators should aim to build broad consensus around this new treaty supplanting the 1967 treaty. An alternate path could include seeking amendments to the 1967 treaty to

“The United States must be clear in its intentions of renegotiating a new treaty, including communicating that the strategic environment has evolved dramatically since the ratification of the 1967 Outer Space Treaty...”

eliminate some of its most outdated provisions. If the new, foundational treaty gains widespread acceptance, then the United States and its allies and partners could decide that customary international law favors its provisions over obsolete elements of the 1967 treaty. If all else fails, US negotiators should consider engaging in consultations with allies and partners about entering diplomatic reservations to the 1967 treaty or even considering withdrawal. Unilateral withdrawal from the 1967 treaty, however, would be deleterious to US foreign relations and would only be justified by a dire turn in the international security environment.

Policymakers should consider potential drawbacks to seeking a new international framework for space, especially one that seeks to increase defense-related activity in space. The United States and its allies must be wary of perceptions that the treaty could be used to legitimize a military buildup in space. It may be that the existing legal regime constrains countries like China and Russia from developing additional weapons in space. On the flip side, even US efforts to negotiate this treaty could touch off fears of US aggression in space. US allies, partners, and other third countries might not perceive the same space threat from revisionist nations or see the same need to secure space for commerce. Countries like Russia and China might perceive US diplomatic efforts to promote security in space as a precursor to fielding weapons or missile defenses in space. This perception could undermine strategic stability on Earth and disincentivize Russia and China from engaging in needed nuclear arms control. Thus, consistent messaging about the nature of the threats and opportunities in space, and a deft reading of international opinion, will be crucial to preventing a diplomatic opening from being perceived as a US attempt to hegemonize space. The United States must be clear in its intentions of renegotiating a new treaty, including communicating that the strategic environment has evolved dramatically since the ratification of the 1967 Outer Space Treaty. By 2050—almost one hundred years later—it is only right to implement updated international norms to fit the strategic environment of a new era.

One specific area the special presidential envoy for space can address is the uncontrolled airspace above the National Airspace System (NAS), currently established at flight level 600 (FL600). One suggestion is to extend the NAS from FL600 to the beginning of space at the Kármán line, defined as 100 kilometers (or 330,000 feet) above Earth. In the short term, governance and regulation need to be addressed for this uncontrolled region, to prevent mishaps and to promote security at the nexus of the high atmosphere and low space.

AMEND EXISTING TREATIES

In the medium term, the United States should lead the review of existing space treaties. The liability convention should be amended to better address future issues arising from space congestion and conflict. Negotiators should reexamine the absolute-liability clause and the totality of government liability for private entities. A more mature space-liability regime would rely on private insurance in place of sovereign financial responsibility.

MOON TREATY

The Moon Treaty was adopted by the UN General Assembly in 1979 and entered into force in 1984.[145] Established with the intention of preventing countries from seizing territory on the Moon, the Moon Treaty reaffirmed the Outer Space Treaty's requirement for peaceful use of celestial bodies. Specifically, it restricted disruptions (such as the establishment of bases or extractive activities). The United States has not signed onto the 1979 Moon Treaty, and neither have Russia and China. The Moon Treaty provides little effective regulation of great-power activities, offering an example of the challenges of navigating space development and negotiating a viable framework for international governance. The United States and the international community should seek to review the Moon Treaty and incorporate any viable components into the new foundational space treaty. When the new treaty is eventually signed and ratified, the Moon Treaty can be rescinded, as it will be obsolete.

US FEDERAL RECOMMENDATIONS

The Biden administration should work with Congress to make permanent, by statute, the US Space Council, revived by the Donald Trump administration. This permanently codified council should consist of a similar body of representatives to its 2020 version, chaired by the vice president, and with the addition of senior heads of the US Space Force, Space Command, and the National Security Council. The inclusion of the vice president is essential to maintaining high-level political focus on space issues. A short-term priority for the National Space Council should be the acceleration of space commerce. One tool at the council's disposal is streamlining federal regulations for space. To do so, the council could solicit feedback from the space industry, including through a body similar to the Users' Advisory Group or public hearings. As many of these regulatory issues as possible should be resolved at the staff level, but the inclusion of Cabinet-level principals is necessary when departments and agencies find themselves at loggerheads. The administration should consider adding the head of the Small Business Administration to the space council to advocate for the important role of smaller firms in the space industrial base.

The US government should continue to review Department of Defense and military departments for inefficiencies in space-related procurement

DOD PHOTO BY US ARMY SGT. JAMES MCCANN

Members of the National Space Council in attendance listen to panel testimony during the 2nd National Space Council meeting at the John F. Kennedy Space Center Space Shuttle Processing Facility, Florida, Feb. 21, 2018

in the short term. Simultaneously, the USSF Space Systems Command, planned to stand up in early 2021, will be the new acquisition arm for the US Space Force.[146] The intent is to capitalize on recent acquisition reform by empowering space experts and more rapidly fielding space capabilities. A streamlined space-procurement process would centralize space-related equipment purchasing and oversight, and potentially increase efficiency in space projects, missions, and technological advancement.

In addition to the bimonthly testimony before the congressional defense committees required in the fiscal year 2020 National Defense Authorization Act through 2023, legislators should consider forming a commission at the end of the mandated reporting period to consider whether it is appropriate to create a Department of the Space Force.[147] The 2019 Space Policy Directive-4 envisioned a "future military department within the Department of Defense that will be responsible for organizing, training, and equipping the US Space Force."[148] The US Space Force may fit the model set out by the Marine Corps, which falls within the Department of the Navy. Or, the Air Force model might be more appropriate—once the US Army Air Corps separated from the US Army in 1947, it became its own service department. Either way, it would be prudent to allow the US Space Force to operate for some time before further disruptive reorganization is considered. Regardless of a potential future decision to sever the USSF from the USAF, the USSF should accept Army and Navy space assets, both personnel and capabilities, that will provide synergies across the DoD. The proposed strategy requires a presidential special envoy for space to tackle the paper's recommendations, based on the broad scope of the challenge. When space norms, governance, and laws become modernized and codified in updated legal documents, a special presidential envoy for space will not be required. When this occurs, an ambassador for space should be designated, who will then represent the United States at the United Nations and across the globe. This transition will mark the difference between the current space environment, "space rush," and a thriving commercial environment that requires stable and predictable representation on the global stage, like an ambassador.

While there are certain benefits to maturing the federal government's space agencies, there is also a risk of stovepiping. For instance, on one hand, a potential Department of the Space Force could be more efficient, by creating a corps of acquisition professionals, doctrine writers, force planners, and other professionals with a sole focus on space. On the other hand, space will remain primarily an enabler of maneuver and combat on Earth (and in cyberspace). So long as the goal is to integrate space capabilities into other elements of national power, a siloed Space Force Department could undermine that goal. Similarly, the construction of a National Space Council would be key to its effectiveness. A council that considered—or only had the authority or staffing to consider—space in isolation could do more harm than good.

US STATE-LEVEL RECOMMENDATIONS

In the short term, state-level decision-makers should review and draft regulations for space launch and landing facilities as the need for this infrastructure develops. These regulations should accommodate space traffic, deconflict airspace, and provide legal avenues for the facilitation of space commerce. While the need for new frameworks may not be apparent to state legislators today, statehouses and governors must be informed by experts and incentivized by federal grants to prepare for future space commerce. State-level legal standardization, such as through a uniform space code, would provide the legal stability for private firms to confidently invest in the infrastructure and facilities that further prepare the domestic US space landscape. Doing so will initiate a virtuous cycle in which a growing space-industrial base enables more ambitious goals for national security purposes, buttressed by technological advances, such as reusable rocketry.

Federal policymakers should encourage, and possibly incentivize, states to enact domestic space infrastructure legislation for launch pad facilities, among other future space-commerce needs. This can be achieved through open dialogue with state governors and legislative members, collaborating on ideas of future space commerce within their states and districts, and specific benefits new legislative groundwork could potentially provide for their respective stakeholders and economies. Further incentivization can be done through federal legislation providing fiscal support to states and municipalities implementing such space-related regulations.

Beyond launch infrastructure, states can incentivize the space economy by investing in state-university research programs and providing incentives to space businesses.

2. Space Security Alliance

In the short (2021-2025) to medium term (2025-2040), to demonstrate the US commitment to space-related security, the president of the United States should direct the US National Space Council to create a plan to develop a space security alliance. The alliance's purpose will be to preserve the collective interests of spacefaring nations and enhance security in space. The National Space Council's plan should require the US secretaries of State and Defense, or the presidential space envoy, to discuss with allied nations the need for a space security alliance in the long term, starting with NATO members. The United States should use the forums of NATO defense and foreign ministerial meetings to advance conversations about space security among NATO allies and partners and develop a consensus around the need to extend collective security guarantees in space. A critical area of focus should be not only how space secures Earth, but also security within space itself, including that of critical assets. Eventually, the United States and other NATO member states must seek buy-in from countries outside of existing alliance networks that are likeminded and spacefaring, necessitating the need for a broader security architecture or alliance for space.

Much like other international organizations, the space security alliance—formed in the long term—should have clear rules for membership, funding, dispute resolution, and defense obligations. Additionally, the new alliance should consider developing and implementing a policy dedicated to creating norms around the deployment of weapons in space and a response plan should they be violated.

While the United States benefits tremendously from its alliance network, alliances are not an unalloyed good. The United States must make sure that its promises to defend allied assets in space are aligned with its capabilities to do so. If a space alliance is seen as the United States' weakest alliance link, that condition could incentivize an attack by near-peer competitors seeking to undo the US alliance network. This risk can be mitigated by the creation of a strong and integrated collective security agreement for space that acknowledges the interconnection between security in space and on Earth.

3. Cislunar Space

NASA should evaluate whether its ambitious timeline and plans to explore the Moon are realistic and work with Congress to ensure that the Artemis program has fiscal and programmatic stability. Future implementation of the Artemis program and other efforts to explore cislunar space should continue to rely on commercial components and create markets for commercial providers wherever possible.

As a long-term consideration for the management of Lagrange points, the United States should set out a plan to construct infrastructure at some of the points by 2050. This infrastructure would lay the groundwork for international collaboration around these points, and would have the capability to monitor and regulate these key gateways to deep space, ensuring collective access to, travel through, and protection of the Lagrange points. The US Space Council should conduct a feasibility study into appropriate Lagrange point infrastructure and determine the costs and steps to build out infrastructure at the most feasible points.

4. Rocket Transportation

In the medium term (2025-2040), the United States should pursue rocket transportation for military and commercial purposes. US Transportation Command should proceed with its plan to develop space ports for both military and civilian use. In doing so, it should collaborate with US delegates to NATO to incorporate space transportation into the Alliance's plan for military mobility. NASA and the national laboratories should identify and conduct proof-of-concept experiments for time-sensitive, civilian payloads, such as rapid transport of organ donations. The Pentagon should also examine the feasibility of establishing voluntary partnerships with the commercial space industry, like the existing Civil Reserve Air Fleet.

5. Emerging Space Defense Technologies

The United States should develop and deploy electromagnetic countermeasures to its most valuable satellites and downlink stations. The United States already deploys some of this technology and should immediately expand EW capabilities to defend US and allied equipment and communications availability, especially in crisis. Space-based EW defenses are a priority both for counter-jamming and for kinetic countermeasures. Both direct-ascent and co-orbital ASATs rely on terminal guidance that can be defeated by EW. The United States should focus on developing electromagnetic defenses to defeat threats in space. This approach will protect US, allied, and partner space-based capabilities, while remaining sensitive to the perception that space is being weaponized.

TECH. SGT. ROBERT BARNETT, SECRETARY OF THE AIR FORCE PUBLIC AFFAIRS

The Space Force is the sixth branch of service that was established during the signing of the National Defense Authorization Act on Dec. 20, 2019. The newest branch is developing its own human-capital strategy, with hopes to capture the STEM skills integral to space operations.

6. Public-Private Partnerships

In the 1850s, the US government recognized the need for efficient rail transport to the Pacific coast. President Abraham Lincoln understood that building infrastructure would allow the United States to secure its claim to the American West against foreign aggression. In 1862, the Pacific Railway Act was signed into law. This law authorized two private railroad companies to construct the lines, and provided government bonds to help fund the work. This public-private partnership led to the successful completion of the transcontinental railroad—considered one of the greatest technological achievements of the nineteenth century—as well as the growth of "[i]ndustries that were unimaginable at the time the railroad was first envisioned."[149] Building on this legacy, and using the tools described above, the United States must work in a creative and aggressive fashion to invigorate the private sector and space industrial base to create the industries of 2050 and beyond, as well as develop the next greatest technological achievements of the twenty-first century.

Innovation is critical to almost every aspect of the human race. To maintain the high ground in space, current and future US administrations must meet recommended science, technology, and basic research levels. Future

"Innovation is critical to almost every aspect of the human race. To maintain the high ground in space, current and future US administrations must meet recommended science, technology, and basic research levels."

opportunities to incentivize, bolster, and minimize unnecessary restrictions when partnering with the commercial sector should be exploited. The Department of Defense has seen success with its relatively new innovation arms that provide an outlet for innovative activity—the Defense Innovation Unit (DIU), the US Air Force's AFWERX, and Space Force's SpaceWERX. These should be expanded and capitalized to further space innovation.

BOLSTER HUMAN CAPITAL

Human capital is the United States' most important asset, so much so that current and future policymakers should take a more active role in developing capacity in the fields of science, technology, engineering, and math (STEM), with a heavy focus on artificial intelligence, robotics, and quantum-related technologies, to name just a few specialized disciplines. Doing so will require sustained effort throughout the thirty-year timeframe of this strategy; the National Space Policy's call to develop and retain space professionals is a welcome first step.[150] A whole-of-government approach will be needed to fill tens of thousands of STEM jobs over the next thirty years that will be vital to ensuring the nation's competitive advantage in both the public and private space sectors.

To achieve this goal, US space agencies should partner with universities and sponsor space manufacturing and defense programs. These programs will bolster basic research capacity and train the future workforce. Another measure to enhance human capital could be a "STEM ROTC (Reserve Officers' Training Corps)," which would provide "targeted undergraduate scholarships for US citizens in return for working in STEM in the United States after graduation."[151]

The USSF is developing a new human-capital strategy that will shatter old paradigms, ensuring that all Space Force professionals can achieve their full potential.[152] This is a perfect opportunity for all US government space agencies to review their own human-capital strategies to ensure they are recruiting, developing, and promoting the best the United States has to offer.

PUBLIC-PRIVATE COLLABORATION

The Pentagon and policymakers should look to enhance collaboration with the private sector to further technological advancements and activity in space. This means paring back the list of space activities previously thought to be inherently governmental and instead leveraging the growing commercial space industry. According to the DIU's analysis of space-portfolio investments, the DoD has leveraged private-capital investment in space for years, "at a ratio exceeding 30:1."[153] For every DoD dollar that goes into a commercial space system, thirty dollars of the development cost was borne outside the government—such as through venture capital.[154] In 2019, investment in commercial space companies reached a record $5.7 billion, up from $3.5 billion the year before, and more than 70 percent of the investment was sourced from venture capital.[155] This record-breaking investment is expected to continue, as investors seek companies with strong growth potential.

As the private sector innovates, the Pentagon should work to adopt and integrate new technologies at the pace of innovation to maintain an edge in the space domain. Accordingly, the Pentagon should work closely with space startup ventures and innovative firms with the current space industry to develop technologies that support security and prosperity in space. Moreover, to ensure the US space industry can effectively work with foreign space programs, the National Space Council—in collaboration with the Pentagon and relevant stakeholders—should annually report to the president and Congress on the state of the space industry and identify steps that could be taken to maintain US leadership in the space domain.

SPEED IS PARAMOUNT; INVESTMENT IS ESSENTIAL

Even as the commercial space sector grows, the US government will continue to be an important element in the success of commercial space—and the government can become a better partner to the private sector. To leverage the growing commercial space industry, the US government should provide a reasonable level of initial and continued funding for promising companies and technologies, which can reduce significant technical risks and uncertainties, thus encouraging venture-capital investment. The US government should also explore the development and deployment of new tools to support the space industrial base, such as space bonds and Space Commodities Exchange (SCE).[156] For the space industrial base, the SCE could help secure vital supply chains for products. The US government can harness its purchasing power by pledging to procure its space-industrial needs through such an exchange. This kind of commitment would instill confidence that the government will provide "anchor support" for companies to continue to innovate. Similarly, the Pentagon and policymakers should take action to provide the space industrial base with long-term commitments and clearly articulated requirements. This aims to drive the technical and fiscal feasibility of commercial investments and signal to private investors that the US government is a reliable customer ready to build on the achievements already made in the space domain.[157]

7. Space Critical Infrastructure and Cybersecurity

Space assets are critical to supporting critical infrastructure, from finance to energy and beyond. In fact, space assets are so critical to the communication, timekeeping, and other functions that society relies on that, under the Biden administration, the Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA) should be directed to evaluate whether space should be declared the seventeenth critical infrastructure sector. Because such designation comes with often-burdensome regulation, that decision should be made only in close consultation with large and small space industry representatives.

Regardless of its official designation, the space sector is critical, and must be protected from threats, including cyberattacks—not even space-based systems are immune to cyberattacks. The US government should insist on cyber best practices—from supply-chain security to penetration testing to cyber-hygiene trainings for employees—in all of the space projects that it funds, operates, or permits. However, as adversaries evolve, the US government must adapt best practices to account for the shifting operating environments over the short, medium, and long terms. The DoD and private sector should prioritize the resilience of space assets and ground stations so that they can limit harm and gracefully overcome failure when it eventually does occur.[158] The National Space Council should regularly study, and publicly report on, cyber threats specific to space.

8. Space Propulsion and ISRU

Continued security and prosperity in space will require responsible use of space nuclear power and propulsion technology in the medium (2025-2040) to long (2040-2050) term. The December 2020 United States National Space Policy provides guidelines and principles for the responsible use of this technology in space.[159] Such uses could enable more expeditious human Mars exploration, powering long-term habitats on the Moon, or manufacturing in zero gravity, to name just a few possibilities.[160] With the increasingly clear risks of astronaut exposure to radiation on a potential Mars mission, it is imperative to travel faster.[161]

Space nuclear-power technology is one way to travel faster, allow for persistent access to abundant resources, and provide a resilient energy source. This technology has been tested over the years, and will be required in space if humankind on Earth is to enjoy the benefits of abundant space

"Continued security and prosperity in space will require responsible use of space nuclear power and propulsion technology in the medium (2025-2040) to long (2040-2050) term."

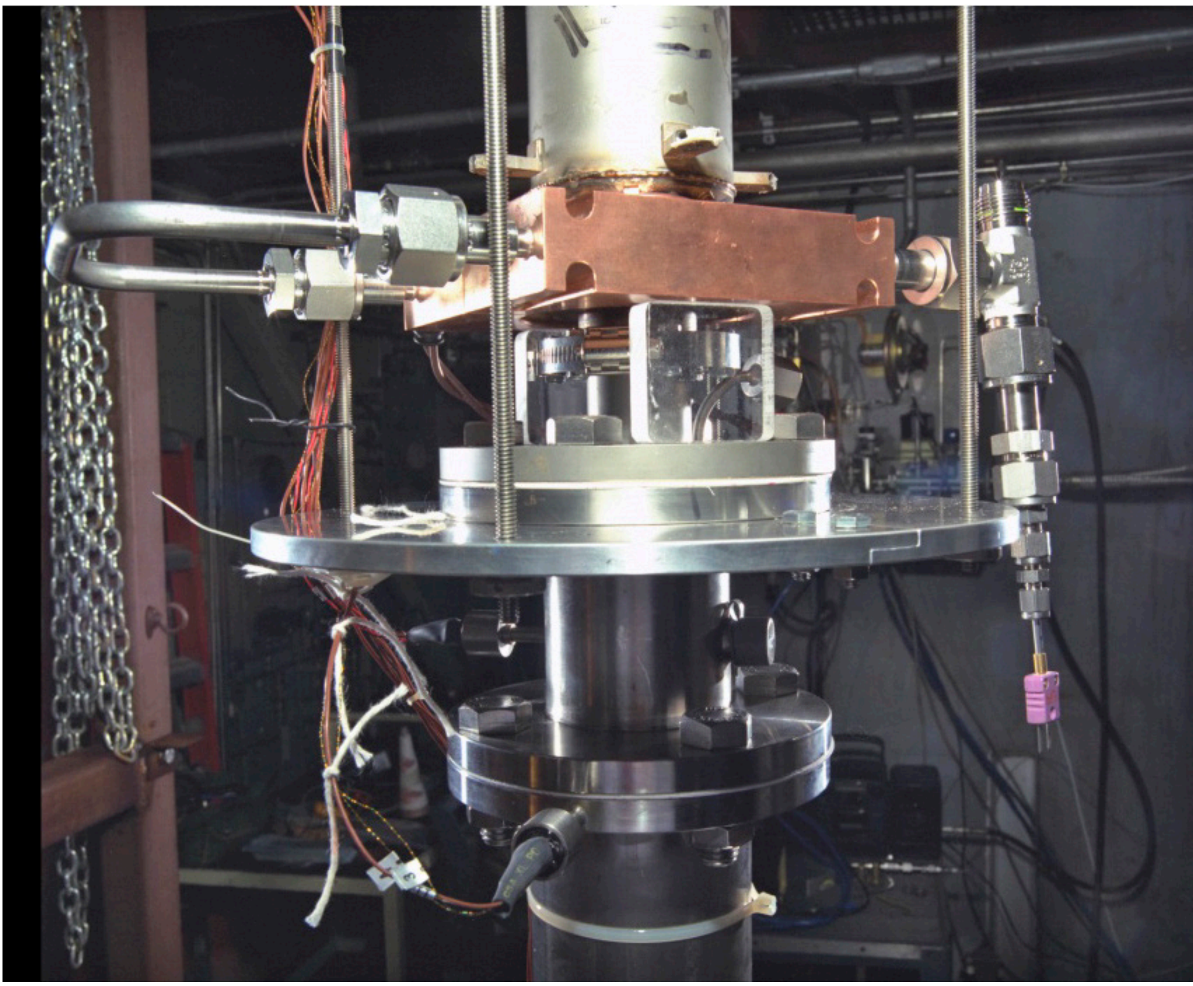
US AIR FORCE PHOTO BY AIRMAN 1ST CLASS KRYSTAL ARDREY

The United States and likeminded nations must fortify their space assets against adversarial cyberattacks. In this picture, two servicemembers work in the Global Strategic Warning and Space Surveillance System Center, which ensures constant dataflow of key information to various US commands.

resources. One notable program consisted of a joint United States-Russia partnership in the early 1990s after the Soviet Union dissolved. The Topaz II program involved testing thermionic space nuclear-power systems for non-defense purposes in the United States.[162] Due to the political climate at the time, the Topaz II program was disbanded a few years after testing began; since then, space nuclear power and propulsion have been waiting for an opportunity to re-emerge. With the United States recently and publicly acknowledging space nuclear power and propulsion as elements to achieve its scientific, national security, and commercial objectives, now is the time to continue research, study, and international science and technology cooperation in this game-changing space-based technology.

In the new administration, NASA should work with the national laboratories to ensure there is a steady supply of satellite-grade nuclear material. Moreover, NASA should include the potential for nuclear propulsion in its public-education programming and attempt to desensitize nuclear power, a potent technology that nonetheless attracts widespread skepticism and safety concerns.

ISRU will be another keystone technology altering space fuel dynamics in the thirty-year timeframe, as it will allow missions to launch with less fuel and, eventually, launch from the Moon. Like other emerging space technology and activity, ISRU will require do-no-harm norms and standard operating procedures in line with a framework for sustainable space development. As a short-term goal, the United States and its industry partners should invest in technology that will enable ISRU activity in support of space security. In the medium term, the United States should seek buy-in from like-minded nations on norms and standard operating procedures that allow for common access to new resources. ISRU will be the next technology catalyst that radically increases space activity and the number of spacefaring nations involved in pursuit of discovering value for all humankind. However, ISRU is ripe for exploitation. Ensuring common access and holding space stakeholders accountable for their actions will be the coin of the realm in securing space over the next thirty years.



NASA

Equipment for Mars In-Situ Resource Utilization. ISRU has the potential to uncover propellants and resources necessary to space flight on Mars, the Moon, and other asteroids.

9. Space Situational Awareness and Space Traffic-Management

To enable activities in space, minimizing the potential for collisions is of the utmost importance. While the United States should lead a global effort to minimize debris creation (or remove already-present debris), spacefaring nations will still need to operate in space despite the presence of debris. To do so, improvements in SSA and STM are critical.

SSA RECOMMENDATIONS

First, the United States needs to improve its ability to obtain a fuller picture of objects in space, particularly smaller objects that are merely centimeters in size. First operational in March 2020, the Space Fence is an excellent model for what valuable additions would look like. Able to see objects the size of a marble, the Space Fence enhances sustainable space governance.[163] Programs such as the Space Fence (or follow-on missions) should be fully funded. One study found that an optimal configuration of existing technology would base twenty-six telescopes at thirteen geographically diverse sites, in addition to an orbiting constellation of two GEODSS satellites in LEO and a three-satellite constellation of sensors in GEO.[164] This is expected to dramatically expand coverage with existing technology. The US Space Force should optimize existing SSA systems for effectiveness.

Second, the United States should explore options to better fuse and synthesize data collected by spacefaring nations. SSA data were managed by the Joint Space Operations Center (JSpOC) until 2018, when this role transitioned to the Combined Space Operations Center (CSpOC).[165] This shift was intended to "improve coordination between the United States, its allies, and commercial and civil partners for defensive space efforts"; however, the secretive nature of certain data has hindered such progress.[166] There needs to be a reliable and comprehensive catalog of data that is shared with partners. While the specific missions or operations of satellites can remain classified (to preserve US government interests), the locations of satellites should be declassified and given to partners as part of a public catalog.[167]

Third, there should be a transition of SSA and STM authorities to a civil agency such as the Department of Commerce (DoC) to reduce the secrecy culture that surrounds SSA information. This process was initiated under Space Policy Directive 3 (SPD-3), signed by President Trump in 2018.[168] Under this transition, the DoD retains control of the "authoritative satellite catalog."[169] However, the DoC will begin developing an open-architecture SSA data repository that makes information substantially more available to international and commercial partners.[170] A shared catalog will reduce

"There needs to be a reliable and comprehensive catalog of [space situational awareness] data that is shared with partners."

concerns about interoperability by allowing all participating nations to fuse and synthesize the relevant data within a centralized repository. Continuing this transition under the new administration will ensure that SSA data are brought into the public domain, allowing the United States to work with partners to develop a truly comprehensive catalog of SSA data.

STM RECOMMENDATIONS

First, the United States should consult with relevant commercial entities on a set of "best practice" guidelines for effective STM. As one recent report emphasized, these best practices will "emerge bottom up" and "bubble up from the domestic level."[171] Through consultation with industry, the United States can identify some of the requirements for responsible space governance. These include, but are not limited to, liability measures, guidelines for long-term sustainability (such as deorbiting requirements), and collision avoidance.

The groundwork has been laid for this approach through SPD-3 and must be allowed to continue. By establishing a "loose regulatory structure," SPD-3 empowered commercial providers to begin taking the lead in creating best-practice guidelines.[172] Once the United States—the largest player in commercial space—has worked with industry to perfect these guidelines, other nations can be brought in. One innovative proposal is to establish a set of incentives for industry players to join an international body of private operators, with the body tasked with establishing a new set of best-practice guidelines.[173] This would allow commercial operators to "pool expertise and develop technical standards" for issues such as orbital-debris mitigation or collision avoidance.[174]

Second, the United States should seize the mantle of international leader, capitalizing on extensive market share in the commercial space sector. Some analysts have predicted that the United States will have the largest market share in nearly all space industrial sectors within the next few decades, including launch, satellite manufacturing, and satellite services.[175] This offers the United States an unusual amount of leverage. In coordination with domestic industry, the United States can set rules for twenty-first century STM—if other nations decide not to abide by these rules, they risk being locked out of a lucrative arena. Intransigent countries would, therefore, have "little choice but to fall in line with the STM designed by the West."[176]

Summary of Guidelines for Implementation and Strategy Timeline

To be effectively executed, this strategy for space security suggests several specific policy initiatives that can be considered and pursued within the next thirty years. The below list summarizes the policy recommendations and proposed timelines.

IN THE SHORT TERM (2021 – 2025)

- The president should appoint, and the Department of State should staff, a special presidential envoy for space to socialize norms of responsible space behavior with likeminded nations.
- The special presidential envoy to space should address the uncontrolled region between flight level 600 and the Kármán line.
- US diplomats and policymakers should engage existing allies, in forums like NATO, about the need for coordinated activity in space.
- The president should direct the National Space Council to create, and regularly reexamine, a long-term plan to develop a space security alliance.
- NASA should evaluate the ambitious timeline of the Artemis program to determine if it is realistic and, if needed, adjust benchmarks for its deep-space exploration program.
- The Department of Defense should invest in keystone technologies and seize future opportunities to bolster, incentivize, and minimize restrictions on collaboration with the private sector, working with start-up ventures and innovative firms when practicable.
- The Department of Defense should increase funding for defense science and technology and basic research.
- NASA should work with the national laboratories to ensure a steady supply of satellite-grade nuclear material and include nuclear propulsion in its public-education programming.
- To avoid redundancy across agency regulations, the president should include in the National Space Council a body representing industry, such as the Users' Advisory Group.
- The president should staff the National Space Council at the Cabinet level, chaired by the vice president, and the US Congress should draft legislation to make this body permanent.
- CISA should evaluate whether space should be designated as a critical infrastructure sector.
- Congress should continue to monitor the US Space Force and review space-related procurement processes.

- The US federal government should incentivize subnational governments to review and draft legislation for space infrastructure and provide space-related state-university research grants.
- The US federal government should seek continued improvements in SSA capabilities, funding initiatives such as the Space Fence that improve the Space Surveillance Network, particularly as it relates to smaller objects.
- The US Department of Defense should seek collaborative partnerships with foreign nations to obtain higher-quality SSA data, particularly tapping into geographic advantages that allies in the Eastern Hemisphere can offer.
- The US federal government should work on a collaborative database for the fusing of SSA data, improving on the steps initiated by the creation of CSpoC. This database should involve a lower level of classification than current data provided.
- Under the guidance of the National Space Council, authorities over SSA and STM should be transferred to a civil agency such as the Department of Commerce, developing an open-architecture SSA repository with an extensive public catalog of SSA data.

IN THE MEDIUM TERM (2025 – 2040)

- The special presidential envoy for space should achieve buy-in from likeminded nations on core principles of space exploration, security, and commerce to set the ground for a new comprehensive space treaty.
- The State Department should transition the US special presidential envoy for space to an ambassador at large.
- US and allied policymakers should review existing space treaties, such as the Moon Treaty and the Space Liability Convention, and incorporate viable components into a new space treaty.
- The US and likeminded governments should synchronize domestic policies in constructing a framework for orbital-debris mitigation.
- US government should work with NATO to prioritize a common understanding of space security and develop an ambitious set of aligned activity for space operations.
- The Department of Defense should consider the implications of military satellites and space situational awareness on the routinization of cislunar space.
- The United States, along with its allies and partners, should expand EW countermeasures to protect growing space assets against adversarial weapon systems.

- The US Congress should consider authorizing a commission to evaluate whether an independent Department of the Space Force is warranted.
- The special presidential envoy for space should achieve buy-in from likeminded nations on norms and standard operating procedures that allow for common access to new resources for ISRU activity.
- The US government should build out rocket-transportation infrastructure and regulate point-to-point launch for commercial and military purposes, eventually coordinating international regulations and constructing space ports with global partners.
- The US Departments of Commerce and State should consult with relevant commercial entities on a set of best-practice guidelines for STM, working to develop bottom-up guidelines that can then be brought to the international community.

IN THE LONG TERM (2040 – 2050)

- The United States and likeminded nations should sign a foundational space treaty that recognizes the transforming nature of the domain and protects a growing future of space commerce.
- The United States, its existing allies, and new partners should commit themselves to a space security alliance that pledges collective security and defense from attacks in the space domain, with clear rules for membership, funding, dispute resolution, and obligations.
- NASA should develop infrastructure at the Lagrange points, while US diplomats seek to negotiate an international framework to regulate use of these points among other valuable cislunar real estate.
- US space agencies should invest in, and sustain, a "culture of education," especially in STEM fields, with a heavy focus on artificial intelligence, robotics, and quantum-related technologies, to name just a few specialized disciplines.
- The United States should seize the mantle of international leader on STM norms, capitalizing on what is likely to be an increase in market share in the commercial space sector. This will give the United States leverage to shape the rules and norms for STM. In coordination with allies and partners, the United States should extend its SSA and STM efforts to cislunar space.

CONCLUSION

For centuries, humankind has gazed up at the cosmos pondering life, yet humans reached this final frontier mere decades ago. Since human arrival in space, the realm of possibility has drastically expanded to incorporate new spacefaring nations and companies, new inventions, and new orbits. One can only imagine the infinite value and potential that space will offer in the decades ahead. As we grapple with existential challenges on Earth, we may continue to look to space to derive potential answers. While a thirty-year US strategy cannot begin to imagine the unimaginable, a long-term vision is critical to advance the position of spacefaring nations and shape the future trajectory of this critical high ground.

Over the next thirty years, space security will continue to evolve as legal frameworks and alliances are developed, technologies advance, and investments in public-private partnerships are made. In order for the United States to protect a promising future of space prosperity, it must work with likeminded nations to: enhance a rules-based international order for space, preserve US and allied leadership in space, strengthen US and allied technological advantages in space, and push space development to cislunar space. In the absence of concerted action, humankind risks diminishing the immense value still being discovered in Earth orbit and beyond.

There are significant first-mover advantages that accrue to the leader of this new "space rush." The United States can set the new do-no-harm standards for conduct in space like resource extraction and access to the Lagrange points. While the United States must be sober in its assessment of the importance of space in great-power competition, it should seek peaceful exploration and cooperation with all spacefaring countries—including China and Russia—where possible. In the interest of global security on Earth and within space, the United States must work with its allies and partners to normalize rules of conduct and engagement and deter against aggression in the space domain. In the timeframe of this strategy, commerce in Earth orbit will become routine, normal, and unremarkable, constituting an increasingly large share of global economic activity. Still, this development faces serious threats. Through new space governance, a new space security alliance, and new space technology, the United States can realize that vision while pushing humanity's economic frontier into cislunar space.

The United States is not just a nation that uses space; it is a spacefaring nation. Space exploration, value, and security are tightly woven into the collective US psyche, not to mention the US scientific, commercial, and military establishments. Russian rocketeer Konstantin Tsiolkovsky famously stated that "the Earth is the cradle of the mind, but one cannot eternally live in a cradle."[177] It is time for the United States to fully enmesh Earth orbit in legal, security, and commercial apparatuses so that space exploration agencies can focus on cislunar space, Mars, and the boundless universe beyond.

In essence, this strategy is laid out with the understanding that "plans are useless, but planning is indispensable."[178] Determining what will and will not be the reality in 2050 is a futile exercise, as benchmarks set out for the next decade may be eclipsed by great and unknown achievements in the coming years. However, paving a roadmap to 2050 is helpful in shaping the goals, policies, and investments necessary to pursue enduring prosperity and security in space tomorrow. Keeping the future at the forefront, regardless of developments that may materialize and on what timeline, situates humankind to reap the benefits of space activity in perpetuity.

Securing space is intrinsically tied to protecting the future of humankind. In this picture, Astronaut Franklin R. Chang-Diaz works with a grapple fixture during extravehicular activity to perform work on the International Space Station.

Appendix A: Pertinent Space Law

The 1967 Outer Space Treaty is significant because it exemplifies the international cooperation necessary for the establishment of a rules-based order in space.[179] The hundred-plus treaty signatories include the United States, Russia, and China. The overarching theme is one of peace, exploration, scientific discovery, and international cooperation, and it includes useful clauses requiring registration and rescue, which have been a positive cornerstone guiding space activity and facilitating space activity. This agreement specifically bans the deployment or use of nuclear weapons and WMD and their testing in Earth's orbit, celestial bodies, and outer space. The 1967 treaty, in prohibiting non-scientific military infrastructure and deployments to celestial bodies, as well as requiring international access to space equipment and facilities, constrains signatories' ability to meet national security needs. Further, the treaty prohibits the national appropriation of celestial bodies, regardless of type, and lacks language regarding mineral rights, resource extraction, ownership and use of celestial bodies for commercial purposes, and rights to specific space land.

The Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space, otherwise known as the 1968 Rescue Agreement, expands the 1967 treaty by requiring signatories to provide recovery and return of astronauts and space equipment.[180] The rescue treaty provides certainty to persons and companies seeking to operate in space, and is akin to norms on the high seas and in aviation to aid vessels in distress. This fosters the kind of international cooperation necessary for a rules-based order in space.

In 1972, the United States signed the Liability Convention, obligating any signatory to absolute liability for damage caused by a nation's space objects or activity, whether on Earth or in space, unless done so in clear self-defense. This treaty creates necessary responsibility for mistakes and accidents inherent in advancing new frontiers. However, the absolute-liability provision and self-defense exception create ambiguity on dispute resolution, as there is no consensus on what constitutes self-defense in space.[181]

In 1974, the United Nations General Assembly adopted the Convention on Registration of Objects Launched into Outerspace, otherwise known as the Registration Convention. Entered into force in September 1976, the Registration Convention builds upon the desire expressed by signees of the Outer Space Treaty, the Rescue Agreement, and the Liability Convention for a mechanism that provides nations with a means to assist in the identification of objects. The treaty expanded the scope of the 1961 United Nations Register of Objects Launched into Outer Space, further addressing state responsibilities for national space objects.[182]

An effectively symbolic space-related multilateral non-armament and governing document for space is the 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, or the Moon Agreement. The Moon Agreement has few signatories, and the United States is not a party. This treaty prohibits any threat, use of force, or hostile action on celestial bodies without exception for self-defense (Article III). It defines more explicitly the activities of countries within the solar system, with particular attention to resource exploration and extraction, with a clause in Article XI, §5, recognizing the need to create a resource-extraction regime and body to address resource extraction when it becomes more technologically feasible.[183] Arguably, this time is rapidly approaching.

Additionally, a host of treaties address issues of nuclear proliferation expanding into the space domain. The 1963 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water, commonly referred to as the Limited Test Ban Treaty or Partial Test Ban Treaty, prohibits nuclear weapon tests or related explosions in outer space in an effort to limit radioactive contamination to the environment. While the treaty allows underground testing, it prohibits nuclear explosions resulting in radioactive debris pollution outside of the jurisdiction wherein such explosions were conducted.[184]

Strategic Arms Negotiation Talks (SALT) between the Soviet Union and the United States, aimed at limiting the manufacture of strategic missiles capable of carrying nuclear weapons, resulted in the SALT I interim agreement between the two superpowers. Article V contains provisions that ban interference with the national technical means (NTM) of verification, applying broadly to the monitoring techniques employed by state satellites.[185] Similarly, Article X of the New Strategic Arms Reduction Treaty (New START), signed in April 2010, included provisions of non-interference on the use of NTM for verification and recognized the role satellites play in monitoring ballistic missiles.[186]

In 2002, the Hague Code of Conduct (HCoC) was founded to control the proliferation of WMD-capable missiles, while strengthening support for existing multilateral disarmament and nonproliferation agreements. HCoC signatories subscribe to the Outer Space Treaty, Liability Convention, and Registration Convention. Moreover, they are obligated to enact transparency measures, which include releasing annual declarations outlining a state's ballistic-missile policies and providing information on launch sites and space launch-vehicle missions and sending pre-launch notifications for both ballistic-missile and space launch-vehicle launches.[187]

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