SECTION 3: CHINA'S AMBITIONS IN SPACE: CONTESTING THE FINAL FRONTIER

Key Findings

- China's goal to establish a leading position in the economic and military use of outer space, or what Beijing calls its "space dream," is a core component of its aim to realize the "great rejuvenation of the Chinese nation." In pursuit of this goal, China has dedicated high-level attention and ample funding to catch up to and eventually surpass other spacefaring countries in terms of space-related industry, technology, diplomacy, and military power. If plans hold to launch its first long-term space station module in 2020, it will have matched the United States' nearly 40-year progression from first human spaceflight to first space station module in less than 20 years.
- China views space as critical to its future security and economic interests due to its vast strategic and economic potential. Moreover, Beijing has specific plans not merely to explore space, but to industrially dominate the space within the moon's orbit of Earth. China has invested significant resources in exploring the national security and economic value of this area, including its potential for space-based manufacturing, resource extraction, and power generation, although experts differ on the feasibility of some of these activities.
- Beijing uses its space program to advance its terrestrial geopolitical objectives, including cultivating customers for the Belt and Road Initiative (BRI), while also using diplomatic ties to advance its goals in space, such as by establishing an expanding network of overseas space ground stations. China's promotion of launch services, satellites, and the Beidou global navigation system under its "Space Silk Road" is deepening participants' reliance on China for space-based services.
- China is taking steps to establish a commanding position in the commercial launch and satellite sectors relying in part on aggressive state-backed financing that foreign market-driven companies cannot match. China has already succeeded in undercutting some U.S. and other foreign launch and satellite providers in the international market, threatening to hollow out these countries' space industrial bases.
- The emergence of China's indigenous space sector has been an early and notable success of Beijing's military-civil fusion strategy. The aggressive pursuit of foreign technology and talent gained through joint research and other means, especially from the United States and its allies and partners, continues to be central to this strategy and to China's space development goals in general.

- The Chinese government and military use Hong Kong-based companies to exploit legal loopholes and uneven enforcement in U.S. export controls to gain access to space capabilities which U.S. law prohibits Beijing from purchasing outright. Collaboration with foreign universities, including in the United States, is another important avenue in China's drive to acquire space technology. Chinese students enrolled in foreign science, technology, engineering, and mathematics programs are treated like employees of China's defense industrial base, with defense enterprises regularly funding their studies in return for service commitments following graduation.
- China views space as a critical U.S. military and economic vulnerability, and has fielded an array of direct-ascent, cyber, electromagnetic, and co-orbital counterspace weapons capable of targeting nearly every class of U.S. space asset. The People's Liberation Army (PLA) has also developed doctrinal concepts for the use of these weapons encouraging escalatory attacks against an adversary's space systems early in a conflict, threatening to destabilize the space domain. It may be difficult for the United States to deter Beijing from using these weapons due to China's belief the United States has a greater vulnerability in space.

Recommendations

- Congress direct the National Space Council to develop a strategy to ensure the United States remains the preeminent space power in the face of growing competition from China and Russia, including the production of an unclassified report with a classified annex including the following:
  - A long-term economic space resource policy strategy, including an assessment of the viability of extraction of space-based precious minerals, onsite exploitation of space-based natural resources, and space-based solar power. It would also include a comparative assessment of China's programs related to these issues.
  - An assessment of U.S. strategic interests in or relating to cislunar space.
  - An assessment of the U.S. Department of Defense's current ability to guarantee the protection of commercial communications and navigation in space from China's growing counterspace capabilities, and any actions required to improve this capability.
  - A plan to create a space commodities exchange to ensure the United States drives the creation of international standards for interoperable commercial space capabilities.
  - A plan to streamline and strengthen U.S. cooperation with allies and partners in space.
  - An interagency strategy to defend U.S. supply chains and manufacturing capacity critical to competitiveness in space.

- Congress direct the U.S. Department of Defense to take the following steps to ensure it is prepared to counter China's and Russia's destabilizing approach to military operations in space:
  - Ensure U.S. Space Command and any future space-oriented service are responsible for protecting freedom of navigation and keeping lines of communication open, safe, and secure in the space domain, as the U.S. Navy does for U.S. interests in the maritime commons.
  - Strengthen the credibility of U.S. deterrence in space by fully integrating the space domain into policy, training, and exercises.
  - Ensure that programs designed to increase survivability, redundancy, reusability, resilience, rapid replacement, and disaggregation of critical U.S. space assets receive continued support, including those programs ordered in the National Defense Authorization Act for 2019 Title XVI, Subtitle A.
- Congress urge the Administration to actively participate in international space governance institutions to shape their development in a way that suits the interests of the United States and its allies and partners and to strengthen U.S. engagement with key coalitional allies and partners in the space domain.

Introduction

At the highest levels of policy, the Chinese government is determined to meet ambitious goals for space leadership, and it has connected its space program with its broader ambitions to become a terrestrial leader in political, economic, and military power. Beijing aims to establish a leading position in the future space-based economy and capture important sectors of the global commercial space industry through the use of subsidies to undercut foreign competitors, including promoting its space industry through partnerships under what it has termed the "Space Silk Road." Some of these initiatives are already challenging the U.S. space industry and U.S. leadership on international space cooperation.

Beijing has also positioned itself to take advantage of the unclear legal regimes concerning the exploitation of space-based resources, while making statements linking its space exploration program to its sovereignty claims on Earth. Despite its insistence that it opposes the militarization of space, Beijing has fielded an array of counterspace capabilities enabling it to hold both civilian and military space assets at risk. The PLA has developed doctrinal concepts for the use of these weapons early in a conflict, threatening to destabilize the space domain. Although the strategic value of some elements of China's space program is not yet proven, Beijing is clearly of the view that the country that leads in space may also be economically and militarily dominant on Earth.

This section examines Beijing's plans for economic and industrial expansion into space; its use of international space cooperation to promote its geopolitical interests; the application of military-civil fusion to China's nascent commercial space sector; and China's counterspace activities, capabilities, and doctrine. It draws from the Commission's April 2019 hearing on China's space ambitions, open source research and analysis, and consultations with outside experts.

National Rejuvenation and a "Space Dream"

China views establishing a leading position in the economic and military use of outer space as a core component of its goal to realize the "great rejuvenation of the Chinese nation," or the "China dream"—an ambitious vision to restore what Beijing views as its historical leadership role in world affairs. According to General Secretary of the Chinese Communist Party Xi Jinping, China's "space dream" is to "explore the vast universe, develop aerospace enterprises, and build a strong aerospace country."[1] To achieve these goals and become what it has termed a "space power in all respects," China has made focused efforts to catch up to and eventually surpass other spacefaring countries in terms of space-related industry, technology, diplomacy, and military power.[2]

Beijing consistently invests high levels of funding and political will to its space program, with both the civilian government and military involved in formulating and executing policy at the highest level.[3] China's program is deeply connected to the "levers of power," meaning its goals often draw support from top leaders and are interconnected with the overall priorities of China's industrial and foreign policies.[4] Furthermore, many officials with backgrounds in the state defense complex have moved to senior government positions. While not all of these officials have backgrounds in space specifically, the result of these moves has been that senior Chinese political leaders often have a stronger technical understanding of the space sector than their foreign counterparts (see Addendum I on page 385 listing key Chinese officials with aerospace sector backgrounds). Beijing has set ambitious goals for its space program and demonstrated its ability to achieve an increasingly sophisticated set of milestones.[5] For example, if plans hold to launch its first long-term space station module in 2020, China will have matched the United States' nearly 40-year progression from first human spaceflight to first space station module in less than 20 years.[6]

A Commanding Position in Cislunar Space and the Future Space Economy

Central to China's economic and strategic goals in space is establishing a commanding position in cislunar space—the space within the moon's orbit of Earth*—to reap the benefits of what Beijing views as its strategic value and the vast potential of the future space-based economy. According to Lieutenant General Zhang Yulin, deputy director of the PLA's Equipment Development Department, cislunar space is "strategically important for the great rejuvenation of the Chinese nation" due to its potential for facilitating solar power and resource exploitation.[7] General James Cartwright, former Vice Chairman of the Joint Chiefs of Staff, also attested to cislunar

*Cislunar space is the sphere comprising all the volume between Earth and the moon. This space includes commonly used orbits such as low-Earth orbit (up to approximately 2,000 km above the Earth), geosynchronous orbit (approximately 3,400–3,800 km), and medium-Earth orbit (between low-Earth and geosynchronous orbits), as well as the much vaster space beyond; geosynchronous orbit is only about a tenth of the distance to the moon. In this section, "cislunar space" generally refers to the space above altitudes currently useful for security and economic purposes. *GIS Geography*, "Geosynchronous vs Geostationary Orbits," February 23, 2018; Marianne R. Bobskill and Mark L. Lupisella, "The Role of Cis-Lunar Space in Future Global Space Exploration," Global Space Exploration Conference, Washington, DC, May 2012, 1; Inter-Agency Space Debris Coordination Committee, "IADC Space Debris Mitigation Guidelines," September 2007, 5.

space's importance, testifying at the Commission's April 25 hearing that it should be viewed as the strategic "hill over the valley" controlling access to space from Earth.[8]

Beijing envisions the cislunar domain as the foundation for this long-term presence in space and jumping-off point for deep space exploration missions.[9] This foundation for long-term presence will potentially include a transport hub orbiting Earth with permanently docked nuclear-powered shuttles for space missions, accessible from Earth via reusable rockets.*[10] Independent analyst Namrata Goswami testified to the Commission that the goal of China's space program is not merely exploration but rather "industrial and economic dominance of the cislunar system."[11] China's 2019 defense white paper stresses the importance of the capacity "to safely enter, exit, and openly use outer space."[12]

Experts disagree on whether humans will be able to exploit cislunar space at scale for economic and strategic purposes anytime soon, largely because much of the technology required to exploit this space has not been developed yet. Although the space economy may reach one to three trillion dollars by 2040, according to some estimates—a figure that does not include the vast potential value of mining space-based minerals—the steps required to fully harness this potential remain undetermined.[13] According to Todd Harrison, a senior space expert at the Center for Strategic and International Studies, in cislunar space there is "nothing really to dominate, at least not yet," because it is so high above the altitudes at which space is currently useful for either commercial or national security purposes.[14] According to a May 2019 joint report by the U.S. Air Force Research Laboratory and the Defense Innovation Unit, however, cislunar space will become an important domain for the United States in the next five years and beyond due to the need to place national security space assets beyond low-Earth orbit (LEO) and geosynchronous orbit (GEO) to limit their vulnerability and enhance their utility, and because this domain will be crucial for establishing infrastructure to enable a long-term U.S. presence on the moon and beyond.[15]

Despite these uncertainties, China has devoted considerable resources to developing technology, especially through its human spaceflight program, to reap the long-term benefits of a sustained presence in cislunar space. China's space station program and planned crewed moon and Mars missions are not ends unto themselves, but rather steps in a long-term plan to develop and maintain presence in this important area.[16] For instance, since early in the Shenzhou spacecraft program—which saw its first launches in the late 1990s—the goal of China's human spaceflight project has been to establish a long-term crewed space station which would serve as a stepping stone to further exploration of cislunar space and beyond.[17] China's increasingly advanced lunar probes, intended to demonstrate all prerequisites for a crewed lunar mission (i.e., launch and orbit,

*The planned nuclear shuttle fleet is beyond China's current technology, since Beijing has not yet mastered even conventional launch vehicles, but it is a key project planned for completion by about 2040 that if successful will enable large-scale exploration and resource exploitation in space. Stephen Chen, "China's Nuclear Spaceships Will Be 'Mining Asteroids and Flying Tourists' as It Aims to Overtake U.S. in Space Race," *South China Morning Post*, November 17, 2017; *Xinhua*, "China to Achieve 'Major Breakthrough' in Nuclear-Powered Space Shuttle around 2040: Report," November 16, 2017.

soft landing, and sample return), provide a technological basis for the ability to land future modules in the same area to be assembled into a lunar surface station, according to Sun Zezhou, chief designer of Chang'e-4, China's latest and most advanced probe.[18] In 2016, Lieutenant General Zhang, who is also deputy director of China's human spaceflight program, said preliminary work had already commenced to begin exploitation of cislunar space after China completes its first long-term crewed space station in 2020.[19]

A key component of China's plan to support its activity in cislunar space and beyond is the establishment of permanent facilities on the moon. Zhao Xiaojin, Party Secretary of the China Academy of Space Technology (CAST), a state-owned aerospace research institution, said in March 2018 China hopes to begin construction of a lunar research station around 2025 prior to visits by taikonauts* in the mid-2030s.[20] China also plans to establish a lunar research and development base around 2050 that will be primarily robotic. The official newspaper of the Ministry of Science and Technology, *Science and Technology Daily*, suggested the far side of the moon—on which China landed Chang'e-4 in January 2019—may be ideal for such a base, likening it to the "holy grail" of locations because it is shielded from terrestrial electromagnetic interference.[21] The value of the moon as a location for national security infrastructure focusing on Earth, however, is debatable. According to Mr. Harrison, communication at that distance is very inefficient, optical sensors would operate at very low resolution, and a projectile traveling from the moon to Earth would require about three days to make the journey.†[22]

Cislunar space will also play an important role in China's plans for space-based solar power, a futuristic power source that China aims to fully deploy by 2050, which may have the potential to provide virtually unlimited power to the whole world.[23] The technology is currently in its initial phases, but the underlying concept for one method of transmitting energy via microwaves has been successfully demonstrated by U.S. and Japanese researchers at short ranges on Earth as recently as 2015.[24] U.S. space-based solar power expert John Mankins argued in 2017 there are no "technological showstoppers" preventing the development of this new power source, but it will be important to demonstrate the systems can work at the necessary distances and from space-based platforms.[25]

China has demonstrated its seriousness in pursuing this concept by establishing an experimental space-based solar power ground station in Chongqing in early 2019.[26] According to Dr. Goswami,

*The terms astronaut (U.S. usage), taikonaut (Chinese usage), and cosmonaut (Russian usage) all refer to trained professionals who travel into space and operate spacecraft. More specifically, the terms each refer to people trained and certified by different space agencies, each of which has different operational philosophies, knowledge areas, and skill sets, and thus they are effectively distinct job titles. Robert Frost, "What Are the Differences between an Astronaut and a Cosmonaut?" *Forbes*, May 11, 2017.

†This is an approximation; transit times vary based on trajectory and the amount of propellant used. The Apollo 11 mission in 1969 took just short of 22 days and 23 hours to return from the Moon—the fastest-ever transit for a crewed craft. The Soviet satellite Luna 1 in 1959 reached the Moon in 34 hours, one of the fastest trips on record. Even a hypersonic missile traveling from the moon at Mach 15 would require approximately 22 hours to reach Earth. Todd Harrison, Director of Defense Budget Analysis and Aerospace Security Project, Center for Strategic and International Studies, interview with Commission staff, June 26, 2019; R. Jeffrey Smith, "Hypersonic Missiles Are Unstoppable. And They're Starting a New Global Arms Race," *New York Times*, June 19, 2019; Tim Sharp, "How Far is the Moon?" *Space*, October 27, 2017; Matt Williams, "How Long Does It Take to Get to the Moon?" *Universe Today*, January 10, 2016.

Beijing's space-based solar power plans would involve satellites exceeding 10,000 tons—the construction of which will only be possible by using lunar resources to build and then launch them onsite at an automated lunar base*—to convert solar power into microwaves and beam energy directly from space to Earth, generating solar power much more reliably and efficiently than terrestrial solar panels.[27] China's project would proceed by using high-altitude stratospheric balloons to test the system in the first half of the 2020s, followed by megawatt-class satellites by 2030 and gigawatt-class satellites by 2050.[28] The projects have received significant funding and policy attention, including through CAST's establishment in 2011 of the Qian Xuesen† Laboratory of Space Technology, which studies space mining and manufacturing, including onsite additive manufacturing.[29]

Chinese scientists and officials and experts from other countries do not all agree space-based solar power will become technologically viable, however. Its success depends on the perfection of both the transmission method and the automated lunar industrial-scale production and launch of large satellites, neither of which has been proven to be feasible at scale. According to an expert quoted in August 2019 in the *Guangming Daily*, a central news portal focusing on the academic and intellectual community, China has in recent years made important advancements in crucial technology associated with wireless energy transmission necessary for space-based solar power.[30]

China has set plans for other technologically ambitious milestones, such as mining of near-earth asteroids, which if successful could generate both significant national prestige and wealth.[31] For example, based on 1997 estimates by U.S. planetary scientist John Lewis that one known near-earth asteroid could contain precious metals worth approximately $20 trillion, Li Mingtao, a scientist at the National Space Center under the Chinese Academy of Sciences, has asserted capturing asteroids and sending them to Earth to be mined may become "a new engine for the global economy."[32] Tech-

*Onsite use of lunar water—estimated at up to 100 million metric tons in the form of ice—and rock should not be confused with mining for precious resources, which is another potential Chinese project. The former type of mining is proposed to enable long-term presence on the moon and the ability to travel elsewhere from the moon by creating rocket fuel, drinking water, and building materials from lunar resources, while the latter type would bring precious minerals to Earth. Lior Rubanenko, Jaahnavee Venkatraman, and David A. Paige, "Thick Ice Deposits in Shallow Simple Craters on the Moon and Mercury," *Nature Geoscience*, 2019; U.S.-China Economic and Security Review Commission, *Hearing on China in Space: A Strategic Competition?* oral testimony of Brian Weeden, April 25, 2019, 120; National Aeronautics and Space Administration, *Lunar South Pole*, September 27, 2010.

†Qian Xuesen, often thought of as the father of China's space program, was born in China but worked in the United States for decades on rocket programs. Qian helped found NASA's Jet Propulsion Laboratory and attained the rank of colonel in the U.S. Army Air Force before being deported to China in 1955 after being accused of harboring Communist sympathies. Qian was then instrumental in establishing China's Long March rocket program and eventually served on the Chinese Communist Party Central Committee. He was the most prominent of several notable Chinese engineers who studied in the United States and returned to China to contribute to its high-tech programs. Zhang Zhihao, "Top Rocket Scientist Dies, Age 102," *China Daily*, February 14, 2017; Michael Wines, "Qian Xuesen, Father of China's Space Program, Dies at 98," *New York Times*, November 3, 2009; *Chinese Academy of Sciences*, "China's Notable Space Scientist Liang Shoupan Died," September 9, 2009; Evan Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age*, Stanford University Press, 2003, 62; Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China, *Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China*: *PRC Missile and Space Forces*, January 2, 1999, 178.

nology to make this type of mining possible does not yet exist, according to testimony from two witnesses at the Commission's April 25 hearing, and it would be extremely difficult to implement. Two U.S. companies have already gone out of business after failing to create a sustainable business model around this concept.[33] Nevertheless, given Li Mingtao's dual affiliation both with the Chinese Academy of Sciences and as part of a specialized team at the Qian Xuesen Laboratory working on a plan to detect, capture, and mine very small near-earth asteroids, Beijing appears to be serious about trying to overcome these technical challenges.[34]

Seeking to Shape Space Governance Norms

China has fought to contest existing norms and sought to promote its leadership role in international space governance institutions to shape global space norms and practices in ways that benefit its economic and other national interests. Contrary to international norms governing the exploration and commercial exploitation of space, statements from senior Chinese officials signal Beijing's belief in its right to claim use of space-based resources in the absence of a clear legal framework specifically regulating mining in space. Reflecting a sense of urgency in establishing its national interests in space, in 2015 Ye Peijian, the head of China's lunar exploration program, likened the moon and Mars to the Senkaku Islands and the Spratly Islands, respectively, and warned not exploring them may result in the usurpation of China's "space rights and interests" by others.[35] Echoing the language of General Secretary Xi's "community of common human destiny," in June 2019, Shi Zhongjun, China's ambassador to the UN, called for the strengthening of outer space governance in order to build a "shared future."[36] Liza Tobin, a U.S. government China specialist, contended in her personal capacity that the underlying meaning of this slogan is "Beijing's long-term vision for transforming the international environment" to be more beneficial to its interests and more receptive to its governance system.[37]

In her testimony before the Commission, Dr. Goswami warned of the consequences of Beijing extending its vision of governance and sovereignty to outer space. In particular, she argued that China's activities in Antarctica and the South China Sea—where it has on paper committed to nonescalatory behavior while incrementally advancing its territorial claims by force—present a "clear systematic pattern" China may one day repeat. To consolidate control over space, China may first develop capacity to be present, then establish this presence, and finally develop claims to justify its presence, she concluded.[38]

Current international space law does not include a legal mechanism to clearly adjudicate ownership of space-based resources, leaving room for interpretation based on the dictates of a country's national interests.[39] The foundational Outer Space Treaty of 1967, to which both the United States and China are parties, specifies that celestial bodies are not subject to national appropriation but is vague on the legal status of resources extracted from those bodies.[40] While most countries believe the extraction of space-based resources is not incompatible with the ban on sovereignty over these bodies, there is no agreement on what the framework for such activities should be.[41]

Both Washington and Beijing have taken steps to secure private commercial interests in space mining. The United States passed a commercial space law in 2015, and in 2018 China signed a memorandum of understanding with Luxembourg—the first European country to develop a legal framework for space mining—to codify law granting companies the rights to materials they mine in space.[42] In 2018, Wu Weiren, chief of the Chang'e project, identified 29 other spacefaring countries that have introduced space laws and pointed out that China is currently the only space power without a space law, claiming China's system of space laws and regulations is not adequately developed.[43] Officials at the China National Space Administration (CNSA), China's public-facing space agency that serves mostly to raise the profile of China's space program, announced in 2014 the CNSA was expecting a comprehensive domestic space law to be introduced by 2020.[44] Although the CNSA asserted China will "always abide by international space law," Beijing's commitment in practice will depend on how comprehensive its own space law is because the international treaties are not self-executing.[45]

To advance its interests in space, China has generally followed norms outlined by existing space governance treaties. Because the multilateral fora established by these treaties are relatively weak, however, China has viewed them as useful venues for demonstrating its adherence to some internationally-accepted protocols while also advancing its own initiatives, a number of which do not align with U.S. interests. For example, according to Brian Weeden, a space expert who has observed China's participation in space governance fora, China played a constructive role in 2018 along with the United States and Russia in helping members of the UN Committee on the Peaceful Uses of Outer Space reach consensus on guidelines to multilaterally address challenges such as space debris, crowded orbits, and traffic management.[46]

In other cases, China has advocated for causes not in line with U.S. interests. Instead of an EU-proposed Code of Conduct in Space, which seeks to enhance safety in space operations through transparency mechanisms and confidence-building measures, China—along with Russia—has supported a draft treaty banning weapons in space and a proposal for a second treaty banning the first placement of such weapons, despite programs in China that appear to be preparations to weaponize space.[47] The United States opposes the Treaty on the Prevention of the Placement of Weapons in Outer Space because it does not define what constitutes a space weapon, include a verification mechanism for treaty adherence, or restrict development or stockpiling of ground-based antisatellite (ASAT) weapons, all of which would allow Beijing to continue placing U.S. and other foreign space assets at risk with its growing arsenal of ground-based counterspace weapons.[48] Then Acting Secretary of Defense Patrick Shanahan said in April 2019 that China would field a new ground-based directed-energy counterspace system by 2020, underlining the main reason for U.S. skepticism of the proposed treaty, which is that terrestrial ASAT capabilities are the most pressing threat to space systems.[49]

Space Program Supports Geopolitical and Economic Goals

China Cultivates Clients for the New Space Economy

China has established plans to dominate the space economy of the future, but it also views its space goals as intrinsically linked with its geopolitical ambitions on Earth. In particular, Beijing views its space program as key to elevating its leadership profile in international space cooperation, including through BRI, and establishing a dominant position in the commercial space industry. In 2008, China founded the Asia-Pacific Space Cooperation Organization (APSCO), its primary vehicle for international space cooperation, in which it offers to share its space expertise with less advanced members.[50] Dues-paying APSCO member are granted access to Chinese space training, ground stations, and satellite development projects.[51] In return, China gains international prestige, promotes the export of its technology and services, and gains access to supplementary data and geographic coverage for its space situational awareness.[52] China also seeks to cooperate with advanced spacefaring countries and market its expertise by selling its technology to less-advanced countries.[53]

As of April 2018, China claimed it had signed 121 space cooperation agreements with 37 countries and four international organizations, which it uses to help promote BRI and develop China's space leadership in the Indo-Pacific.*[54] According to a 2016 address by then CNSA Administrator Xu Dazhe, all APSCO members had "reached broad consensus" on BRI's role as a framework for helping facilitate space capacity-building in the Indo-Pacific region, highlighting the degree to which China has linked space initiatives with its broader foreign policy.[55] In his testimony, Mr. Harrison cited China's ability to leverage participation in its civil space program to strengthen its terrestrial partnerships; for instance, some countries may be willing to support China's political priorities in exchange for a chance to carry out low-gravity research in the future China Space Station.[56] In September 2019, China and Russia announced their intent to cooperate in developing Russia's future Luna-26 lunar orbiter, China's Chang'e-7 lunar polar lander, and a joint lunar and deep space data center with a hub in each country, demonstrating the extension of the two countries' cooperation to space research and exploration (for more on China-Russia relations, see Chapter 4, Section 2: An Uneasy Entente: China-Russia Relations in a New Era of Strategic Competition with the United States").[57]

The China Space Station positions Beijing to leverage its presence in space into diplomatic and scientific gains.[58] Mr. Harrison

*APSCO members include Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey. The Chinese government has not made publicly available a full list detailing all of these agreements or identifying partnering countries. A selection of bilateral agreements it has publicized include an Outline of China-Russia Space Cooperation from 2013 to 2017 through the mechanism of a bilateral Space Cooperation Subcommittee; an Outline of China-European Space Agency Space Cooperation from 2015 to 2020 within the framework of the China-Europe Joint Commission on Space Cooperation; and the China-Brazil Earth Resources Satellite program. Multilateral agreements include a memorandum of understanding signed between CNSA and the UN on Earth Observation Data and Technical Support; support to the activities of the Beijing office of the UN Platform for Space-based Information for Disaster Management and Emergency Response; and participation in the APSCO Joint Small Multi-mission Satellite Constellation Program. Asia-Pacific Space Cooperation Organization, "Member States," February 20, 2019; State Council Information Office, *China's Space Activities in 2016*, December 27, 2016.

contended that China might offer other countries the opportunity to conduct crewed missions to the China Space Station and later to the moon or even Mars as incentives to cooperate with China's priorities on Earth.[59] According to Bleddyn Bowen, a space expert at the University of Leicester, opening the China Space Station to international participants is part of China's effort to establish itself as a U.S. rival in space and to demonstrate that countries can stimulate their space technology sectors without relying on the United States.[60] In June 2019, the UN Office of Outer Space Affairs and the China Manned Space Agency announced six experiments from institutions in 17 countries had received approval for inclusion on the China Space Station and three others had received conditional approval, and the two organizations confirmed they would invite applications for a second group of experiments.*[61] If the International Space Station—which carries experiments selected by each participating country's space agency[62]—is not extended beyond 2024, and a planned small U.S.-built station in lunar orbit is delayed, China may be the only country to have an active space station.† Citing the planned retirement of the International Space Station, Charles Bolden, former administrator of the National Aeronautics and Space Administration (NASA), told the Commission that even if China's intent is not to replace the United States, Beijing is slowly doing it by default.[63]

The Beidou global navigation satellite system is another vital component of China's space diplomacy, figuring prominently in BRI as part of the so-called Space Silk Road.[64] Although Beidou is free to users, similar to the U.S.-built Global Positioning System (GPS), China has used it as a tool of geopolitical and diplomatic competition which would deepen users' reliance on China for space-based services, potentially at the expense of U.S. influence. After Thailand, a U.S. treaty ally, was granted access to Beidou in 2013, for instance, a Beidou expert from Wuhan University who participated in the negotiations with the Thai government claimed Beijing's goal was to show that Beidou "can do anything GPS does [and] in some areas it can do even better. If Thailand can embrace Beidou, other countries may follow, and the [United States'] … power in the region will be reduced."‡[65]

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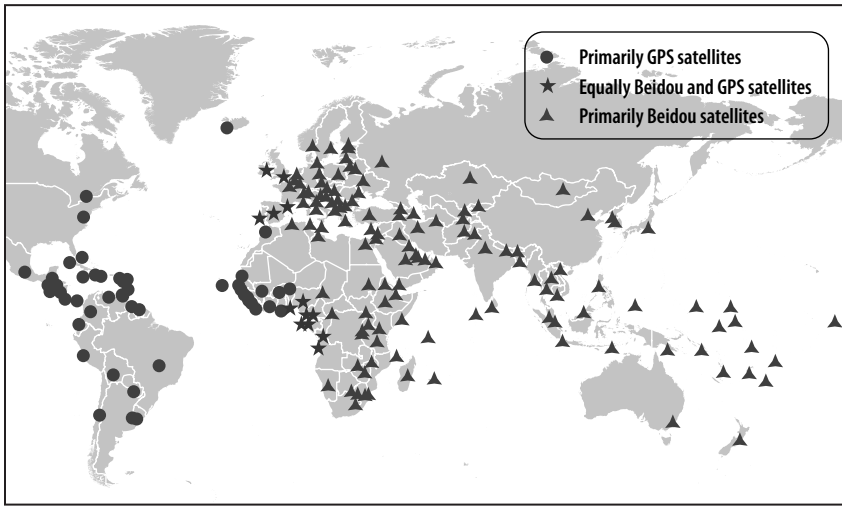
*The 17 countries are Belgium, China, France, Germany, India, Italy, Japan, Kenya, the Netherlands, Norway, Mexico, Poland, Peru, Russia, Saudi Arabia, Spain, and Switzerland. The approved experiments cover astronomy, microgravity fluid physics, microgravity combustion, space medicine, and the conditionally approved experiments cover Earth observation and space technology. UN Office for Outer Space Affairs, "United Nations/China Cooperation on the Utilization of the China Space Station (CSS)," June 12, 2019, 1–6.

†The United States and Russia produced each of the foundational segments of the International Space Station. The United States provides roughly three quarters of the funding to manage the U.S. Orbital Segment, with the rest provided by the Japan Aerospace Exploration Agency (12.8 percent), the European Space Agency (8.3 percent), and the Canadian Space Agency (2.3 percent), while Russia entirely funds the Russian Orbital Segment; the U.S. segment hosts rotations of three to four astronauts from NASA and its three partners, compared to the Russian segment's complement of two to three cosmonauts. Without continued funding from the United States or the introduction of new funding from the private sector, continued operations of the U.S. Segment would likely no longer be feasible. National Aeronautics and Space Administration Office of Inspector General, *NASA's Management and Utilization of the International Space Station*, July 30, 2018, 2, 5–6.

‡The agreement with Thailand included establishing three continuously operating reference stations in Thailand for Beidou, which are ground-based components to improve the network's accuracy. *Xinhua*, "China's BeiDou System to Expand Cooperation to SE Asia," April 1, 2017.

Following a 2013 agreement, Pakistan was the first partner country to be granted access to Beidou's restricted high-precision signal for military use, a model for Beidou's expansion which the *New York Times* reported China could extend to other BRI participants.[66] Chinese state media have praised the Arab world's progress in adopting Beidou, which has included the Arab League's and Chinese government's joint establishment of a center of excellence in Tunis to promote the system.[67] China has also promoted a plan to use existing satellites with a tailor-made data-sharing network to contribute to the development of BRICS countries (Brazil, Russia India, China, and South Africa), and in January 2019 China established a new remote sensing satellite data center in Fuzhou, Fujian Province, that it has billed as part of its Maritime Silk Road, the maritime component of BRI.[68] The *Nikkei Asian Review* reported in August 2019 that as of late June not only had the Beidou constellation exceeded that of GPS in size, but Beidou satellites were more frequently observable than GPS satellites in 130 of 195 UN member countries and also more frequently visible in more than 100 of the 137 BRI participant countries.[69]

Figure 1: National Capitals Where Positioning Satellites Can Be Observed



Note: As of June 28, 2019. Adapted from Kazuhiro Kida and Shinichi Hashimoto, "China's Version of GPS Now Has More Satellites than US Original," *Nikkei Asian Review*, August 19, 2019.

Beijing has also linked its space program with its ambitions to lead terrestrial digital connectivity. The powerful State Administration for Science, Technology and Industry for National Defense (SASTIND) and the National Development and Reform Commission have issued plans to use communications, remote sensing, and navigation satellites to complete the construction of a BRI Space Information Corridor—another name for the Space Silk Road—by the late 2020s.[70] A 2016 guiding opinion issued by the two agencies found that China's space cooperation agreements had established strong governmental and commercial mechanisms with dozens of countries

participating in BRI but that China's satellite technology still required improvement—a shortcoming the construction of the BRI Space Information Corridor now aims to resolve.[71] The project is further intended to improve China's industrial high-tech cooperation with BRI countries, accelerate the "going out" of China's space industry and increase the competitiveness of Chinese space firms, promote the image of China as a responsible big country by facilitating humanitarian assistance and disaster relief,* and increase the level of marketization and internationalization of China's space information industry.[72] A future space-based solar power network might also become part of the Space Silk Road, which has the potential to "dramatically deepen" China's influence over participants, according to Australian Strategic Policy Institute expert Malcolm Davis.[73]

Expanding Global Network of Ground Stations

Beijing has had some success expanding its space tracking and observation capabilities through partnerships established through its space-related diplomacy, which it has used to advance both its space capabilities and geopolitical influence. In recent years, China has also used these partnerships to extend its overseas military presence. Whereas China largely was forced to rely on deploying expensive communications ships to track spacecraft in orbits not visible from Chinese territory in the 1970s, beginning in 1997 it began efforts to emulate a U.S.-style network of overseas tracking stations by opening its first overseas ground station on a Kiribati-owned atoll in the Pacific Islands.[74] In 2001, China and Sweden signed an agreement for mutual access to each other's tracking networks. Beijing dismantled its facility after Kiribati switched recognition to Taiwan in 2003 but currently operates satellite tracking stations in Chile, Sweden, Australia, Namibia, Pakistan, and Kenya.[75] In 2015, Beijing secured a deal for a much larger and more capable satellite and space mission control center in Patagonia, Argentina.[76]

The space control center in Argentina, which Beijing gained approval to construct and operate at a time when Argentina was deeply indebted to China, represents a significant expansion of China's ability to track and control space assets via a global network of ground stations and may represent a new model for Chinese overseas basing.[77] In 2015, it was reported that China planned to allow Argentina to use up to ten percent of the station's antenna time and grant it access to imagery from China's surveillance satellites.[78] Former Argentine foreign minister Susanna Malcorra, however, claimed in 2019 Argentina has no "physical oversight" of the station, though Argentine officials have sought—so far without success—to gain more insight into its operations.[79]

China maintains the purpose of the base, which it began constructing in 2013 before Argentina granted official approval and which became operational in early 2018, is to support deep space exploration and other civilian space activities, including during the December 2018 landing of the Chang'e-4 probe on the far side of the

*For more on China's humanitarian assistance and disaster relief operations, see Matthew Southerland, "The Chinese Military's Role in Overseas Humanitarian Assistance and Disaster Relief: Contributions and Concerns," *U.S.-China Economic and Security Review Commission*, July 11, 2019.

moon.[80] However, as a result of the merger of the former China Satellite Launch and Tracking Control General with other space-related military organizations in 2015, the base is operated by the Space Systems Department of the Strategic Support Force—the part of the PLA responsible for telemetry, tracking, and command of Chinese military space missions as well as counterspace activities.[81] Experts assert the facility operates with virtually no transparency and could be used to collect intelligence on satellites, missile launches, and drone movements, and to interfere with or compromise communications, electronic networks, and electromagnetic systems in the Western Hemisphere.[82]

China Making Inroads to Command the Global Commercial Space Sector

China is determined to grow its market share in commercial launch and satellite sectors relying in part on aggressive state-backed financing that foreign firms cannot match, seeking in some cases to displace U.S. and other foreign launch and satellite providers.[83] China seeks to expand its market share in part by catering to developing countries and by building strong relationships both with its traditional partners and with established satellite operators such as U.S.-based Global Eagle or France-based Eutelsat.[84] At the heart of this program is the PLA contractor China Great Wall Industry Corporation (CGWIC), China's sole provider of commercial satellite and launch services for international clients. CGWIC offers as much as 70 percent financing for satellite construction to international clients, with funds available immediately upon signing instead of the usual delay of six months to a year. In some cases it has also provided ground control systems, training, and insurance.[85] CGWIC provided China's first full in-orbit satellite delivery for a foreign client—comprising financing, construction, launch, testing, ground stations, and personnel training—in its NigComSat-1 deal with Nigeria in 2007.[86]

Due to the generous financing terms China provides, it is unclear whether China can generate a profit at all from these arrangements, indicating profit may not be a driver in these deals.[87] Mike Gold, a senior U.S. commercial space industry executive, testified to the Commission that due to the aggressive financing offered by CGWIC, the company he represents did not even bother to bid in 2016 for an Indonesian government contract for a high-throughput satellite because it simply could not compete.[88] This tactic is indicative of what Mr. Gold called China's broader strategy "to capture a majority share of the global communications satellite and launch market."[89] Even if Chinese satellites are not as high-quality as those made by the United States, they are in some cases more readily available and their quality is adequate, making them more attractive options, especially at a time when the telecommunications satellite industry is moving to smaller, less expensive constellations in LEO.*[90] Beijing is capitalizing on current market conditions to grow its mar-

*Cutting-edge satellites designed by CAST currently have a throughput capacity of 20 gigabits per second, compared to those made by U.S. companies Boeing, SSL, and Orbital ATK, which are capable of throughput speeds of 260, 220, and 100 gigabits per second, respectively. Brian Spegele and Kate O'Keeffe, "China Exploits Fleet of U.S. Satellites to Strengthen Police and Military Power," *Wall Street Journal*, April 23, 2019.

ket share, according to Mr. Gold, threatening to hollow out the U.S. space industrial base.[91]

China's aggressive and well-coordinated export finance practices are forcing other countries' export credit agencies to defensively change their policies and practices simply to maintain their access to large global markets, let alone expand their share.[92] According to a June 2019 report from the U.S. Export-Import Bank, China's export financing system, which comprised $39 billion in total official export credits in 2018, was larger than the next three countries' official export credit agencies combined. It has led foreign buyers for large projects to view the availability of government-backed financing as a "core component" of their evaluation of bids.[93] For example, ExPace, a subsidiary of one of China's main space contractors, plans to price satellite payloads at less than half market rates, and some Chinese companies have offered free launches, providing these companies a significant advantage over foreign competitors (see table below for a list of recent Chinese satellite launches for foreign customers and the financing source for these deals).[94] According to Mr. Gold, this change in market share, and the resulting decreases in orders for U.S.-made satellites, risks causing the long-term loss of U.S. secondary and tertiary space component suppliers and associated critical workforce skills.[95] CGWIC has branched out from launching mainly Chinese-made satellites for foreign customers to more recently contracting with foreign entities to provide launch services for their own products. In most cases, China Export-Import (EXIM) Bank has provided funding.

Table 1: Satellites Launched for Foreign Customers by China, 2007–2018

Country	Satellite	Builder	Launch	Bus	Cost	Funding
Nigeria	NigComSat-1	CGWIC	May 2007	DFH-4	$300 million	China EXIM Bank
Venezuela	VeneSat-1/ Simon Bolivar	CGWIC	Oct. 2008	DFH-4	$241 million	China
Pakistan	PakSat-1R	CGWIC	Aug. 2011	DFH-4	$222 million	China EXIM Bank
Nigeria	NigComSat-1R	CGWIC	Dec. 2011	DFH-4	$300 million	Insurance from NigComSat-1
Venezuela	VRSS-1	CAST	Sep. 2012	CAST-2000	Unknown	Unknown
Sri Lanka	SupremeSat-1/ChinaSat 12	Thales Alenia Space	Nov. 2012	SB4000	$100 million (leased transponders)	Unknown
Bolivia	Túpac Katari-1	CGWIC	Dec. 2013	DFH-4	$302 million	85 percent financed by China Development Bank

Table 1: Satellites Launched for Foreign Customers by China, 2007–2018—*Continued*

Country	Satellite	Builder	Launch	Bus	Cost	Funding
Laos	Laosat-1	CGWIC	Nov. 2015	DFH-4	$259 million	China EXIM Bank
Belarus	Belintersat-1	CGWIC	Jan. 2016	DFH-4 bus with Thales transponders	$280.9 million	China EXIM Bank
Venezuela	VRSS-2	CAST	Oct. 2017	CAST-2000	Unknown	Unknown
Algeria	Alcomsat-1	CAST	Dec. 2017	DFH-4	$250–300 million	Algerian Space Agency
Pakistan	PRSS-1	DFH Satellite Co. Ltd.	Jul. 2018	CAST-2000	$200 million	70 percent financed by loan from China
Pakistan	PakTES-1A	Pakistan Space and Upper Atmosphere Research Commission (SUPARCO)	Jul. 2018	Unknown	Unknown	Unknown
France	CFOSAT	CAST and French National Centre for Space Studies	Oct. 2018	CAST-2000	Unknown	Unknown
Saudi Arabia	SaudiSat 5A & SaudiSat 5B	King Abdulaziz City for Science and Technology	Dec. 2018	Unknown	Unknown	Unknown
Thailand	High-throughput satellite	CGWIC	Late 2019 (est.)	DFH-4	$208 million	Unknown
Argentina	90 microsats (multiple launch agreement)	Satellogic	Late 2019 (est. first launch, then quarterly)	Unknown	Unknown	Unknown
Indonesia	Palapa-N1/ Nusantara Satu-2	CGWIC	2020 (est.)	DFH-4	$220 million	Unknown
Nigeria	NigComSat-2, NigcomSat-3	CGWIC	2021 (est.)	Unknown	$700 million	China EXIM Bank
Indonesia	PSN-7 (nonbinding agreement)	CGWIC	2022 (est.)	DFH-4	Unknown	Unknown

Source: Various.[96]

Jumpstarting the Space Industry with Military-Civil Fusion

As China seeks to increase its share in the international commercial space market, it has aggressively sought to leverage military-civil fusion to commercialize its existing space technology in part by granting new space companies access to some formerly restricted intellectual property.[97] Lorand Laskai, visiting researcher at the Georgetown Center for Security and Emerging Technology, testified to the Commission that China's emerging private space sector has been "a notable priority and early success" in General Secretary Xi's military-civil fusion campaign (for more on military-civil fusion, see Chapter 3, Section 2, "Emerging Technologies and Military-Civil Fusion: Artificial Intelligence, New Materials, and New Energy").[98]

China's strategy to build up its domestic space industry, according to the May 2019 joint report by the Air Force Research Laboratory and Defense Innovation Unit, includes intellectual property theft, direct integration of state-owned entities and their technology with commercial startups, using front companies to invest in U.S. space companies, gaining vertical control of supply chains, and predatory pricing.[99] For example, according to the report, germanium wafer production, solar cell production, and commercial launch services are especially sensitive markets China seeks to dominate. Refined germanium wafers are the basis for nearly all specialized satellite solar panels, and as a result of aggressive stockpiling of and export taxes on germanium, China now accounts for over 70 percent of global germanium mining, refining, and production, meaning that production of these critical panels is effectively impossible without China's raw materials.[100] Unlike rare earth elements, germanium is produced primarily by refining zinc nitrates, but since only three zinc mines and one zinc smelter are in operation in the United States, U.S. capacity to produce germanium domestically is currently limited.*[101]

The goal of military-civil fusion in China's space sector is not primarily to develop cutting-edge technology but to produce existing technology that meets most customers' needs at lower cost and at greater commercial scale and efficiency.[102] In 2014, Beijing opened the space industry to the non-state-owned sector, allowing these companies to build and launch satellites for the first time, although the PLA still retains a monopoly on approving launches. Most of these new companies are in fact connected in some way to the Chinese military, defense industrial base, or state-owned research and development institutions.[103] As of June 2019, according to analyst Jean Deville, the burgeoning Chinese space sector (not counting large state-owned space industry contractors) comprised 87 private space startups, state-sponsored space startups, and large private corporations that had diversified into space in some way, with two thirds founded since 2015.†[104]

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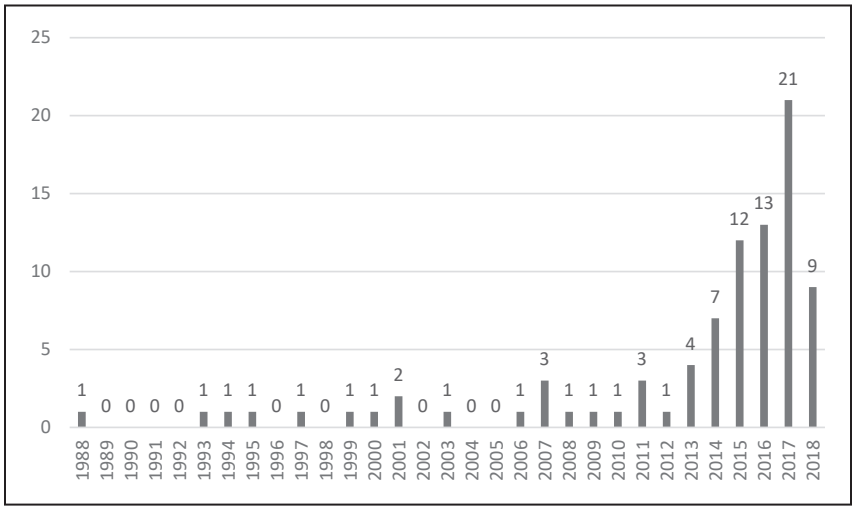
*A Canadian company, Teck Resources, owns two of the mines, and a Belgian company, Nyrstar, owns the third mine and the smelter. From 2014 to 2017, 58 percent of U.S. germanium stockpiles were imported from China and 26 percent from Belgium. Amy Tolcin, Assistant Chief, Mineral Commodities Section, National Minerals Information Section, U.S. Geological Survey, interview with Commission staff, July 26, 2019; U.S. Geological Survey, "Germanium," February 2019, 1; U.S. Geological Survey, "Mineral Commodities Survey 2019," February 2019, 68–69; Nyrstar, "Clarksville Smelter."

†Of these companies, roughly one third appear to have private investors, another third are identifiable as having received state funding, and the ownership and financing of the remaining

The Chinese government has also begun subsidizing launches by these companies at its Jiuquan launch facility in the Gobi desert.[105] In June 2019, SASTIND released new regulations outlining guidelines for commercial launch vehicle development under military-civil fusion, mandating among other things that companies obtain official governmental permission before engaging in research and development or testing of launch vehicles.[106] In July 2019, Beijing-based iSpace, a new firm that received early-stage funding from SASTIND, achieved the first orbital satellite launch by a Chinese startup, marking a major success of China's military-civil fusion space drive.[107]

Figure 2: New Chinese Space Companies Founded per Year



Source: Jean Deville, "A Large Scale Update of the China Aerospace Blog NewSpace Mapping (June 2019 Edition)," *China Aerospace Blog*, June 10, 2019.

Leveraging Foreign Technology to Achieve Space Goals

The pursuit of foreign technology and talent, especially from the United States, continues to be central to military-civil fusion and China's space development modernization goals.[108] Under military-civil fusion, so-called "guidance funds" pool state-owned and private capital together for investments, allowing the state to steer ostensibly private capital toward investments in nascent dual-use sectors it deems strategically important—a tool China has consistently applied to the development of its space sector.[109] Assistant Secretary of State for International Security and Nonproliferation Christopher A. Ford testified to the Commission that universities are the "front line" of military-civil fusion, and students enrolled in foreign science, technology, engineering, and mathematics programs are treated like employees of China's defense industrial base. Defense enterprises regularly provide living stipends during their studies in return for service commitments.[110] Chinese universities that contribute to China's defense modernization goals also aggressively

companies is unclear and requires further investigation.

pursue research partnerships with prominent U.S. and other foreign universities, especially in aerospace research, raising concerns about export controls since the research resulting from these partnerships may ultimately contribute to China's military.[111]

Several notable Chinese universities are especially active in carrying out international academic cooperation to advance China's space development.[112] For example, Beijing University of Aeronautics and Astronautics, also known as Beihang University, describes itself as the "leader and backbone" of China's national defense and aerospace industry.[113] Beihang, which conducts research supporting China's planned lunar research station and space-based solar power, among other things, has collaborated on space-related science and technology with a number of U.S. universities despite being on the Entity List maintained by the U.S. Department of Commerce's Bureau of Industry and Security—a list comprising persons subject to specific license requirements under U.S. export controls—since 2005.[114] In November 2012, Chinese Communist Party mouthpiece *People's Daily* praised Beihang for its long contribution to the modernization of China's national defense and military.[115] *People's Daily* cited the 2005 establishment of a joint Beihang engineering institute with the French Central Polytechnic University Group as aiming to "cultivate high-end, world-class, and top-notch innovative talent" by combining international standards with China's national conditions.[116] According to *China Daily*, Beihang has links with 152 universities in 40 countries, including in the United States, and at least some of them—such as with The Ohio State University College of Engineering and Arizona State University*—have been verified.[117] However, not all of Beihang's claims are accurate. A spokesperson for the University of California, Los Angeles, for example, flatly denied the existence of a joint laboratory that Beihang claimed to have established with the university.[118]

Chongqing University, which claims to have established cooperation with 115 universities in over 20 countries, including the United States, Canada, and other countries with advanced science and technology, is another notable elite Chinese institution active in promoting aerospace cooperation.[119] China University of Science and Technology, Shanghai Jiaotong University, the Harbin Institute of Technology, and others have also established dual-degree and student exchange programs focusing on science and technology innovation with U.S. universities.†

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*In August 2019, nine Chinese undergraduate students at Arizona State University were detained by U.S. Customs and Border Protection officials in Los Angeles and then denied permission to re-enter the United States to continue their studies. Customs and Border Protection deemed them inadmissible and sent them back to China, citing unspecified information discovered during the inspection process. Rachel Leingang, "9 Chinese ASU Students Detained at Los Angeles Airport, Denied Admission to U.S.," *Arizona Republic*, August 30, 2019.

†U.S. universities that have established these dual-degree programs with the University of Chongqing include the University of Cincinnati; the University of North Carolina at Wilmington; Tulane University; Michigan Technological University; and University of Arkansas, Fayetteville. The Chinese universities mentioned above signed a cooperation agreement with the Strategic Support Force in 2017 under which the military would, among other things, "[promote] exchanges between experts and scholars." For more details, see U.S.-China Economic and Security Review Commission, *Hearing on China in Space: A Strategic Competition?* written testimony of Namrata Goswami, April 25, 2019, 249–251; *Xinhua*, "Strategic Support Force Cooperates with Nine Local Units to Cultivate High-End Human Talent in New-Type Combat Forces" (战略支援部队与地方9个单位合作培养新型作战力量高端人才), July 13, 2017. Translation.

Beijing Exploits Loopholes to Access Controlled Satellite Technology

Kevin Wolf, former Assistant Secretary of Commerce for Export Administration, testified to the Commission that U.S. export controls of military, dual-use, and commercial space-related technologies concerning China effectively amount to "a complete embargo."[120] These controls have been strengthened by the addition to the Department of Commerce's export controls of a strict rule mandating that any spacecraft or space asset containing a U.S.-origin component, regardless of the component's value or end use, will always remain subject to U.S. jurisdiction, no matter where it is in the world.[121] Furthermore, then Assistant Secretary Wolf implemented a rule in January 2017 imposing additional requirements for exports and re-exports to Hong Kong—which enjoys special customs status under the U.S.-Hong Kong Policy Act of 1992—by leveraging the Export Administration Regulations to compel Hong Kong authorities to provide proof of compliance with Hong Kong law.[122]

Despite these strong regulations, Chinese entities have nonetheless been able to acquire stakes in U.S. space companies due to legal loopholes, especially those relating to Hong Kong.[123] For instance, the *Wall Street Journal* reported in December 2018 that a Los Angeles-based startup, Global IP, had received about $200 million in funding originating from a Chinese state-owned financial firm, China Orient Asset Management Co., to buy a Boeing-constructed satellite.[124] A Chinese businessman, Charles Yiu Hoi Ying, set up a cut-out company for China Orient in the British Virgin Islands to conceal the money's connection to the Chinese government. Because he held a Hong Kong passport and was thus able to take advantage of the region's special export control status, he was then able to invest China Orient's money in Global IP. The deal ultimately was canceled due to nonpayment.[125] Other Chinese companies with Hong Kong subsidiaries have pursued similar investments. In December 2018, Cloud Constellation Corporation, a U.S. startup focusing on establishing a network of cloud computing servers based in LEO, received a $100 million funding commitment from HCH Group, a Hong Kong-based subsidiary of Haier Group, a major Chinese electronics and appliance giant with suspected ties to the Chinese government.[126]

An additional loophole allows Chinese entities barred from investing in or acquiring U.S. satellites to leverage U.S. satellite capabilities by renting their bandwidth—a problem U.S. export controls were not originally designed to address. A notable example is the Hong Kong-based satellite operator AsiaSat, which has Chinese government and military end users despite operating satellites with controlled U.S. technology. According to an April 2019 *Wall Street Journal* report, the Chinese state-owned firm Citic Group, which co-owns AsiaSat alongside the U.S.-based Carlyle Group, rents satellite bandwidth to Chinese state-owned telecommunications companies, which then parcel out their rented bandwidth to Chinese military and intelligence entities. Four U.S. administrations, most recently in 2017, have approved this ar-

Beijing Exploits Loopholes to Access Controlled Satellite Technology—*Continued*

rangement.[127] AsiaSat does not regulate the content its satellites carry, and the Chinese government has used these satellites, for example, to maintain government communications during police crackdowns in Xinjiang and Tibet in 2008 and 2009 and to provide internet access to China's military bases in disputed regions of the South China Sea in 2016.[128]

Another Hong Kong-based company, CMMB Vision—which enjoys high-level Chinese government support and whose work the National Development and Reform Commission has designated a "key national development project"[129]—contracted Boeing in 2015 to construct an advanced satellite.[130] According to the *Wall Street Journal*, the satellite is being built on behalf of CMMB Vision's New York-based partner company, which will then lease the satellite's capacity back to the Hong Kong company for use in promoting the Space Silk Road and improving the accuracy of Beidou.[131] The National Defense Authorization Act for 2019 contains a provision that would allow the U.S. government to close this bandwidth-leasing loophole, but it has yet to be implemented.[132]

Space as the "Commanding Heights" of Future Military Conflict

Beijing's first priority in a modern conflict is to seize dominance in the "information domain," a combination of space, cyberspace, and the electromagnetic spectrum, in accordance with China's identification of the cyber and space domains as "new commanding heights in strategic competition."[133] Chinese sources describe space superiority, which they identify as the goal of military space operations, as the means to ensure Beijing's ability to fully use space while simultaneously constraining and destroying enemy forces in space—a concept not unlike the traditional maritime function of sea control.*[134] An article published by the PLA Academy of Military Science argued the only way for China to achieve parity with the United States is to hold U.S. space assets at risk by increasing its asymmetric capabilities.[135]

The PLA has reorganized its structure, including through the establishment of the new Strategic Support Force, and fielded a broad array of counterspace weapons to be capable of achieving these goals.[136] The formation of the Strategic Support Force in late 2015 is the organizational result of China's conclusion from observing the Gulf War that it must be able to gain battlefield advantage through attacks in the space, cyber, and electromagnetic domains.†[137] Although the PLA began applying these foundational concepts to its organization, training, and research and development in the late

*The U.S. Department of Defense defines space superiority as "the degree of control in space of one force over any others that permits the conduct of its operations at a given time and place without prohibitive interference from terrestrial or space-based threats." Chairman of the Joint Chiefs of Staff, *Joint Publication 3–14, Space Operations*, April 10, 2018, GL-6.

†For more on the background of the Strategic Support Force, see U.S.-China Economic and Security Review Commission, *2018 Annual Report to Congress*, November 2018, 237–239.

1990s, their unification in the new functional command embodied in the Strategic Support Force will significantly improve the PLA's ability to carry out strategic-level operations in these domains.[138] According to testimony presented to the Commission by Mark Stokes, Executive Director of the think tank Project 2049 Institute, the new organizational construct represented by the Strategic Support Force is "central to China's ability to compete in space."[139]

As a result of the PLA's reorganization, the Strategic Support Force's Space Systems Department is now responsible for PLA operations in space, including space attack and defense; space launch, including from operationally-responsive mobile launchers; telemetry, tracking, and control; and information, surveillance, and reconnaissance operations.[140] The Strategic Support Force also took over China's space-related research programs.[141] Dr. Goswami testified to the Commission that the Strategic Support Force's establishment represents an innovation in China's ability "to develop futuristic doctrines, training and capabilities" to suit new mission requirements for space operations and will play a role in establishing China's presence in cislunar space while helping deny this space to the United States.[142] In a role complementary to the Space Systems Department's, the Strategic Support Force Network Systems Department oversees China's cyberforces in carrying out computer network exploitation, cyber surveillance, computer network attack, and computer network defense missions. The Network Systems Department is also "central" to the counterspace mission, according to Mr. Stokes, since it oversees the PLA's nonkinetic counterspace mission, comprising electronic countermeasures, space surveillance, technical reconnaissance, and possibly directed energy attacks.[143]

A Destabilizing Approach to Space Warfare

China views space as a critical U.S. military vulnerability, and its counterspace capabilities are designed to threaten space as an enabler of U.S. operations, including nearly every class of U.S. space asset.[144] According to the 2013 edition of *Science of Military Strategy*, an authoritative book published by the Academy of Military Science, space systems are "easy to attack and difficult to defend," and "critical node targets of the enemy space systems" are especially valuable targets.[145] Another Academy of Military Science text, *Textbook for the Study of Space Operations*, argues command and control systems are "crucial" targets and space information systems are "the crucial of the crucial."[146]

Moreover, authoritative PLA writings on military operations in the space domain contain a number of principles almost entirely absent from U.S. and other foreign military doctrine that would encourage a highly escalatory approach to space warfare. In particular, these would allow for attacks against an adversary's space assets early in a conflict to deter an opponent from decisively intervening in or continuing a military confrontation.[147] William Roper, Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics, testified to the Commission that Beijing is well aware of the extent to which U.S. sea, air, and land operations rely on space-based assets for communication, navigation, and precision fires and has thus concluded it is much more feasible to threaten these assets in space

than the terrestrial capabilities they enable.[148] China's development of offensive space capabilities may now be outstripping the United States' ability to defend against them, increasing the possibility that U.S. vulnerability combined with a lack of a credible deterrence posture could invite Chinese aggression.[149] According to Mr. Harrison, China is "developing, testing, and operationalizing counterspace weapons at a faster pace than [the United States is] making progress protecting [its] space systems against these threats."[150]

China's counterspace doctrine is intended to deter the United States from entering a conflict and provide options for rapid escalation once conflict has begun, representing an approach to space warfare which risks destabilizing the space environment. Kevin Pollpeter, senior research scientist at CNA, testified to the Commission that China's counterspace architecture is intended "to deter the United States at the nation-state level [and] achieve operational goals should deterrence fail."[151] According to *Science of Military Strategy*, space deterrence requires "developing space capability, displaying an asymmetric operational posture, and when necessary firmly resolving to conduct space counter-preemption operations … to achieve the deterrence goals."[152]

Beijing views space and cyberspace as domains to dominate and to deny to its adversaries, and it would likely seek to accomplish this in part by deploying cyberattacks or electromagnetic attacks against space-based assets, including commercial or civilian assets, both in steady state* and early in any conflict.[153] Jonathan Ray, Research Director of the Special Programs Division at SOS International, testified to the Commission that Chinese strategists see the United States as so reliant on satellites for critical military functions that threatening to degrade or destroy these crucial systems may be enough to force the United States to stand down in a conflict.[154] *Science of Military Strategy* supports this conclusion, recommending conducting "limited space operational activities with warning and punishment as goals to stop the adversary from willfully escalating the intensity of a space confrontation."[155] Mr. Ray noted further that PLA strategists appear to view "soft" cyberattacks as less escalatory than kinetic strikes, which may make them more tempting, especially since the adversary may either not be able to immediately determine what has happened or be willing to retaliate.†[156]

China has been implicated or suspected in cyberattacks against U.S. space systems at least four times since 2007 (see Addendum II of known Chinese counterspace or dual-use weapons tests, including cyberattacks on U.S. space systems, on page 386), though Chinese officials consistently deny Beijing's involvement.[157] According to Mr. Pollpeter, Chinese strategists apparently have also not discussed how individual tactical actions in space may unintentionally result

*Multiple witnesses argued China is already in a state of constant competition or seeking to actively undermine the United States, so the juxtaposition of "peace" and "conflict" is not appropriate. Mr. Ray suggested "steady state" to describe a sub-kinetic but persistent state of competition. U.S.-China Economic and Security Review Commission, *Hearing on China in Space: A Strategic Competition?* oral testimony of Mark Stokes, April 25, 2019, 242; U.S.-China Economic and Security Review Commission, *Hearing on China in Space: A Strategic Competition?* oral testimony of Jonathan Ray, April 25, 2019, 242.

†Cyberattacks can cause lasting damage to space systems, such as by expending propellant, damaging sensors or electronics, or shutting down communications. Todd Harrison et al., "Space Threat Assessment 2019," *Center for Strategic and International Studies*, April 2019, 5.

in escalation.[158] Moreover, despite extensive discussion of prioritizing attacks on vulnerable U.S. space assets, Chinese strategists have not seemed to openly recognize that Beijing may be developing the same or similar weaknesses as it expands its own reliance on space.[159]

China's space doctrine suggests it may be difficult to deter the PLA from targeting important U.S. space assets. According to several witnesses at the Commission's hearing, the near-term emergence of a "mutually assured destruction" doctrine in space is unlikely. Mr. Pollpeter contended that the PLA's temptation to target U.S. space assets will add "a layer of instability to any conflict with China."[160] One problem with such a tacit understanding is the fact that while the United States has many singularly valuable space systems, China does not have comparable individual platforms it values as much.[161] Thus, according to Dr. Weeden, the cost-benefit analysis of "I'll kill yours if you kill mine" cannot reliably deter China from making a first strike.[162]

China's Counterspace and Dual-Use Weapons Tests Threaten U.S. Assets

China has made substantial investments for over a decade in developing a full array of direct-ascent, cyber, electromagnetic, and co-orbital counterspace weapons and demonstrated the credibility of these systems.[163] Although China has not shot down a satellite since its 2007 test that destroyed a defunct weather satellite with a direct-ascent missile, which created a great deal of dangerous debris, it has continued to test kinetic counterspace systems nearly every year, sometimes disguised as midcourse ballistic missile intercept tests.[164] General John Raymond, U.S. Air Force, nominee for Commander of U.S. Space Command, said in 2015 that China's investment in ASAT research would soon allow it to threaten "every satellite in every orbit."[165] The new Strategic Support Force has reportedly already carried out training with direct-ascent ASAT weapons capable of striking targets in LEO, according to the National Air and Space Intelligence Center.[166] In April 2019, then Acting Secretary of Defense Patrick Shanahan stated the PLA would likely field a ground-based laser system targeting LEO systems by 2020.[167] Taken together, the fielding of these capabilities demonstrates the increasing vulnerability of U.S. space assets, especially in LEO.

China has engaged in dual-use activities such as rendezvous and proximity operations (RPO)—which demonstrate co-orbital capabilities—that, while not prohibited, create problems for U.S. national security. These capabilities can be used for peaceful purposes, such as removing harmful orbital debris and repairing other satellites, but also for counterspace activities, such as disabling other satellites, though there is no evidence China has used co-orbital capabilities for destructive purposes.[168] According to Dr. Weeden, China's testing of RPOs has been similar to past U.S. tests, and no country has criticized RPOs carried out by China as illegal or violating any norm.[169] China's RPO activities have been consistent with the use of technologies for nonmilitary satellite service, inspection, and situational awareness, such as activities the United States has carried

out, including U.S. inspections of satellites in LEO in 2005 and 2006 and of satellites in GEO since 2016.[170]

Still, given the PLA's involvement in China's space program, there is a distinct possibility that platforms with dual-use capabilities could be used for offensive purposes when needed.[171] For example, the Chinese satellite Aolong-1 has robotic arms for grappling other satellites to inspect or service them, and although these capabilities have peaceful uses, they would be easy to weaponize.[172] Some analysts have also been especially concerned by the RPO activities in GEO of the Chinese satellite SJ-17, reportedly a testbed for new propulsion, surveillance, and solar panel technology.[173] SJ-17 has transited the geostationary belt, and its movements suggest it has a significant maneuverability, including the ability to change its orbit.[174]

Implications for the United States

The United States retains many advantages over China in space, including the organization and technical expertise of its space program, its vibrant commercial space sector, and its long history of space leadership and many international partnerships. Indeed, as posited to the Commission by former NASA Administrator Bolden, much of what China is attempting to do in space is based on its view that the United States has already established these same goals—and is well ahead of China in achieving them. Some areas of cooperation may be beneficial to the United States. For example, according to former Administrator Bolden, NASA shared the International Docking System Standard with China to ensure U.S. and Chinese spacecraft airlocks would be compatible in emergencies, and the countries' space agencies have collaborated in observing China's moon landings.[175]

Still, China's single-minded focus and national-level commitment to establishing itself as a global space leader harms other U.S. interests and threatens to undermine many of the advantages the United States has worked so long to establish. In his testimony to the Commission, General Cartwright attributed China's relative advances in space capabilities in part to the fact that the United States under-prioritized strategic concerns in space for six to eight years, providing an opportunity for competitors to narrow the gap.[176] China's strategy to capture the global launch and satellite markets using aggressive financing and subsidies that U.S. market-driven firms cannot match is only one of the challenges posed to the United States by Beijing's drive for space leadership.[177] Like the international solar panel and telecommunications industries before it, the commercial space sector now risks being hollowed out by China's plans to attain leadership in key technologies.

Beijing's promotion of the China Space Station as a future venue for international cooperation, for instance, provides China an opening to capitalize on a diplomatic opportunity created by the U.S. government potentially ending support for the International Space Station as early as 2025. China may replace the United States by default as the most important country for international civil space cooperation.[178] In the face of determined attempts by China to gain access to controlled U.S. technologies, witnesses at the Commission's

hearing stressed the importance of ensuring U.S. export controls are both up to date and implemented on a multilateral basis while also avoiding unintentionally harming U.S. companies.[179] General Cartwright and Assistant Secretary Roper testified to the Commission that U.S. deterrence strategy does not yet adequately incorporate the space domain, with both warning that Beijing may be tempted to extend a conflict into space as long as it perceives the benefits as outweighing the costs.[180]

The emergence of what the 2017 U.S. National Security Strategy calls the "democratization of space," a new paradigm of space access built on small, low-cost systems and commercial rather than government leadership, will extend the "critical economic veins" of the United States into space where they will become increasingly vulnerable to disruption.[181] With space no longer a benign domain in which the United States can assume it will retain its historical advantage, it may be even more important for the U.S. national security architecture to extend into space to guarantee the security of U.S. economic interests, which historically has been the case with maritime commerce.[182] In particular, the cislunar domain and the space beyond may play a key role in the United States' future security and economic interests due to its value for space-based communication, transport, and security—characteristics of critical sea lines of communication that must remain unimpeded.[183]

If and when technology necessary to realize the economic potential some experts attribute to space becomes mature, China appears to be well positioned to compete with the United States in establishing a commanding position in the resulting new economy. For these reasons, concluded Dr. Goswami in her testimony to the Commission, the historical U.S. "flags and footprints" model characterized by exploration without building capacity for a long-term presence may no longer suffice.[184]

Addendum I: Key Chinese Officials with Aerospace Sector Backgrounds

Name	Birthdate	Current Position	Former Aerospace Position
Zhang Qingwei (张庆伟)	Nov. 1961	Central Committee full member (16th–19th Party Congresses) Heilongjiang Party Secretary	SASTIND Director CASC General Manager COMAC Chairman
Chen Qiufa (陈求发)	Dec. 1954	Central Committee full member (19th Party Congress) Liaoning Party Secretary	SASTIND Director CNSA Director MIIT Vice-Minister
Jin Zhuanglong (金壮龙)	Mar. 1964	Central Committee full member (19th Party Congress) Central Commission on Military and Civilian Integrated Development Executive Vice-Director	SASTIND Deputy Director CASC Deputy General Manager COMAC General Manager CNSA Deputy Director
Ma Xingrui (马兴瑞)	Oct. 1959	Central Committee full member (18th–19th Party Congresses) Guangdong Governor	MIIT Vice-Minister SASTIND Director CASC General Manager CAST Vice-Dean
Xu Dazhe (许达哲)	Sep. 1956	Central Committee full member (18th–19th Party Congresses) Hunan Governor	SASTIND Director CNSA Director MIIT Vice-Minister CASC President and Party Secretary CASIC General Manager
Yuan Jiajun (袁家军)	Sep. 1962	Central Committee full member (19th Party Congress) Zhejiang Governor	CAST President and Vice-Chairman Shenzhou Program Chief Commander
Tang Dengjie (唐登杰)	Jun. 1964	Central Committee alternate member (19th Party Congress) Fujian Governor	SASTIND Director CNSA Director
Huang Qiang (黄强)	Apr. 1963	Gansu Vice-Governor	SASTIND Deputy Director SASTIND Director-General AVIC First Aircraft Research Institute Director

Note: Acronyms in order, top to bottom: State Administration for Science, Technology, and Industry for National Defense (SASTIND); China Aerospace Science and Technology Corporation (CASC); Commercial Aircraft Corporation of China (COMAC); China National Space Administration (CNSA); Ministry of Industry and Information Technology (MIIT); China Aerospace Science and Industry Corporation (CASIC); Aviation Industry Corporation of China (AVIC).

Source: Various.[185]

Addendum II: China's Counterspace or Dual-Use Weapons Tests 2005–2019

Type	Year	Description	Comments
Direct Ascent			
	2005	Kinetic kill vehicle (KKV) rocket test	Rocket test for SC-19 direct-ascent missile.
	2006	KKV test	Failed intercept and destruction of an orbital target.
	2007	KKV test	Successful intercept and destruction of an orbital target. Created debris.
	2010	Midcourse ballistic missile defense test	Successful intercept and destruction of a suborbital target.
	2013	Midcourse ballistic missile defense test	Successful intercept and destruction of a suborbital target.
	2013	KKV test	Test of DN-2 rocket. China called it a "high-altitude science mission." The test indicated an attempt to develop the capability to target satellites in medium-Earth orbit, highly-elliptical Earth orbit, and GEO.
	2014	KKV test	China called it a ballistic missile defense test; United States assessed it was an ASAT test.
	2015	Unknown test	
	2017	Unknown test	
	2018	Midcourse ballistic missile defense test	
Co-orbital			
	Sep. 2008	SZ-7, BX-1	Shenzhou-7 spacecraft deployed the BX-1, a miniature imaging satellite, which then positioned itself into an orbit around the spacecraft. BX-1 may have been designed to test in-orbit ejection of "companion" satellites, dual-use on-orbit inspection capabilities, and use of attitude control and propulsion systems for formation flying.
	Jun.–Aug. 2010	SJ-O6F, SJ-12	At 570–600 km and 97.6°, SJ-12 maneuvered to rendezvous with SJ-06F. The satellites may have bumped into each other.

Addendum II: China's Counterspace or Dual-Use Weapons Tests 2005–2019—*Continued*

Type	Year	Description	Comments
	Jul. 2013–May 2016	SY-7, CX-3, SJ-15	At approximately 670 km and 98°, SY-7 released an additional object with which it performed maneuvers and which may have had a telerobotic arm. CX-3 performed optical surveillance of other in-space objects. SJ-15 demonstrated altitude and inclination changes to approach other satellites.
	2016	Aolong-1	Tested robotic arm to remove space debris.
	Nov. 2016–Feb. 2018	SJ-17, YZ-2 upper stage	At 35,600 km and 0°, YZ-2 upper stage failed to burn to the graveyard orbit and stayed near GEO. SJ-17 demonstrated maneuverability around the GEO belt and circumnavigated Chinasat 5A.
	Jan. 2019	TJS-3, TJS-3 AGM	At 35,600 km and 0°, TJS-3 AKM separated from the TJS-3 in the GEO belt and both performed small maneuvers to maintain relatively close orbital slots.
Cyber			
	Oct. 2007–Jul. 2008	NASA and U.S. Geological Service satellite Landsat-7 experienced 12 or more minutes of interference on two occasions.	The responsible party did not achieve all steps necessary to issue commands. The attack was consistent with techniques described in authoritative Chinese military writings.
	Jun. 2008–Oct. 2008	NASA earth observation satellite AM-1 experienced two or more and then nine or more minutes of interference.	The responsible party achieved all steps necessary to issue commands but did not issue any. The attack was consistent with techniques described in authoritative Chinese military writings.
	2012	Computer network attack against NASA Jet Propulsion Laboratory.	Allowed "full functional control" over networks.
	2014	Computer network attack against National Oceanic and Atmospheric Administration.	

Addendum II: China's Counterspace or Dual-Use Weapons Tests 2005–2019—*Continued*

Type	Year	Description	Comments
	2017	Computer network attack against Indian satellite communications.	
	2018	Computer network attack against satellite operators, defense contractors, and telecommunication companies.	
Directed Energy			
	2006	China reportedly dazzled U.S. reconnaissance satellites.	
Electromagnetic			
	2005	China reportedly conducted satellite jamming tests.	

Source: Various.[186]

ENDNOTES FOR SECTION 3

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