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CHINA'S SPACE NARRATIVE

EXAMINING THE PORTRAYAL OF THE US-CHINA SPACE RELATIONSHIP IN
CHINESE SOURCES AND ITS IMPLICATIONS FOR THE UNITED STATES

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PREFACE

Both China and the United States, have created separate parts of their military dedicated to space. Commercial, scientific, and military endeavors in space are all intimately linked, and one must understand how they are viewed to better understand how a nation might proceed in one or all of those fields. In accordance with our charter to support the Secretary of the Air Force, the Chief of Staff of the Air Force, the Chief of Space Operations, and other DoD and U.S. government leaders, the China Aerospace Studies Institute designed its 2020 CASI Conference around China's space activities. This report serves as the baseline and the core of that effort. This report was a collaboration between CASI and CNA's China and Indo-Pacific Security Affairs Division. We would like to thank the team at CNA for their work on this project. The authors would like to thank Second Lieutenant Owen Ou (USA) for contributing his research for this project, and Dr. Brian Weeden for his review of the study.

The rise of China's space program presents military, economic, and political challenges to the United States. In March 2019, Vice President Michael Pence stated that the United States and China are in a new space race "with even higher stakes" than the space race between the United States and the Soviet Union and that China has an "ambition to seize the lunar strategic high ground and become the world's preeminent spacefaring nation."

This report examines Chinese perceptions of the U.S.-China space relationship. It argues that China's space program is one component of the Chinese Communist Party's goal of making China rich, strong, and proud. China regards its space program as an important expression of its national power that serves its political, economic, and military interests. Although Chinese sources describe the United States as the leading space power, they see their own space program as catching up with the United States and surpassing it by mid-century.

This report finds that Chinese perceptions of the U.S.-China space relationship are a reflection of the overall U.S.-China relationship. Chinese sources weave a space narrative that portrays China as a modernizing nation committed to the peaceful uses of space and serving the broader interests of advancing humankind through international space cooperation, economic development, and scientific discovery. Chinese sources minimize the military role of China's space program. In contrast, the same sources portray the United States as the leading space power bent on dominating space, restricting access to space, and limiting international space cooperation to countries with similar political systems and level of economic development.

This report concludes that the United States and China are in a long-term competition in space in which China is attempting to become a global power, in part, through the use of space. China's primary motivation for developing space technologies is national security. However, as China's space program advances, its commercial and scientific activities will become more prominent and will extend the competition to encompass economics and diplomacy, challenging U.S. leadership in space just as China challenges the United States across the full range of diplomatic, military and economic power. In this respect, China's space program is one element of its efforts to transition the current U.S.-dominated international system to a multipolar world.

To date, China's success in space can be attributed in large part to top-level leaders recognizing the benefits of space power, consistent planning, and stable and ample funding. U.S. success in competing with China will need to rely on the same fundamentals.

As the era of great power competition continues to evolve, we must understand the full breadth and depth of the competition, how they think, and how they are likely to act or react. This report lays the foundation to better understand the nature of the PRC's vision of space, and its role in comprehensive national power.

Dr. Brendan S. Mulvaney
Director, China Aerospace Studies Institute

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CHAPTER I: INTRODUCTION

The world is in the midst of a geopolitical transition driven by the rise of China. In 2010, China became the world's second largest economy, and China is now the top trading partner with all five of the United States' treaty allies in Asia. It is the second largest trading partner with the European Union, and it is Africa's largest trading partner.¹ Its defense budget is also the world's second largest, reaching \$177.61 billion in 2019.² China's rising economic and military power have led to an increased presence not only in Asia, but also globally. China's Belt and Road Initiative, a global trade and investment effort, involves countries across four continents. In an acknowledgement of China's growing accomplishments and power, Chinese leader Xi Jinping stated in October 2017 that China "has stood up, become rich, and is becoming strong."³

China's rise and the changing character of the U.S.-China relationship has led to concerns of an emerging Sino-American Cold War.⁴ Previous U.S. policy welcomed "the rise of a peaceful, stable, and prosperous China" and was "committed to expanding [U.S.-China] cooperation."⁵

U.S. policy now regards China as a revisionist power that is "antithetical to U.S. values and interests."⁶ The U.S. *National Defense Strategy* calls out long-term strategic competition with China as "the central challenge to U.S. prosperity and security" and accuses China of seeking "Indo-Pacific regional hegemony in the near-term and displacement of the United States to achieve global preeminence in the future."⁷

One prominent aspect of China's rise as a world power is its rise as a space power. China's ambition to become a space power is driven by a belief that space contributes significantly to China's national power. Its space program is seen as portraying China as a modernizing nation committed to the peaceful uses of space, while at the same time serving its political, economic, and military interests.⁸ Space is also seen as contributing to China's overall influence and helping to maintain China's national security. China sees its space program as catching up with the U.S. space program and surpassing it by mid-century.

China has made important progress across a broad range of space technologies, including launchers, satellites, lunar exploration, human spaceflight, and counterspace technologies. China now has the second largest number of satellites in orbit. It is building a robust suite of counterspace capabilities that include direct ascent kinetic kill vehicles (KKVs), directed energy, electronic warfare, cyber, and co-orbital satellite systems.⁹ Chinese military doctrine stresses the crucial nature of space in winning wars.¹⁰ Some observers in the United States are concerned that China's nascent commercial space industry may displace the U.S. commercial space industry through mercantilist trade policies. China has conducted robotic missions to the Moon, and its space station will become operational at a time when the International Space Station is nearing the end of its service life. China's space proponents also envision a long-term plan to extract natural resources in space.

The rise of China's space program poses military, economic, and political challenges to the United States and is stoking fears that the United States may lose its leadership position in space. In March 2019, Vice President Michael Pence stated that the United States and China are in a new space race "with even higher stakes" than the space race between the United States and the Soviet Union, and that China has an "ambition to seize the lunar strategic high ground and become the world's preeminent spacefaring nation." He then committed the United States to the goal of being the first country to land humans on the Moon in the 21st century.¹¹ In December 2018, Vice President Pence linked the proposal to establish a space force within the military to China's counterspace program and stated that the United States "must be as dominant in the heavens as it is on Earth."¹²

This report examines China's perceptions of its space program and the U.S. space program. It concludes that the United States and China are in a long-term competition in space. Although advancing rapidly, China's space program is viewed by Chinese officials and analysts as trailing the U.S. space program. Nevertheless, China's space industry plans to surpass the United States in space by mid-century. To date, China's success in space can be attributed in large part to top-level leaders' recognition of the benefits of space power, consistent planning, and stable and ample funding. U.S. success in competing with China will need to rely on the same fundamentals.

China's primary motivation for developing space technologies is national security. However, as China's space program advances, its commercial and scientific activities will become more prominent and will extend the competition to encompass economics and diplomacy, challenging U.S. leadership in space, just as China challenges the United States across the full range of diplomatic, military and economic power. Chinese leaders state that their country's space program is both a symbol of and a contributor to China's national power. As a result, China's space program is one component of the Chinese Communist Party's (CCP) goal of making China rich, strong, and proud.

CHAPTER 2: THE CHINA DREAM, WEALTH, POWER, AND CHINA'S SPACE PROGRAM

China's space program is one element of what the Chinese Communist Party calls the "China Dream"—a slogan that connotes a future China stronger and more prosperous. In 2013, Chinese leader Xi Jinping stated that "the greatest Chinese dream is the great rejuvenation of the Chinese nation."¹³ The motivation to redress what the Chinese call "national humiliation" lies at the heart of China's national rejuvenation drive. China at one time was the world's prominent superpower. It was the world's most technologically advanced country and had the largest economy. Smaller states around China's periphery acknowledged its dominance.

The Chinese Communist Party understands that if it is to remain in power, it must make China rich, powerful, and respected.¹⁴ According to Johns Hopkins University's David Lampton: "One almost universally shared goal in the PRC is to make China rich and powerful and to regain the nation's former status as a great power that controls its own fate."¹⁵ As the Council on Foreign Relations' Elizabeth Economy explains, the rejuvenation narrative suggests "to the rest of the world that the current situation in which the United States is the reigning Pacific power, the global leader in innovation, and the country with unrivaled soft power is merely a historical aberration." Xi's national rejuvenation rhetoric "suggests that China today is simply reclaiming its proper place in the global order and righting the scales of history."¹⁶

According to Xi Jinping, the realization of the China Dream means an "improvement of people's livelihoods, prosperity, construction of a better society, and military strengthening."¹⁷ Two timetables established by the CCP take China through a process from being a moderately prosperous society to a "modernized strong socialist nation" by mid-century.

From 2020 to 2035, the CCP plans to significantly increase China's economic, scientific, and technological strength and plans for it to be one of the most technologically innovative countries and with greatly enhanced soft power. From 2035 to the middle of the century, China plans to become a "prosperous, strong, democratic, civilized, harmonious, and beautiful modernized socialist strong country." China's comprehensive national power and international influence "will be at the forefront," and the "Chinese nation will stand tall among the nations of the world."¹⁸ According to the CCP, the realization of the China Dream will result in "China's greatly enhanced economic strength and comprehensive national power as well as international status and influence."¹⁹

Western assessments differ, however, of China's ultimate rejuvenation goals. Graham Allison argues that China wants to return to its role as the predominant power in Asia and to command the respect of other great powers.²⁰ The U.S. Department of Defense (DOD) offers two views of China's desired end state. The 2019 report on China's military states that China wants to become a great power and become the "preeminent power in the Indo-Pacific region."²¹ DOD's *National Defense Strategy* and *Indo-Pacific Strategy Report*, however, state that China "seeks Indo-Pacific regional hegemony in the near-term and, ultimately global preeminence in the long-term."²²

Oriana Skylar Mastro offers a similar, but more nuanced conclusion that China's goal is to displace the United States, not to replace it. In her assessment, China does not want to take on the responsibilities of a global superpower. Instead, it wants the freedom to do what it wants and the ability to prevent others—namely, the United States—from impinging on its national interests.²³

A similar assessment is offered by Tsinghua University's Yan Xuetong, who argues that Chinese leaders "hope that their country will be on par with the United States," but that China will not take on the responsibilities of

a global superpower. In his scenario, China will act as an “enlightened, benevolent hegemon whose power and legitimacy derive from its ability to fulfill other countries’ security and economic needs—in exchange for their acquiescence to Chinese leadership.”²⁴

THE PURSUIT OF “COMPREHENSIVE NATIONAL POWER”

Although there is a debate over the type of international power China wants to become, there is little debate over how China intends to achieve its goal. China is taking a whole-of-nation approach to the pursuit of the “China Dream” and its goal of national rejuvenation through the accumulation of comprehensive national power (CNP).²⁵ *Comprehensive national power* refers to “the complete power and international influence that a sovereign country uses and develops.”²⁶ This includes “the economy, science, technology, education, culture, values, military, governance, diplomacy, and other sectors.”²⁷ In short, it is “the sum total of coercive, economic, and ideational power of a nation.”²⁸ According to George Washington University’s David Shambaugh, “The Chinese have wisely learned one key lesson from studying the experiences of other previous powers: genuine powers possess multidimensional strength.”²⁹

THE IMPORTANCE OF SCIENCE AND TECHNOLOGY IN BUILDING COMPREHENSIVE NATIONAL POWER

A critical part of China’s accumulation of CNP is the ability to independently develop high technology. Chinese leaders since Mao Zedong have stated that technology is the “first productive force” that underpins China’s economic success and national security. The importance of technological innovation was highlighted in a June 2014 speech by Xi Jinping in which he urged China’s scientists and engineers to “innovate, innovate, and innovate again.” According to Xi, China “must continue by resolutely implementing the strategy of using science and education to rejuvenate the country and innovation to drive development and unswervingly continue on the road of making China into a strong science and technology power.” Xi concluded that China “cannot lag in the competitive arena of science and technology” and must catch up to and eventually surpass the current science and technology leaders.³⁰

Reflecting this emphasis on technology, China’s leadership since the founding of the PRC in 1949 has taken a techno-nationalist approach to science and technology.³¹ The Chinese view of techno-nationalism stresses four aspects:³²

- *Leadership in technology can determine a country’s fate.* China hopes to become a leading power by becoming a technology leader and leading the next technological revolution. China’s leadership argues that since the sixteenth century, every science and technology revolution has influenced the global power structure. Great Britain’s economic leadership during the Industrial Revolution allowed a small country to establish a global empire. The information technology revolution is seen as enabling the United States to achieve global dominance.
- *A country’s military security is tied to its ability to independently develop advanced technologies.* China’s leadership has stated that the strength of a country cannot simply be based on the size of its population or territory. China’s leaders cite their country’s relative backwardness in science and technology for its losses to foreign powers during the “century of humiliation.”
- *China must be able to independently develop technologies.* China’s leadership has exhibited a strong desire for self-reliance in science and technology. China’s leaders view foreign dependence on technology as allowing other countries to deny China access to critical technologies and other countries to maintain their lead

and dictate the standards by which they are developed. Although China has relied on foreign technology since the PRC's founding, the ultimate goal of such efforts is to be able to independently develop core technologies—technologies central to success in a particular industry.

- *Technology development is a state-led effort.* Technology development is seen as a competition between countries, not companies. The state must lead efforts to organize and fund China's scientific research and technology.

THE SPACE DREAM AND BECOMING A STRONG SPACE POWER

The pursuit of the China Dream and the role of technology in building up comprehensive national power is reflected in China's desire to transition from being a "major space power" (*hangtian daguo*; 航天大国) to a "strong space power" (*hangtian qianguo*; 航天强国) that surpasses the United States as the leading space power by mid-century. According to Chinese leader Xi Jinping, China's space program is "a powerful force for the realization of the rejuvenation of the great Chinese nation."³³ Much like the national-level themes, Chinese political and space industry leaders also refer to a space dream (*hangtian meng*; 航天梦). According to Xi, building China into a strong space power is the "unremitting pursuit of the China dream."³⁴ Echoing Xi Jinping, an article in *Seeking Truth*, a publication of the Chinese Communist Party's Central Party School, notes that China's space program "plays an important role in standing up, being rich, and becoming strong."³⁵

China has released four space white papers, each entitled "China's Space Activities," that discuss China's space policy. According to China's 2016 space white paper, China's space program does the following:

- Explores outer space and enhances understanding of the Earth and the cosmos, and utilizes outer space for peaceful purposes
- Promotes human civilization and social progress, and benefits the whole of mankind
- Meets the demands of economic, scientific, and technological development; national security; and social progress, and improves the scientific and cultural levels of the Chinese people
- Protects China's national rights and interests, and builds up its overall strength
- Provides strong support for the realization of the Chinese Dream of the renewal of the Chinese nation
- Makes positive contributions to human civilization and progress³⁶

All four white papers have stated a commitment to independence and self-reliance while at the same time welcoming cooperation with international partners. Reflecting the progress its space program has made since the initial white paper in 2001, the principles by which China has sought to achieve these aims have become more sophisticated as its technology has become more advanced. The 2001 white paper, for example, stated that China would only select a "limited number" of technological areas for breakthroughs.³⁷ By 2006, China would instead "maintain comprehensive, coordinated, and sustainable development."³⁸ In 2011, China stated that it would concentrate on making breakthroughs in key technologies.³⁹ The 2016 space white paper stresses "innovative development" and "independent innovation as the core of the development of its space industry" in a reflection of its improving R&D capabilities.⁴⁰

As with the overall goal of China's national rejuvenation effort, determining the specific end state of China's ambition to become a strong space power remains elusive. According to China's 2016 space white paper, China's space program must be able to:

- Independently innovate
- Conduct cutting edge scientific discovery and research

- Promote economic and social development
- Guarantee national security
- Exercise sound and efficient governance
- Carry out mutually beneficial international exchanges and cooperation⁴¹

A TECHNO-NATIONALIST APPROACH TO SPACE

China's techno-nationalist approach to science and technology is reflected in the management of its space program. China takes outer space as a domain of strategic competition.⁴² According to a 2018 China Aerospace Science and Technology Corporation (CASC) work report, "Seizing the commanding height of space development is the consistent strategy of major spacefaring countries. Future competition will be more intense, making the mission of building a strong space power even more glorious." The report also stated, "China's national security situation is becoming increasingly complex and severe. The role of space weapons and equipment in supporting the construction of a world-class military is increasingly prominent and the demand is more urgent."⁴³

Reflecting techno-nationalism's emphasis on state-led technology development, China's approach to its space program is characterized by high-level leadership support, medium- term and long-term funding programs, and military-civil fusion (MCF).

High-level leadership support

China's leadership recognizes the importance of space. Chinese presidents and premiers from Jiang Zemin and Li Peng to the current leadership of Xi Jinping and Li Keqiang have sought to associate themselves in public ways with the space program, in particular the human spaceflight and lunar programs. This leadership attention, as well as the centrally controlled nature of China's political system, has translated into policy attention and stable policy guidance and funding over a broad range of programs.

Long-term planning

China's space program's impressive performance can also be attributed to an adherence to long-term planning and funding. China has been able to maintain a stable policy environment for its space program that appears to match funding with program goal deadlines.

China manages its space program goals through a series of short-, medium-, and long-term plans that mandate goals—and funding—well beyond the traditional one-year increments of the U.S. budgeting system. Medium-term planning is administered through a series of five-year plans (FYPs). China is in the final year of its 13th FYP, which covers the time period from 2016 to 2020. Long-term planning governs China's space goals over a 10- to 15-year period. China's current space program goals were mandated by the Medium and Long-Term Plan for Science and Technology Development (MLP) that has governed overall S&T work since 2006. This document established a number of policies to foster innovation by setting various goals for China's S&T development over three FYP periods covering the time period from 2006 to 2020. Prominent within the MLP were 16 "megaprojects" that set long-term project-based technology objectives across a number of sectors, including space. The 13th FYP plan extends the megaproject approach, setting objectives to the year 2030.⁴⁴

Military-Civil Fusion

A third factor contributing to China's successful space program is the role of military-civil fusion in promoting technological advancement. China's space program is a dual-use, military-run enterprise made up of numerous organizations spanning the military, government, and defense industry. This system has resulted in a space program that blurs the lines between military, government, and civilian operations with technology development geared from the outset towards achieving national security, economic, and/or scientific outcomes. The benefit of an integrated civil-military approach to space is that it can breakdown institutional barriers to space technology development so that space technologies are developed with the intent of carrying out both military and civilian applications.

CHINA'S PROGRESS IN SPACE TECHNOLOGIES

China's techno-nationalist approach to its space program has resulted in the program making tremendous progress since 2000, and it has laid a foundation for it to achieve its goal of becoming a strong space power. Gone are the days when Chinese launchers were unreliable and China had just a few satellites in orbit. Today, China has more than 300 satellites in orbit, and the reliability of its space launch vehicles is at international standards. China is also launching more rockets and satellites than at any other time in its history. China launched just one satellite in 2001, but in 2010 and 2011, China first equaled and then surpassed the number of U.S. launches. In 2019, China exceeded all space powers with 32 successful launches. The nearest country, the United States, had 27 launches.

Not surprisingly, China now has the second largest number of satellites in orbit. According to information collected by the Union of Concerned Scientists, 2,218 satellites were in orbit on September 30, 2019. Of these, 1,007 were U.S., 323 were Chinese, and 164 were Russian. The number of Chinese satellites in orbit has increased at a faster rate since 2006. The majority of satellites launched annually have been remote sensing satellites, followed by communications, navigation, and technology development satellites.

Figure 1. U.S. and Chinese Space Launches, 2000–2019

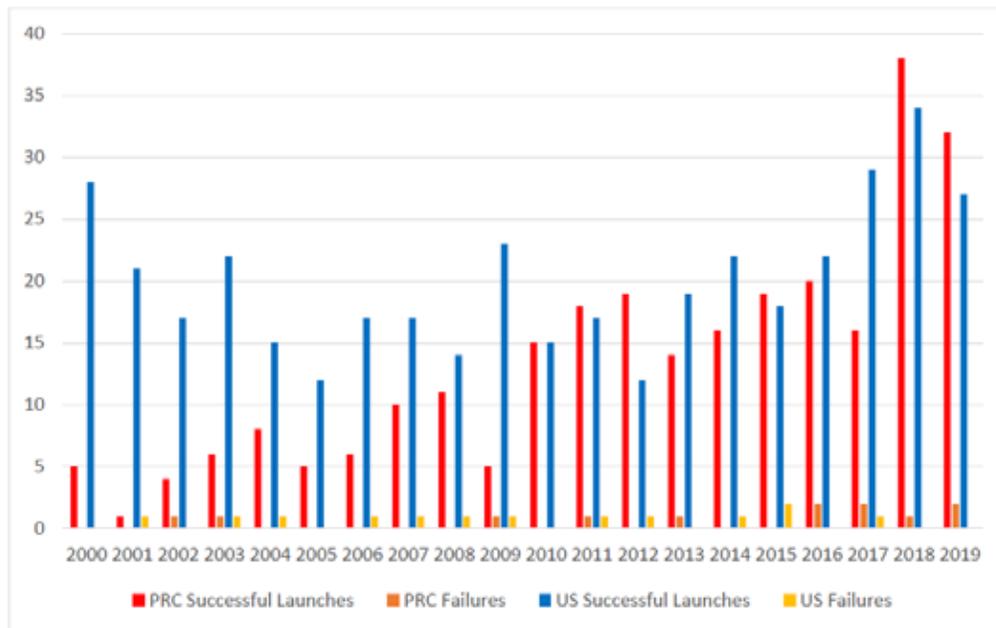
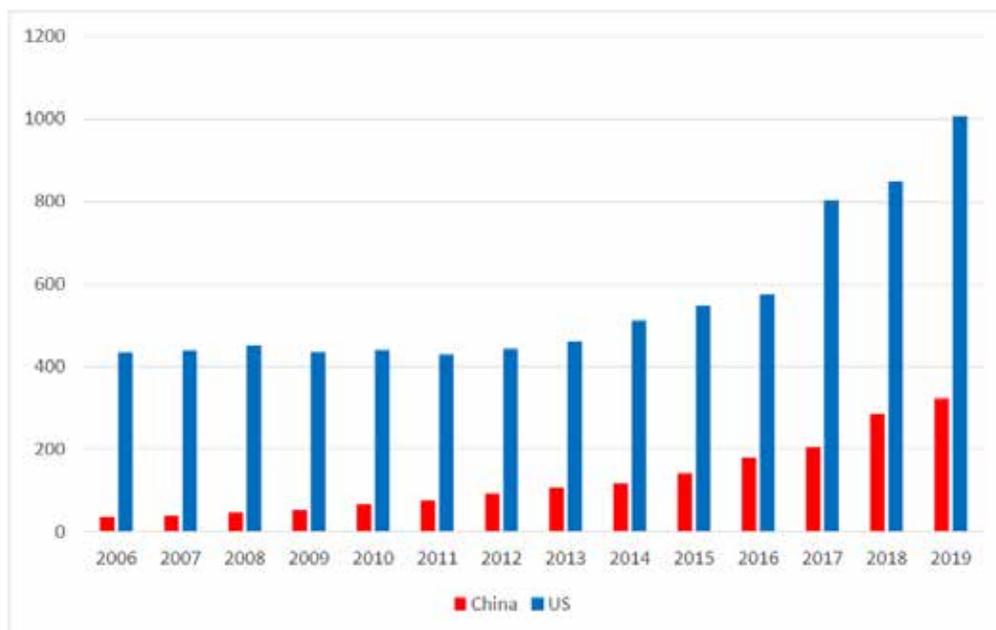


Figure 2. U.S. and Chinese Satellites in Orbit, 2006–2019



Source: Union of Concerned Scientists

China is also developing a wide range of counterspace technologies that are intended to threaten adversary space systems from ground to geosynchronous orbit (GEO).⁴⁵ These include direct-ascent kinetic-kill (KKV) vehicles, co-orbital satellites, directed-energy weapons, jammers, and cyber capabilities.⁴⁶ In 2007, China destroyed one of its weather satellites with a direct-ascent KKV. According to the Director of National Intelligence, “the PLA has an operational ground-based antisatellite (ASAT) missile intended to target low-Earth-orbit satellites, and

China probably intends to pursue additional ASAT weapons capable of destroying satellites up to geosynchronous orbit.”⁴⁷ The PLA is also expected to deploy a ground-based laser system for use against satellites in LEO by 2020.⁴⁸ In 2018, cyber security company Symantec revealed that attacks coming from Chinese IP addresses had targeted a satellite communications operator and a geospatial imaging and mapping organization.⁴⁹

Table 1. Counterspace-related testing and operations

Type	Year	Description	Comments
Direct Ascent	2007	KKV test	
	2010	Mid-course ballistic missile defense test	
	2013	Mid-course ballistic missile defense test	
	2013	KKV test	Test to GEO. China called it “high altitude science mission.”
	2014	KKV test	China called it ballistic missile defense test. U.S. called it ASAT test.
	2015	Unknown test	
	2017	Unknown test	
Co-orbital	2010	Two Shijian satellites involved in close proximity operation, causing slight change in one satellite’s orbit	
	2013	Three satellites involved in close proximity operation to test space debris removal and robotic arm technologies	
	2016	Aolong-1 tested robotic arm to remove space debris	
	2016	Shijian-17 rendezvous with ChinaSat-5A	
	2019	TJS-3 satellite released probable subsatellite	
Cyber	2012	Computer network attack Propulsion Laboratory	Allowed “full functional control” over JPL networks.
	2014	Computer network attack against NOAA	
	2017	Computer network attack against Indian satellite communications	
	2018	Computer network attack against satellite operators, defense contractors, and telecommunication companies	
Directed energy	2006	Lased U.S. remote sensing satellite	Intent unknown.

Sources: Brian Weeden and Victoria Sampson, eds., *Global Counterspace Capabilities: An Open Source Assessment*, April 2019 and Todd Harrison, Kaitlyn Johnson, and Thomas G. Roberts, *Space Threat Assessment 2019*, April 2019.

CHINA'S SPACE BUDGET

By U.S. standards, China’s progress in space has been accomplished with minimal funding. Getting reliable data on how much China spends on its space program is difficult, but indications show that China spends much less on space than the United States. The U.S.-based Space Foundation estimates China’s space budget at a little over \$8 billion,⁵⁰ while the Organization for Economic Cooperation and Development (OECD) estimates China’s space budget at \$8.4 billion.⁵¹ According to a 2012 Chinese source, China invests less than 0.1 percent of its GDP on its space program, or less than \$8.227 billion.⁵² For comparison, the entire U.S. space budget in 2017 was a little over \$43 billion.⁵³ According to a Chinese space official speaking in 2016, Western estimates of China’s space budget as one-tenth of the U.S. space budget have “a certain degree of accuracy.”⁵⁴

BECOMING A STRONG SPACE POWER

Despite China's success in space, Chinese industry sources characterize China as a major space power not yet the equal of the United States.⁵⁵ Much like China's two-step process for achieving national rejuvenation, China's space industry provides two timelines for turning the country into a strong space power by 2045. By 2030, China will become a strong space power by supporting China's military modernization with advanced space technologies.⁵⁶ China's space industry currently assesses that 30 percent of its technologies are at world-class levels. By 2030, the space industry's goal is for 60 percent of China's space technology to be at world-class levels and for China to have surpassed Russia as a strong space power.⁵⁷ By 2045, the space industry's goal is for China to become the world's leading space power, with a space program that supports the country's full range of scientific, technological, economic, and military development needs while leading the United States in some technologies.⁵⁸

In order to achieve these goals, China has committed to meeting a number of short-, medium-, and long-term technology goals mandated through its five-year plans and the MLP.

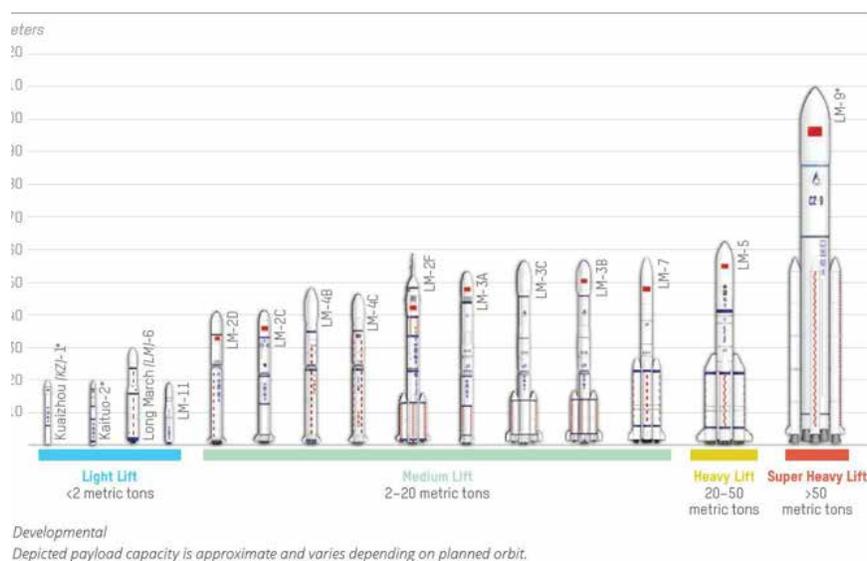
2020 GOALS

Develop a new generation of space launch vehicles

China's space program prioritizes the development of a new generation of space launch vehicles. In 2012, then-CASC president Ma Xingrui told a delegation of U.S. space engineers and scientists: "I remind government leaders that engines are the heart of space launch technology, and that is where money must be invested."⁵⁹ China's new generation of launch vehicles is designed to meet China's launch needs for the next 30–50 years through increased reliability and adaptability, larger payloads, and "nonpoisonous" and "nonpolluting" engines.⁶⁰ These new rockets use liquid hydrogen, liquid oxygen, and kerosene as fuel instead of the toxic hydrazine used on the older generation of launchers.

China's plan is to complete initial development of these new rockets by 2020 and by 2025 establish an efficient, flexible, and safe space transportation system with a series of heavy, medium, and light lift rockets that are equal in capabilities to their international counterparts.⁶¹ These rockets are planned to reduce China's launch costs by 20 to 30 percent and launch preparation times to less than 15 days (see Figure 1).⁶²

Figure 3. Chinese space launch vehicles



Source: Defense Intelligence Agency, *Challenges to Security in Space*, 16.

Develop a 60-ton space station

China conducted a total of 11 manned and unmanned missions between 1999 and 2016. This includes the launch of two eight-ton space laboratories, the Tiangong-1 (天宫-1/Heavenly

Palace) in 2011 and the Tiangong-2 in 2016.⁶³ By 2022, China plans to complete a 60-ton space station. Originally scheduled to be completed by 2020, China's space station was likely delayed due to manufacturing challenges encountered during the development of the Long March 5 launch vehicle that will transport the three 20-ton modules of the space station into orbit.⁶⁴

Conduct robotic lunar exploration

China's lunar exploration program, Chang'e, involves three steps described as "orbit, land, return" and is intended to culminate in a robotic mission that will gather lunar soil samples and return them to Earth. The first step of the lunar exploration programs consisted of two missions, Chang'e-1 and -2, that orbited the Moon in 2007 and 2010, respectively. The second step consisted of three missions: the Chang'e-2 and -3 missions soft landed rovers on the lunar surface in 2013 and 2018, and the 2019 Chang'e-4 mission soft landed a rover on the far side of the Moon. The program's third step will involve a robotic mission to the Moon, Chang'e-5, to retrieve and return samples of lunar soil to be completed by 2020.⁶⁵

Establish a 24-hour, all-weather, global Earth remote sensing system

China plans to establish a high-resolution Earth observation system capable of stable, all-weather, 24-hour, multi-spectral, various-resolution observations by 2020. China operates 28 types of intelligence, surveillance, and reconnaissance (ISR) satellites, including satellites with electro-optical (EO) sensors for remote sensing during daylight and moderate weather conditions, synthetic aperture radar (SAR) for observations at night or during inclement weather, and video cameras to capture movement.⁶⁶ China also has a number of satellites that are reportedly equipped with electronic intelligence (ELINT) payloads to collect electronic transmissions.⁶⁷

China is deploying remote sensing satellite constellations that will add redundancy, flexibility, and timeliness to its remote sensing capabilities. The Superview series of satellites is planned to form a 24-satellite constellation made up of EO and SAR satellites and several mini-satellites by 2022.⁶⁸ A second constellation made up of the Jilin-series of satellites is planned to consist of 60 satellites by 2020 and 138 satellites by 2030. The constellation consists of satellites with EO and video payloads and, by 2030, will have a revisit rate of 10 minutes.⁶⁹

Establish a global navigation satellite system

China's Beidou satellite navigation system is intended to reduce China's reliance on the U.S. Global Positioning System (GPS). Like GPS, Beidou is a military-run program with civilian applications. In the first step, the experimental system Beidou-1 became operational in 2003 and covered only Chinese territory. In the second step, a more advanced Beidou-2 system was initiated in 2007 and began operating on a regional basis in 2012. In the third step, Beidou will provide complete global service by 2020, with 35 satellites in medium and geosynchronous orbits. Unlike GPS, the Beidou system provides a short message service that enables users to send messages of up to 120 characters to other Beidou users.⁷⁰

Conduct space science

China will launch satellites to study dark matter, quantum mechanics, space physics, black holes, and microgravity. Specifically, China plans to launch a dark matter particle detection satellite, a solar wind-magnetosphere interaction panoramic imaging satellite, an Einstein probe satellite to study high-energy astrophysics, and a space-based solar observatory satellite.⁷¹

Conduct deep space exploration

This technology area focuses on the origin and evolution of the solar system and the Moon, asteroids, the impact of solar activities on the earth, and the exploration of extraterrestrial life. It includes sending probes to an asteroid and to the Jupiter system.⁷²

Explore Mars

China's first Mars mission will be launched in 2020. The mission will both orbit Mars and land a rover equipped with a ground-penetrating radar, a multispectral camera, a laser-induced breakdown spectroscopy instrument, and payloads for analyzing the Martian climate and magnetic environment.⁷³

2030 GOALS

China's 13th FYP outlines China's space technology goals for 2030 through two "megaprojects" (*zhongda xiangmu*; 重大项目) and one "mega-engineering" project (*zhongda gongcheng*; 重大工程).

Deep space exploration

China's deep space exploration plan is a megaproject that includes missions to orbit Mars, land a rover on the Martian surface, and bring back Martian soil. It also includes missions to an asteroid, the Jupiter system, and planetary flybys.⁷⁴

In-orbit servicing and maintenance of spacecraft

China's in-orbit servicing and maintenance of spacecraft plan is another megaproject intended to improve the effectiveness and reduce the cost of Chinese spacecraft by extending their service life through regular maintenance and refueling.⁷⁵ With the exception of the International Space Station, currently no spacecraft is designed to be repaired or refueled in orbit or otherwise maintained beyond its original service life while in orbit. The ability to conduct in-orbit servicing and repair would reduce the need to launch replacement satellites and could allow Chinese satellites to operate more effectively for longer periods of time. The ability to service and maintain satellites has counterspace applications as well. Rendezvous and proximity operations, such as those involved with servicing and maintenance operations, would allow China to operate satellites close enough to adversary satellites to collect intelligence and conduct attacks.

Space-ground integrated information network

The space-ground integrated information network (*tiandi yitihua xinxi wangluo*; 天地一体化 信息网络) is a mega-engineering project intended to build on the 2006 MLP's earth remote sensing megaproject by developing a "completely fused" global information network composed of a space-based information network, a future internet, and mobile communication systems. The network will consist of remote sensing satellites, communication satellites, and navigation satellites whose information will be integrated through a ground-based network.⁷⁶ Suggested

applications for the network include a global satellite communications system for global telephone and internet access, air traffic management, maritime resources management, and space situational awareness.⁷⁷

In addition to official Chinese government medium and long-term plans, China's space industry has also issued roadmaps for technology goals out to mid-century. It is unknown if these roadmaps have been officially approved. CASC's technology roadmap, issued in 2018, lists a number of goals to be accomplished by 2045. According to the document, China's space industry will build upon its advances in propulsion, satellite navigation, and electronic information and will develop earth return transportation, planetary landing and return, in-orbit manufacturing, and hydrogen energy propulsion capabilities. It will also achieve a leading international position in pulsar navigation, gravitational wave detection, space resource development and utilization, space tourism, quantum information, terahertz technologies, metamaterials, and nuclear propulsion.⁷⁸

In addition to the CASC roadmap, CASC's subsidiary the China Academy of Launch Vehicle Technology (CALT) issued its own "Space Transportation Roadmap" in 2017 that proposed developing the world's most advanced launch vehicles to support an ambitious program of human exploration of the Moon, Mars exploration, asteroid mining, and space-based solar power.

The Roadmap listed a number of goals to be accomplished by 2025, 2030, 2035, and 2040:

2025 GOALS

- Develop suborbital launch capabilities for use in a space tourism.
- Develop air launched space systems that can provide launch capabilities on an hourly basis.
- China's launch vehicles will be able to support the operation of China's space station and will be used to build a robotic lunar scientific base.
- China's commercial space efforts will comprise an integrated system of commercial launch, space tourism, and orbital services.

2030 GOALS

- Conduct the first flight of a heavy lift launch vehicle to support human exploration of the Moon and a mission to bring back samples of the Martian soil (likely referring to the development of the Long March 9, a proposed launcher similar in power to the Saturn V rocket that launched U.S. astronauts to the Moon).
- Develop a two-stage fully reusable launch vehicle.

2035 GOALS

- Develop a completely reusable rocket.
- Launch the first flight of an "intelligent" rocket using unidentified advanced propulsion technologies.

2040 GOALS

- Develop a combined propulsion two-stage reusable rocket.⁷⁹
- Make breakthroughs in nuclear rocket propulsion.
- Employ launch vehicles capable of supporting large-scale space mining and space-based solar power.⁸⁰

CHAPTER 3: MAKING CHINA RESPECTED: CHINA'S SPACE DIPLOMACY

China's space program is one element of the Chinese Communist Party's goal of making China more respected and influential. It is one aspect of China's goal to refashion the international system by lessening U.S. influence and making it more suited to serving China's interests.⁸¹ Paralleling China's foreign policy message of "building a community of shared future for mankind," China's space diplomacy advocates the building of "a shared vision for humanity in space" that emphasizes China's role in promoting the peaceful uses of space, international space cooperation, and the advancement of humankind, while downplaying the national security aspects of its space program. In contrast, Chinese depictions of the U.S. space program portray the United States as emphasizing the military aspects of space, limiting international cooperation, restricting access to space, and working to destabilize humankind.

China's policy of "building a shared vision for humanity in space"

The success of China's space program has resulted in increasing international political recognition for China. Through its "community of shared future for mankind" framework, China states that it will improve the lives of people around the world by promoting a "new type of international relations" that acts with benevolence and generosity and bases its relations with other countries on "mutual respect, fairness, justice, and win-win cooperation" and "peace, universal security, and common prosperity."⁸² According to Ambassador Fu Ying, a former vice minister of foreign affairs, China "respects the legitimate interests and values of nations, regardless of their social systems or their levels of development."⁸³

China's argument that it can be a better world power than the United States is founded on the belief that its system of domestic authoritarian governance is a viable alternative to Western democracy. The Chinese Communist Party proposes that its record of accomplishment since 1979 is a model of successful governance that should be shared with other countries.⁸⁴ According to one Chinese academic, "China's wisdom, experience and philosophy are rapidly becoming global, providing Chinese solutions to global governance problems."⁸⁵

Although such thinking may not gain traction in Western liberal democracies, China's political model emphasizing an authoritarian system capable of achieving successful domestic and foreign policy goals may appeal to many developing countries wary of Western-style democracy. In this context, China's space policy reinforces China's broader narrative of building a world as a "community of shared future."⁸⁶ China's ambassador to the United Nations, Shi Zhongjun, has stated that China's space program is "open, equal, mutually beneficial, and inclusive." Shi noted that space is a new frontier that enhances all people of the world, but that access to space is distributed unequally. He stated that China is committed to space exploration through international cooperation, promoting the governance of outer space, and working to increase the participation of countries, especially developing countries, in space in order to build "a shared future for mankind in space."⁸⁷ According to Shi, China's vision of a shared future for humanity in space is "consistent with the objectives and purposes" of the Outer Space Treaty, particularly the Treaty's statement that "the exploration and use of outer space should be for the benefit and in the interests of all countries."⁸⁸

China's use of the "shared future for humanity in space" framework is a relatively new development. Nevertheless, China has gained some success in international space diplomacy with this narrative: it has increased its prestige

by allowing international participation in its space station, has begun shaping the debate over the international governance of outer space, and has promoted the benefits of the “Space Information Corridor,” the space component of China’s Belt and Road Initiative.

China’s space station and a shared future for mankind in space

China’s long-term space station, China Space Station (CSS), is the major component of China’s human spaceflight program. CSS is intended to become operational by the end of 2022. When completed, it will be an approximately 60-ton station capable of supporting three crew members with a service life of 10 years.⁸⁹ In comparison, the International Space Station weighs over 419 tons and supports six crew members. The ISS has been continuously crewed since 2000. Without U.S. Congressional approval of additional funding, however, the ISS will discontinue service in 2024 if efforts to commercialize it fail.⁹⁰ Around the same time, the CSS will become operational.

China is using the CSS to further its narrative that it is a more inclusive space power than the United States. The ISS is a collaboration between the United States, Russia, Canada, Japan, and the participating countries of the European Space Agency. The space station has been visited by astronauts from 18 countries. Most have been from ISS-member countries. Notably, China has not been permitted to join the ISS due to opposition from the United States, although the European Space Agency has expressed support for Chinese membership.⁹¹

China, in contrast, has stated that the CSS will be open to all UN-member countries regardless of political system or level of development.⁹² Chinese space officials state that China is open to a wide variety of international cooperative efforts, including hosting astronauts and experiments, building modules for inclusion on the space station, and launching resupply missions. The *People’s Daily* states that opening up China’s space station to all UN-member countries is described as “an important symbol” of China transitioning from independent development to international cooperation as well as a demonstration of China’s self-confidence and openness.⁹³ According to *Xinhua*, China’s space station belongs to China and the world and, China is committed to opening the space station to all countries so that “cooperation, mutual benefit, and win-win bloom in space.”⁹⁴

In coordination with the United Nations Office for Outer Space Affairs (UNOOSA), in June 2019 China announced the acceptance of nine proposals by non-Chinese entities for experiments to be conducted on the CSS. The *People’s Daily* stated that the selection of the nine projects for inclusion on the China Space Station marks “a new stage in international cooperation” that strengthens “international cooperation in the field of peaceful uses of outer space in order to realize the vision of a community of destiny for the benefit of all mankind.”⁹⁵

According to the UNOOSA director, Dr. Simona Di Pippo, China is the first country to open up a space station to all UN-member countries.⁹⁶ Di Pippo stated that the act “will reinforce international cooperation for the peaceful use of outer space” and shows that “China is really trying to open up the possibility for everyone in the world to use the facility that China is developing”⁹⁷ “International cooperation on the Chinese space station,” she stated, “will promote human awareness of the application of space science and technology and help countries, especially developing countries, enter space.”⁹⁸

International space governance and a shared future for humanity in space

China is also using its “shared vision” narrative to shape the international governance of outer space in its favor. China has been able to insert language referring to a “shared vision” into international documents on space governance in statements by the Group of 77, a coalition of developing countries at the United Nations, as well in

the “Report of the Committee on the Peaceful Uses of Outer Space” written by the Committee on the Peaceful Uses of Outer Space (COPUOS), a United Nations organization that governs the exploration and use of space.

According to a statement by the G-77 and China during the 61st session of the United Nations Committee on the Peaceful Uses of Outer Space:

*The Group of 77 and China underscores its firm conviction that the use and exploration of the outer space shall be carried out exclusively for peaceful purposes, with the view to realizing a shared vision for the future, for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and in conformity with the body of applicable international law.*⁹⁹

The “Report of the Committee on the Peaceful Uses of Outer Space,” a consensus document agreed upon by the members of COPUOS, including the United States, and presented to the 61st session of the United Nations General Assembly, goes even further in its use of the “shared vision” phrasing, using it three times. The report stated that participants celebrating the 50th anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space noted the need to strengthen international cooperation in order to “contribute to realizing a *shared vision* for the future in the exploration and use of outer space for peaceful purposes.”¹⁰⁰ The report also noted that “in their exploration and use of outer space, including the Moon and other celestial bodies, States should realize a *shared vision* for the future that was in the best interests of all countries, irrespective of their degree of economic or scientific development, and in conformity with international law.”¹⁰¹ Finally, the report noted that countries should “initiate a productive dialogue through a substantive analytical endeavor and form a *shared vision* of realistic ways to increase safety and security in outer space.”¹⁰²

The Belt and Road Space Information Corridor

China’s “shared vision” framework is also evident in China’s “Belt and Road Space Information Corridor,” the terrestrial element of China’s Belt and Road Initiative (BRI), a Chinese economic effort involving more than 70 countries spanning Asia, Europe, and Africa. According to a *People’s Daily* article, “China is expanding its ‘circle of friends’ among the Belt and Road countries by taking an active role in serving those countries with advanced space technologies.”¹⁰³ To support this effort, China has signed “98 intergovernmental and interdepartmental agreements with 30 countries and three international organizations, including 23 pacts with 11 countries along the [BRI] route” for space-related cooperative activities.¹⁰⁴

The Space Information Corridor will provide the benefits of space-based earth observation, communications and broadcasting, and navigation and positioning to member countries, including the use of ground and application systems.¹⁰⁵ According to the 2016 “Guiding Opinions on Accelerating the Building and Application of the One Belt, One Road Space Information Corridor,” China expects the building of the Space Information Corridor to take 10 years and eventually cover Southeast Asia, South Asia, Western Asia, Central Asia, Africa, Oceania, and Central and Eastern Europe. According to the document, the Space Information Corridor at that point will be a “bright spot” of the BRI that will lay a solid foundation for the “marketization and internationalization” of China’s space industry that will promote the “economic and social development” of BRI-member countries.¹⁰⁶

Chinese space-based remote sensing, satellite navigation, and communication capabilities will support BRI-member countries’ infrastructure, such as ports, railroads, and highways, and will support maritime search and rescue, marine resource development, marine disaster prevention and mitigation, coastal zone environmental monitoring, telemedicine, disaster relief, transportation, entertainment, policing, and counterterrorism in BRI member countries.¹⁰⁷

The space information corridor will also support joint research between China and member countries. China will establish an open laboratory to research space information technologies, and China's space program will conduct joint research on climate change, water resources, and geological disasters.

In addition to joint research, China will train personnel from BRI-member countries on the use of space technologies through its Asia-Pacific Regional Center for Space Science and Technology Education and the Asia-Pacific Space Cooperation Organization (APSCO) Education and Training Center. According to an APSCO document, member states “commit to working together through a community of shared interest to shape the future through Asia- Pacific partnership.”¹⁰⁸

Finally, China will promote the export of satellites and related technologies to BRI member countries. Chinese exports are intended to promote both the use of Chinese technologies and the adoption of Chinese technology standards, including building satellite telecommunications systems and ground-based satellite receiving and processing stations.¹⁰⁹

SPACE INFORMATION CORRIDOR ACTIVITIES

China's efforts to promote the Space Information Corridor focus on providing the benefits of space to members of the BRI. China has conducted a number of activities to develop the Space Information Corridor.

- China uses 17 communications satellites and nearly 300 transponders to extend service to countries in South Asia, Africa, Europe, and America.¹¹⁰
- China's Beidou satellite navigation system, planned for global operations in 2020, began partial global operations in 2018 with coverage optimized for countries involved in BRI.¹¹¹ Beidou coverage in Pakistan, through the use of ground stations, is reported to now achieve two-centimeter accuracy.¹¹² Of note, China has also allowed Pakistan the use of the Beidou system's military signal.¹¹³
- China has offered the use of its Fengyun meteorological satellites to 81 countries and regions for weather forecasting and disaster monitoring.¹¹⁴
- In 2018, China sold the Techo-1 communications satellite to Cambodia in the first satellite deal explicitly linked to the BRI. The deal also included ground systems, insurance, and technology transfers.¹¹⁵
- In 2015, China announced the 10,000 Villages Project that is, in part, intended to provide inexpensive satellite television to underserved parts of Africa. Chinese satellite television provider StarTimes offers 30 channels with monthly subscriptions available for as little as \$4. StarTimes offers international news from Chinese news sources and provides four channels with Chinese content to 30 million customers in Africa.¹¹⁶

Chinese views of U.S. space policy

This section of the report looks at Chinese views of several aspects of U.S. space policy and U.S. national security policy related to space. It examines Chinese reactions to the designation of China as a strategic competitor in the U.S. *National Security Strategy* and *National Defense Strategy*, Chinese views of U.S. national space policy and national security space strategy, Chinese views of the reestablishment of the National Space Council, and Chinese reactions to the U.S. announcement of the new deadline of sending humans to the Moon by 2024.

In contrast to the depiction of its space program as peaceful and benefiting humankind, Chinese sources portray the United States as “bringing a Cold War mentality” to outer space by emphasizing the military aspects of space and designating China as a strategic competitor. Some Chinese media commentary view the reestablishment of the National Space Council as having a beneficial effect on the U.S. space program that China could seek to

imitate. Chinese media, on the other hand, has tended to doubt the ability of the United States to return to the Moon by 2024 due to funding and technology challenges.

PRC REACTION TO U.S. DESIGNATION OF CHINA AS A STRATEGIC COMPETITOR IN THE SPACE DOMAIN

Both the 2017 U.S. *National Security Strategy* (NSS) and the 2018 *National Defense Strategy* (NDS) speak to the role of space in great power competition. The NSS states that the United States is increasingly dependent on space assets just as the number of international actors participating in space-related activities has grown. According to the NSS, the “democratization of space” will effect U.S. military operations and the “ability to prevail in conflict.”¹¹⁷ The NDS describes space as a “warfighting domain” that is being contested during peacetime. Like the NSS, the NDS emphasizes the emergence of “new threats to commercial and military uses of space” at the same time that “all aspects of life” in the United States are increasingly reliant on space.¹¹⁸

NO OFFICIAL PRC RESPONSE TO THE 2017 NSS AND 2018 NDS REGARDING SPACE

Official PRC reactions to the NSS and NDS were devoid of discussions of great power competition in space. Remarks from PRC officials depicted the United States as exaggerating the threat posed by China and urged the United States to abandon its “Cold War mentality.” Reporting in PRC media repeated this claim and portrayed the U.S. designation of China as a strategic competitor as inaccurate. Despite the official responses to both the NSS and NDS, no official spokesperson linked the U.S. designation of China as a competitor to space.¹¹⁹

PRC MEDIA VIEWS UNITED STATES AS BRINGING GREAT POWER COMPETITION INTO SPACE DOMAIN

Despite no official Chinese statements linking China to strategic competition in space, PRC media reporting has argued that the United States is bringing great power competition into the space domain.¹²⁰ A report from China’s official Xinhua News Agency incorrectly highlighted the Department of Defense’s 2019 \$4.3 billion (actually \$12.5 billion) budget request for space, and cited remarks from the Comptroller of the Pentagon that the budget proposal was in line with the focus on great power competition found in the NSS and NDS.¹²¹ A separate Xinhua report underscored then acting Secretary of Defense Michael Shanahan’s remarks on the Department of Defense 2020 budget request, stating that the “strategy-driven budget makes necessary investments in next-generation technology, space, missiles, and cyber capabilities,” which Shanahan described as putting the U.S. military in a strong position for “great power competition for decades to come.”¹²²

PRC commentary also depicted the designation of China as a strategic competitor in space as a flawed assessment.¹²³ *Beijing News* characterized President Trump’s international view as “dark and pessimistic,” leading him to bring great power competition to space. The report contended that the president has “taken hold of the wrong vein and grabbed the wrong medicine,” and that the current trends are “peace, development, cooperation, and win-win,” rather than great power competition.¹²⁴ *China Daily* claimed that the Trump administration was handling “imagined threats” from China to adopt an “increasingly aggressive defense strategy,” including the creation of a space force to maintain U.S. dominance in space. The report urged the United States to “look boldly forward to the future” and form a “new type of relations” with China.¹²⁵ China’s national web-based television broadcaster CGTN repeated this sentiment, urging the international community to “prevent a ‘great power tragedy’ from happening in the space domain.”¹²⁶

Chinese views of U.S. national space policy and national security space strategy

The current *U.S. National Space Policy* was issued by the Obama administration in 2010 and remains in place.¹²⁷ The Trump administration has released four Space Policy Directives (SPD) that have added to or revised the 2010 document:

- *SPD-1, Presidential Memorandum on Reinvigorating America's Human Space Exploration Program.* SPD-1 replaces the Obama administration's plans to send humans to an asteroid and orbit Mars in the 2030s with a plan to return humans to the Moon for "long-term exploration and utilization," along with a human mission to "Mars and other destinations."¹²⁸
- *SPD-2, Streamlining Regulations on Commercial Use of Space.* SPD-2 puts forth specific provisions for modifying commercial space regulations in order to "promote economic growth; minimize uncertainty for taxpayers, investors, and private industry; protect national security, public safety, and foreign policy interests; and encourage American leadership in space commerce."¹²⁹
- *SPD-3, National Space Traffic Management Policy.* SPD-3 recognizes that space is becoming more "congested and contested" and proposes priorities for establishing an approach to space traffic management to address the increase in space activities.¹³⁰
- *SPD-4, Establishment of the United States Space Force.* SPD-4 identifies the space capabilities of potential U.S. adversaries as a national security risk to the United States and calls for the establishment of a space force within the Department of the Air Force.¹³¹

In addition to the space policy directives, on March 23, 2019, the Trump administration released an unclassified fact sheet of a revised classified national security space strategy (NSSS).¹³² The fact sheet highlighted five key points:

- *America First among the Stars.* The strategy prioritizes U.S. interests; emphasizes cooperation among the national security, commercial, and civil space sectors; and promotes regulatory reforms to guarantee U.S. industry remains the "leading global provider of space services and technology."
- *Space Preeminence through the American Spirit.* The administration aims to "lay the groundwork" for future U.S. space exploration and make the scientific, commercial, and national security benefits of space a "top priority."
- *Peace through Strength.* The strategy guarantees the protection of U.S. space assets and asserts a "deliberate response" to any "harmful interference" of vital U.S. interests in space. This section asserts that U.S. "competitors and adversaries have turned space into a warfighting domain" and that the United States will "deter, counter, and defeat" hostile threats within the domain.
- *Four Pillars for Unified Approach.* This section calls for partnerships with the U.S. private sector and allies alongside a "whole-of-government approach to U.S. leadership in space." The four pillars of this approach include "transforming to more resilient space architectures...strengthening deterrence and warfighting options...improving foundations capabilities, structures, and processes, and fostering conducive domestic and international environments."
- *A New Direction for U.S. Space.* In this strategy, the president took steps to "reorient" US space policy by reestablishing the National Space Council and instructing NASA to return Americans to the Moon and conduct a human mission to Mars through the signing of a new policy directive.¹³³

SPD-1 RECEIVES CONSIDERABLE ATTENTION IN PRC MEDIA

Among the four directives signed by President Trump, “Reinvigorating America’s Human Space Exploration Program” received much of the attention in PRC reporting, along with SPD-4 on the creation of a space force (see chapter on “Chinese Views of Military Space: Making China Strong”).

During the signing of SPD-1, President Trump remarked that the directive was a step toward “reclaiming America’s proud destiny in space, and space has so much to do with so many other applications, including a military application.”¹³⁴ Although there is no mention of a military application to space in the policy directive, a small number of PRC commentary reporting on the directive highlighted the president’s remarks on the potential military application of space.¹³⁵ In response to the president’s comments, the MFA spokesperson argued that China’s position on the weaponization in space has been “clear and distinct,” and that China hopes international parties will commit to a treaty that “aims for the prevention of weaponization of outer space.”¹³⁶ China’s official English-language newspaper, *China Daily*, echoed the spokesperson’s comments and urged the United States to “forge increased cooperation with other spacefaring countries.”¹³⁷

Other reporting cast doubt on the ability of the United States to send humans to the Moon. A small number of PRC reports highlighted the high costs of space travel and argued that sending humans to the Moon and Mars may be difficult for the United States to achieve.¹³⁸ The *China Daily* cited a report by the National Research Council that NASA would not be capable of achieving the “next giant leap for mankind” without “sufficient funding or help from nations such as China.” The same report also surmised that President Trump’s “business acumen may come in handy,” citing a White House statement that the president will “create incentives” for private companies and foreign countries to help the United States achieve this goal.¹³⁹

LIMITED PRC REPORTING ON SPD-2 AND SPD-3

In contrast to SPD-1 and SPD-4, presidential directives SPD-2, “Streamlining Regulations on Commercial Use of Space,” and SPD-3, “National Space Traffic Management Policy,” received scant attention in PRC reporting, consisting mostly of brief explanations of the contents of both directives.¹⁴⁰ In a report published by the China Institute of International Studies, the official think tank of the PRC Ministry of Foreign Affairs, professor He Qisong of the Shanghai University of Political Science and Law argued that the Trump administration prioritizes U.S. interests in its space strategy and that the United States is attempting to use an American standard to create regulations on international space traffic management.¹⁴¹

PRC MEDIA REACTION TO REESTABLISHMENT OF NATIONAL SPACE COUNCIL

On June 30, 2017, President Trump issued an executive order reestablishing the National Space Council as a means to “advise and assist the President regarding national space policy and strategy.”¹⁴² The executive order appointed Vice President Pence as the chair and gave responsibility to the council for a number of tasks, including providing recommendations to the president; encouraging civil, national security, and commercial sector cooperation and exchange; and counseling on international space activities.¹⁴³

Chinese reports commonly provided short biographies of the members of the National Space Council, explained its role of advising and providing recommendations to the president on space-related issues, and gave brief descriptions of the history of previous presidential advisory groups similar to the council.¹⁴⁴ Although the militarization of space is a major theme in PRC reporting on U.S. space activities, only two of the PRC reports reviewed briefly mentioned the council in the context of the U.S. military in regards to space.¹⁴⁵ PRC media frequently reported the president’s remarks during the signing of the executive order to reestablish the council that

the United States is “going to lead again” in space.”¹⁴⁶ China National Radio stated that President Trump sees the National Space Council as an important move in returning the United States to its leadership status in space.¹⁴⁷

Two of the PRC reports reviewed depicted the National Space Council as a mechanism that can streamline the decision-making process for space-related activities. China’s state-run broadcaster, CCTV, argued that because Vice President Pence chairs the council, “all government departments will be required to coordinate when a clear plan is set,” which ensures that there is an “open chain from strategy to implementation.”¹⁴⁸ In an interview with the *Global Times*, the first commander of the Long March 11 space launch vehicle project, Yang Yiqiang, argued that the Council could be a potential model for PRC space commercialization efforts. When asked about China’s current regulatory framework for managing rocket launches, Yang argued that there are “overlapping supervisory responsibilities among different government bodies” and that the council “could provide clues” for what China can do to establish a “well-functioning mechanism for space commercialization.”¹⁴⁹

One researcher, however, questioned the effectiveness of the National Space Council. Zhang Ming, an associate researcher at the Shanghai Academy of Social Sciences Institute of International Relations and a former visiting scholar at the George Washington University Space Policy Institute, argued that reestablishing the Council to restore the United States to its leadership position in space is a “false proposition.” Zhang claimed the United States has not lost its leading position in space, and that the United States is not just seeking to become “great again,” but “even greater” in space. In addition, Zhang contended that the Council has never been the “primary mechanism that guides U.S. space policy” and that the possibility the Council will “accomplish nothing” cannot be ruled out.¹⁵⁰

Chinese reactions to U.S. announcement to send humans to the Moon by 2024

On March 26, 2019, Vice President Pence directed NASA to send astronauts to the Moon by 2024. The accelerated target date is four years earlier than NASA’s previous plans to send astronauts to the Moon by 2028.¹⁵¹

Although the Moon mission is planned to support a number of scientific and technological objectives, it is also a stepping-stone toward a crewed mission to Mars.¹⁵² One major portion of the project, NASA’s Lunar Gateway station, will play an important role in a future crewed mission to Mars. Gateway will enable a number of “science and technology activities,” but will also function as a waystation for astronauts “to depart to and return from Mars.”¹⁵³

PRC MEDIA REACTION

The PRC media response to Vice President Pence’s announcement depicted the plans as an ambitious goal that faces major technological and funding challenges. PRC reports frequently highlighted the debate among U.S. lawmakers, administration officials, experts, and NASA officials regarding the possibility that NASA will be able to achieve its goals of carrying out crewed missions to the Moon and Mars.¹⁵⁴

PRC media reporting on the administration’s motives for the accelerated deadline contended that the year 2024 was chosen for political reasons.¹⁵⁵ China’s state-owned English-language news channel CGTN described 2024 as “politically significant” for the administration, because it would be the final year of a potential second Trump administration.¹⁵⁶ Another report from the *Shanghai Observer* argued that the mission “served the president’s own political interests” and likely had “nothing to do with scientific exploration.” The report continued by noting that the last president to propose a Moon landing was George W. Bush, whose deadline was set at 2020, long after he left office. The author argued that President Trump likely hoped to write a major political event into his presidency that any successor would be unlikely to surpass.¹⁵⁷

Only three of the PRC reports reviewed mentioned the Moon landing plans in the context of U.S.-China competition.¹⁵⁸ The *Shanghai Observer* argued a Moon landing is a matter of “national pride” that can guarantee that the United States “does not fall behind in great power competition” and noted Vice President Pence’s statement that the United States is once again in a space race.¹⁵⁹ Another report by *Shipborne Weapons*, a magazine affiliated with China’s state-owned China Shipbuilding Industry Corporation, contended that the decision was likely provoked by China’s successful Chang’e-4 mission and that the January 2019 landing “clearly threatens the United States’ reigning position.”¹⁶⁰

PRC reporting also discussed the technological and funding challenges to the U.S. Moon mission. PRC reporting frequently underscored the technological challenges that NASA faces regarding the program’s space launch vehicle, the Space Launch System (SLS).¹⁶¹ Two reports from *CGTN* stressed the delays in launching the SLS, arguing that there is concern among experts and lawmakers that NASA will not be able to achieve the 2024 deadline.¹⁶² A report from China’s official *Xinhua News Agency* also contended that the SLS delays present “additional difficulties” to the realization of the 2024 deadline. The report went further in questioning the potential commercial replacements to the SLS, citing NASA Administrator Jim Bridenstine’s April 1, 2019, remarks at a town hall meeting that the Delta IV and Falcon Heavy are “technically challenged in terms of thrust capability, launch pad availability, and docking ability.”¹⁶³ Notably, several PRC reports underscored Vice President Pence’s remarks that the United States will achieve its goals “by any means necessary” and that the administration will consider commercial alternatives if NASA is unable to “fulfill the task.”¹⁶⁴

Reports in PRC media also drew attention to the high cost of the Moon mission and the president’s request for an additional \$1.6 billion from Congress.¹⁶⁵ The *Shanghai Observer* argued that NASA is asking Congress for a new budget because it is attempting to achieve a nine-year endeavor within a five-year timetable.¹⁶⁶ Another report from the *Science and Technology Daily*, the official newspaper of the PRC Ministry of Science and Technology, argued that the administration is “asking the horse to run without providing it any hay.”¹⁶⁷ Similarly, another *CGTN* report highlighted the potential challenges to the 2033 Mars deadline. The report argued that many do not think the 2033 goal is “realistic.” It cited comments from an author of the assessment on the Mars mission conducted by the Institute for Defense Analyses’ Science and Technology Policy Institute: “The purpose of our report was to say, well, take it easy, it’s not gonna happen in ‘33, it can happen later in the decade.”¹⁶⁸

CHAPTER 4: MAKING CHINA RICH: CHINA'S VIEWS ON COMMERCIAL SPACE AND SPACE NATURAL RESOURCE EXTRACTION

As part of China's overall military-civil fusion policy that is intended to capitalize on the crossover between military and civilian technology applications, China's space program is increasingly focused on generating commercial and economic benefits. China's space program appears to be establishing a long-term rationale for space exploration that goes beyond national security and scientific exploration to treating space as the final frontier of economic expansion. This chapter covers Chinese views on commercial space and the extraction of natural resources from space. Chinese sources view both activities as increasingly integral to making China a strong space power, but significant regulatory, budgeting, economic, and technological challenges remain to be resolved before this can become a reality.

China and commercial space

The space economy, once the exclusive realm of government and military actors, is today dominated by private businesses. Nearly three-quarters of the global space economy's \$350 billion value comes from an array of commercial space companies, many based in the United States.¹⁶⁹ A growing number of firms are competing for a slice of a space market that could be worth as much as \$1 trillion within the next two decades.¹⁷⁰

Chinese analysts argue that commercial space is an essential element of China's strategy to become a "strong space power." An article in *China Space News* asserts that "it is widely known that [China's] urgent priority in transitioning from a 'big space power' to a 'strong space power' is developing a commercial space brand with strong international influence."¹⁷¹

Since 2014, the Chinese government has been placing greater attention on developing China's commercial space industry. China currently has more than 100 commercial space companies, offering products and services ranging from satellite manufacturing to orbital launch. Yet unlike the United States and other Western countries, which have been commercializing aspects of their space programs for decades, China is a latecomer. Most Chinese commercial space companies were established in the past five years, and their business operations are largely constrained to the domestic market. Chinese analysts perceive a sizeable gap between China's commercial space development and that of the Western world. They view U.S. companies—particularly SpaceX—as role models that Chinese companies should emulate and perhaps someday surpass.¹⁷² But many questions remain over the genuine nature of China's commercial space companies and their ability to be truly innovative.

This chapter examines China's commercial space companies with the aim to determine their genuine commercial nature and their ability to innovate. We focus largely on China's commercial launch companies and find that most are either directly owned by or maintain essential relationships with China's state-owned space industry. The non-private nature of these companies calls into question their ability to lower costs and innovate—two key promises of commercial space.

It finds that due to national security concerns, China's commercial space efforts have focused on incentivizing the domestic satellite manufacturing and applications industry, rather than commercial launch. Nevertheless, China's space program continues to plan for significant advancements in its launch capabilities without a commitment to the U.S. notion of commercial space. As a result, China continues to rely on its traditional space industry to build upon its successes and increase its position as a major space power.

What is *commercial space*?

Commercial space can be difficult to define. Some definitions limit commercial space activities to those performed by a “private sector entity [that] puts its own capital at risk and provides goods or services primarily to other private sector entities or consumers rather than to the government.” Other definitions include “sales of consumer equipment by companies even though the satellite system is owned by the government” and private companies offering products and services to government clients as commercial space activities.¹⁷³

The most official Chinese definition of commercial space is a 2019 regulatory notice that defines commercial launch activities as “companies using their own capital, private capital, and joint-capital/joint-venture models” to “satisfy national security and public interests with “profit as the main objective.”¹⁷⁴

An examination of both U.S. and Chinese definitions of commercial space reveal several similarities:

- *A focus on profitability.* Commercial space companies should aim to efficiently allocate resources, control costs, and optimize return on investment.¹⁷⁵
- *The potential for clients outside the government and military.* Commercial space companies should be capable of offering their products and services to customers outside the government and military sectors.¹⁷⁶
- *The inclusion of private capital.* A substantial amount of the investment in commercial space companies should come from private sources.¹⁷⁷

U.S. and Chinese definitions do diverge on one key point: the *ownership structure* of commercial space companies. According to U.S. definitions, commercial space companies are private sector enterprises.¹⁷⁸ In China, commercial space companies can be either state-owned or private firms.¹⁷⁹ Notably, two of China’s commercial launch companies, Expace and ChinaRocket, are subordinate to the state-owned China Aerospace Science and Industry Corporation (CASIC) and CASC, respectively. As a result, some Chinese commercial space companies are not “commercial” in the U.S. sense of the definition—not only in regards to ownership structure but also clientele.

China’s state-owned space industry, for example, states that it has long been involved in commercial activities, including launch services and satellite exports. China Great Wall Industry Corporation (CGWIC), a subsidiary of the state-owned CASC, states on its website that it is “the sole commercial organization authorized by the Chinese government to provide commercial launch services, satellite systems and to carry out space technology cooperation.”¹⁸⁰ It claims that it has conducted 60 commercial launches since the late 1990s.¹⁸¹ CGWIC’s “commercial” launches, however, have not been carried out for private clients. CGWIC launched the Chinasat-6, -20, -22A, and Sinosat-2 satellites—all for satellite communication companies subordinate to CASC.¹⁸² CGWIC also launched the Jilin-1 satellites, built by the Chang Guang Satellite Technology Ltd., a satellite manufacturer partially owned by the Jilin provincial government.¹⁸³

Expectations for Chinese commercial space

China currently does not expect its commercial space sector to produce the world’s next SpaceX, nor does it foresee major innovations in space technologies coming from private Chinese companies. Instead, China hopes that in developing its commercial space industry, it can help offset government expenditures and improve the efficiency of its SOEs involved in the domestic space program. In the future, Chinese commercial space companies may be useful in driving down the cost of existing technologies and may provide the Chinese government with more options for acquiring products and services.

OFFSETTING GOVERNMENT EXPENDITURES

National space programs are expensive to maintain, and their costs can be difficult to justify amid competing government priorities.¹⁸⁴ Chinese space activities have historically been funded exclusively by government expenditures. This approach has yielded significant results. Chinese authors observe that state-directed capital has been useful for accomplishing “big things” such as Moon landings.¹⁸⁵ However, the same authors argue that relying solely on state funding for the full range of space activities has been costly and is unsustainable.¹⁸⁶

The Chinese government appears to be seeking ways to leverage private capital to offset the costs of the domestic space program. Notably, in 2014 the State Council released a notice encouraging private investment in “major areas of importance,” including the space sector.¹⁸⁷ The document called for opening up channels for private capital in the development, launch, and operations of commercial remote-sensing satellites and ground-based systems building.¹⁸⁸

IMPROVING THE EFFICIENCY OF SOES

Although the Chinese government has divested itself of many SOEs in past decades, it retains SOEs in sectors of the economy that it views as strategic, including space. Maintaining SOEs provides the Chinese government with some benefits. For one, China is able to centrally plan and exercise direct control over the types of products and services that these enterprises produce. SOEs can also be leveraged to provide public goods that more profit-oriented enterprises would not pursue.

Yet because China’s SOEs dominate their respective economic sectors, and because they lack credible competition from private enterprises, the lack of incentives leads to inefficiencies that produce a drag on domestic economic development. CASC and CASIC have tens of thousands of employees and control the country’s main research organizations dedicated to space technologies, yet they are described as suffering from chronic management and resource allocation issues.¹⁸⁹ Indeed, some Chinese authors argue that China’s state-owned space industry has fallen behind the private sector in terms of management culture, investment channels, cost control, and incentive structures.¹⁹⁰

One of the hopes of China’s commercial space development is that competition from new entrants in the space industry can incentivize SOEs to become more efficient. In the near term, competition from space startups would likely be in only niche areas, given the diversified lineup of products and services offered by SOEs. Furthermore, the focus of product development will likely be on driving down the price of existing technologies rather than developing new ones.¹⁹¹ Although providing competition for SOEs, commercial space companies could also provide the government with diversified channels for acquiring necessary products and services. One Chinese newspaper article contends that the benefit of private rocket companies is that China will not have to “put all [its] eggs in one basket.”¹⁹²

MAJOR INNOVATIONS WILL STILL COME FROM THE PUBLIC SECTOR

Although China’s commercial space startups may create some competition for SOEs and provide the Chinese government with new options for acquisition, they are not expected to make any major technological breakthroughs. Chinese authors point out that China’s major achievements in space, including manned spaceflight and the Beidou satellite navigation system, have been attained via the state-owned space sector, China’s “main space strengths.”¹⁹³

The idea of SOEs as the main players and commercial space companies as supporting cast is reflected in the marketing language of China’s commercial launch startups. For example, the website of the commercial launch company LandSpace claims that it is “confident to become a beneficial supplement” to China’s space program.¹⁹⁴

Marketing materials from iSpace used similar language, stating that the company aims to be “a beneficial complement” to Chinese space activities.¹⁹⁵

Existing policies and regulations

Despite the promise of commercial space activities, China does not have a dedicated policy for commercial space.¹⁹⁶ China’s efforts to commercialize space fall broadly under China’s policy of military-civil fusion, a national strategy aimed at creating synergistic relationships between the defense industry and commercial sectors. MCF is based on the recognition that, unlike in the 1950s and 1960s, advances in technology now more often occur in the private sector rather than through military-funded R&D programs. To leverage the opportunities of the commercial market, the military’s R&D apparatus must work more closely with the private sector. In a parallel effort, China’s defense industry is also expected to enter into the commercial market by seeking opportunities to convert military technologies for civilian application.¹⁹⁷

A number of Chinese policy documents lay out a more market-oriented approach to the promotion of the domestic space industry. Unlike U.S. policy, which seeks to create a policy and regulatory environment for private space companies, China’s use of market principles in pursuing commercial space opportunities is not restricted to private entities. Indeed, regulatory documents only promote a more commercial approach to space without specifically favoring SOEs or private commercial entities. In this respect, the documents can be seen as not only opening up space to private commercial entities, but also ordering SOEs to operate according to market principles. In so doing, SOEs are encouraged to use outside investment instead of government funding for their commercialization ventures.

The push to make China’s space industry more responsive to commercial space opportunities appears to have occurred around 2014. In 2013, China began advancing a strategy of “mixed- ownership” reform (*hunhe suoyouzhi gaige*; 混合所有制改革) of its SOEs. The idea behind the reform was to open up SOEs to private capital in the hopes of improving their management and capital allocation. CASC-affiliated researchers note that China’s space industry has long been dominated by state investment, but argue that a purely state-led model is not compatible with the domestic requirements for commercial space development.¹⁹⁸

In 2014, the Chinese government released a landmark document entitled “Guiding Opinions on Investment and Financing Mechanisms for Innovation in Key Areas to Encourage Social Investment.”¹⁹⁹ The document designated the market, not government directives, as playing a decisive role in the allocation of resources by “breaking down industry monopolies and market barriers, reducing barriers to entry, establishing fair, open, and transparent market rules, and creating an investment environment with equal rights, equal opportunities, and equal rules.” Although not devoted exclusively to the space industry, the policy encouraged private capital to participate in the construction of national civil space infrastructure and encouraged private capital to develop launch vehicles and operate commercial remote sensing satellites.²⁰⁰

In 2019, China issued its first regulations on commercial space activities entitled “Notice from SASTIND and CMC Equipment Development Department on Promoting the Orderly Development of Commercial Launch Vehicle Regulations” (*guojia guofang keji gongye ju zhongyang junwei zhuangbei fazhan bu guanyu cujin shangye yunzai huojian guifan youxu fazhan de tongzhi*; 国家国防科技工业局 中央军委装备发展部关于促进商业运载火箭规范有序发展的通知). The regulatory notice defines commercial launch activities as “companies using their own capital, private capital, and joint-capital/joint-venture models” to “satisfy national security and public interests with “profit as the main objective.”²⁰¹

The regulations “encourage the healthy and orderly development of commercial launch vehicles to make progress in lowering the costs of entering space, to supplement and enrich the channels for getting into space, to strongly drive forward space transportation system technology and industry innovation, and to accelerate China’s capability to enter space and be competitive in the international market.” The notice also states that all launches must be conducted at “nationally-recognized space launch sites” and that these launch sites should support commercial launches. The regulatory notice also provides guidelines for the conduct of launches, launch vehicle R&D, and the export of launch vehicle technology. It does not, however, provide guidelines for government support of private launch providers.

Other, perhaps more powerful, policy decisions appear to have the potential to retard the development of China’s commercial space sector, however. Despite the 2014 document promoting private investment and funding in Chinese SOEs and advocating the break up of monopolies, China under Xi Jinping has emphasized and prioritized the role of SOEs in China’s economy. Xi has called for SOEs to become “stronger, better, and bigger,” stating that China “will further reform SOEs, develop mixed-ownership economic entities, and turn Chinese enterprises into world-class, globally competitive firms.”²⁰² Speaking in 2018, Xi noted that “such statements as ‘there should be no state-owned enterprises’ and ‘we should have smaller- scale state-owned enterprises’ are wrong and slanted.”²⁰³

A series of more focused policy documents directed at the space industry are summarized in Table 1. As discussed later in this chapter, Chinese analysts see these policy and regulatory documents as improving the business environment for commercial space, but greater transparency and clarity are needed if commercial space companies are to be successful.

Table 2. Selected Chinese policies and regulations for commercial space

Time	Organization(s)	Document	Related content
2007	SASTIND, NDRC	Several Opinions on Promoting the Development of the Satellite Applications Industry	Accelerate the development of satellite applications industry
Nov. 2014	State Council	Guiding Opinions on Investment and Financing Mechanisms for Innovation in Key Areas to Encourage Social Investment	Encourage private capital in civil space infrastructure building, including: (1) development, launch, and operations of commercial remote-sensing satellites; and (2) ground-based systems building
July 2015	Ministry of Finance, State Tax Administration	Notice of the Ministry of Finance and the State Administration of Taxation on Value-Added Tax Policies concerning Space Launch	Organizations providing space transportation services within Chinese borders permitted a zero value-added tax rate
Oct. 2015	NDRC	Medium and Long-term Plan for the Development of Civil Space	Promote diversified investment and industrialized application; support private investment for satellite development and systems building
May 2016	NDRC, MIIT	Notice on Implementing Manufacturing Upgrade and Renovation of Major Engineering Packages	“Commercial space product development project” listed among major projects
2016	State Council	China’s Space Activities in 2016	Encourage private investment and business in space-related R&D and production, infrastructure building, information products and services, and satellite operations
Jun. 2019	SASTIND, CMC Equipment Development Department	Notice from SASTIND and CMC Equipment Development Department on Promoting the Orderly Development of Commercial Launch Vehicle Regulations	Provides commercial launch companies with some regulations for: (1) space launch reporting, (2) launch and test site procedures, and (3) security and export control

Sources: Liu Yan and Zhang Wei, “Analysis on the Development Trend of Commercial Aerospace in China Based on PEST Model,” 43; “Notice from SASTIND and CMC Equipment Development Department.”

China's commercial space companies

China currently has at least 141 commercial space companies, most of which are described as “private” entities. Although much attention has been placed on China’s emerging commercial launch sector, only about 15 percent of China’s commercial space companies provide launch services. The majority of China’s commercial space companies are engaged in satellite manufacturing, operations, and applications. Reflecting the dominance of the state in China’s commercial space sector, most companies are located in Beijing, and state-owned commercial space companies appear to be prioritized for funding.

Although there is no shortage of reporting on China’s commercial space activities, much of the information on these companies remains murky, making it difficult to verify information and leaving gaps in our understanding. Many Chinese academic writings and newspaper reports on commercial space are anecdotal and do not offer insights into the state of the domestic industry as a whole. As a result, this section relies heavily on market analysis from a small number of Chinese sources, notably a recently published report by the Chinese industrial think tank Futuraerospace.

MARKET VALUE

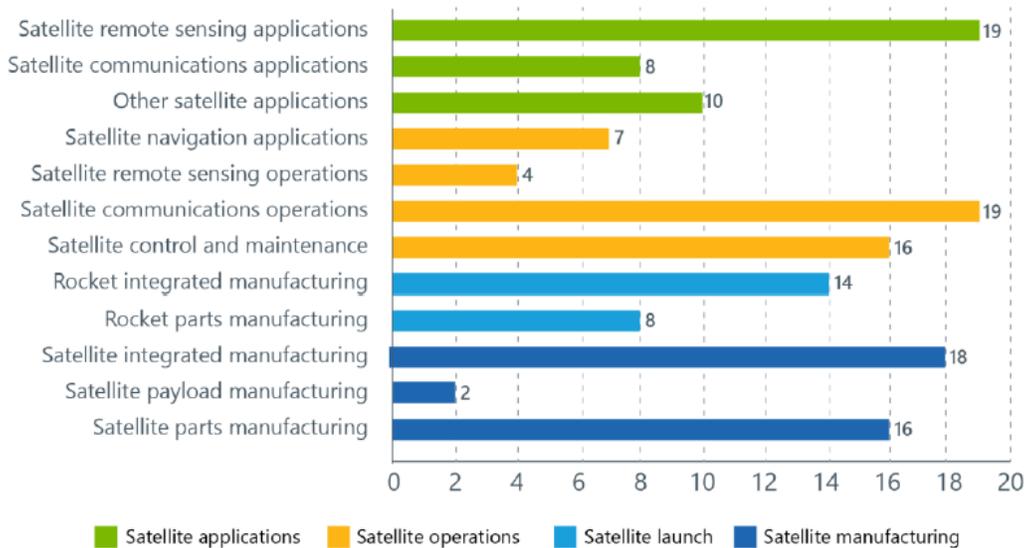
Chinese analysts assess China’s commercial space market to be small, but expect quick growth. According to Futuraerospace, in 2018 Chinese commercial space investment and financing had a total value of about \$520 million (3.6 billion CNY).²⁰⁴ By 2025, the think tank expects the value of the domestic commercial space market to surpass \$4.4 billion (13.6 billion CNY in the commercial satellite manufacturing industry and 17 billion CNY in the commercial satellite launch market).²⁰⁵

Considering the small size of the commercial space sector in China and its limited technological level, Futuraerospace’s projected growth of China’s commercial space market may be overly optimistic. The think tank foresees the domestic market’s growth as being fueled by a major uptick in satellite launch, arguing that China may launch as many as 3,100 commercial satellites by 2025.²⁰⁶ Reaching this figure, however, would mean that China will need to launch more than 500 satellites annually—more than any other country has ever launched on an annual basis. In 2019, for example, the global combined total for satellites launched into orbit was 516.²⁰⁷ As of September 2019, China had only 323 operational satellites, 56 of which are commercial. In 2018, it launched just 25 commercial satellites.²⁰⁸ Furthermore, in July 2019 a China National Space Administration (CNSA) official said that China would launch “nearly 100” satellites by 2025—far short of the thousands of satellites imagined by Futuraerospace.²⁰⁹

BUSINESS SECTORS

Futuraerospace found that out of 141 Chinese commercial space companies, 36 were involved in satellite manufacturing, 22 in satellite launch, 39 in satellite operations, and 44 in satellite applications.²¹⁰ Futuraerospace further divided the four sectors, as shown in Figure 5 below.²¹¹

Figure 4. Number of Chinese commercial space companies by subsector (as of end of 2018)

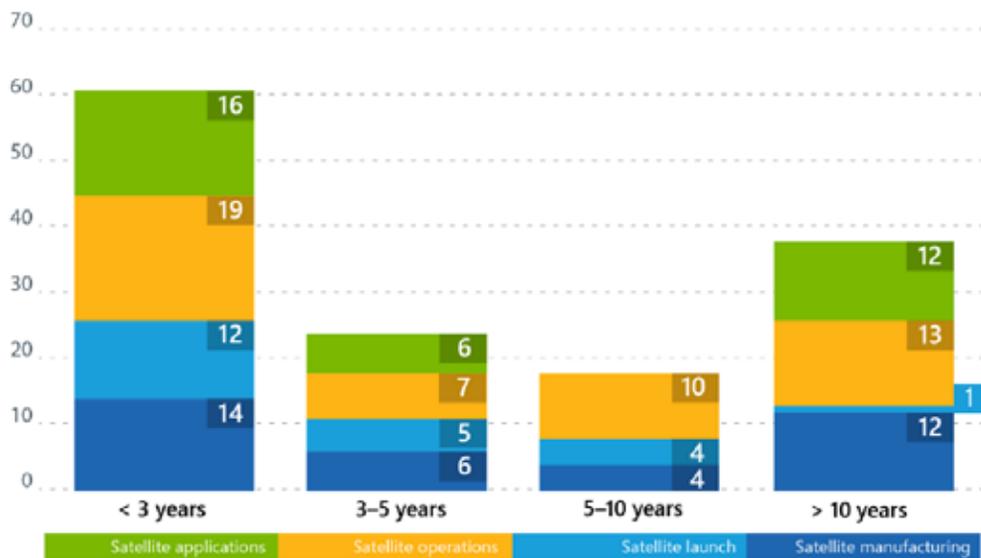


Source: Adapted from Pinhe Cultural Investment, "Futureaerospace Releases 'Investment in China's Aerospace Sector 2018.'"

DATE OF ESTABLISHMENT

Reflecting the global enthusiasm for commercial space, 85 companies (60 percent) were established in the past five years. This has been especially true for commercial launch companies, 12 (77 percent) of which have been established since 2014.²¹² The number of satellite application startups in the past five years has remained strong and most likely reflects the emphasis on commercializing space-based remote sensing data, satellite communications, and satellite navigation services.

Figure 5. Age of Chinese commercial space companies by sector based on date of establishment (as of end of 2018)



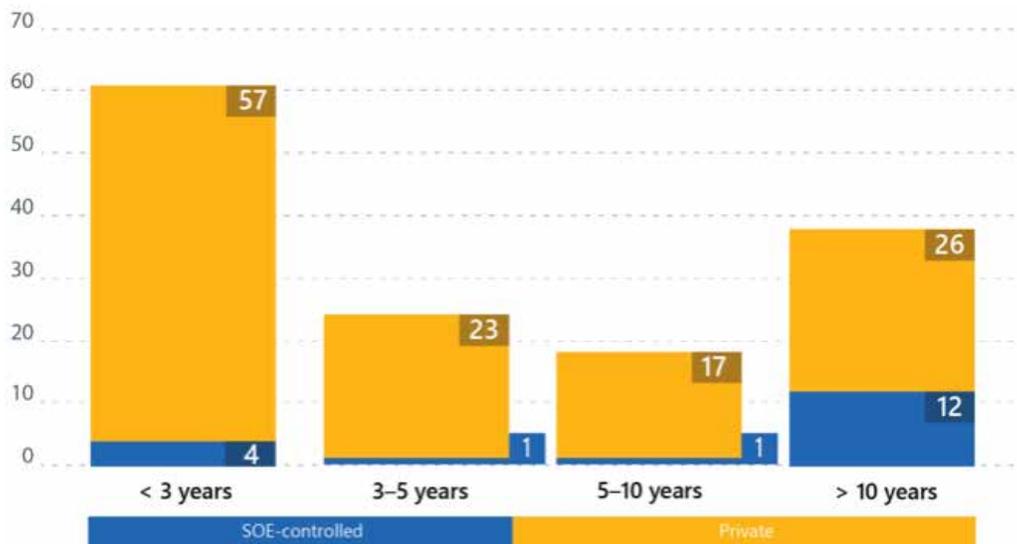
Source: Adapted from Pinhe Cultural Investment, "Futureaerospace Releases 'Investment in China's Aerospace Sector 2018.'"

OWNERSHIP STRUCTURE

China's commercial space sector consists of both state-owned and private companies.²¹³ Just a small number of these companies are publicly listed.²¹⁴ The majority of China's commercial space companies are nominally private—123 out of 141 (87.2 percent).²¹⁵ Most state-owned companies were established more than a decade ago, whereas the newer entrants mostly self-identify as private companies.

The corresponding figure should be approached with caution, however, as the degree to which the state has invested in these companies is unclear. Chinese investment funds, for example, are often vehicles for state-led investment in China's commercial sector.

Figure 6. Age of Chinese commercial space companies by ownership structure (as of end of 2018)



Source: Adapted from Pinhe Cultural Investment, "Futureaerospace Releases 'Investment in China's Aerospace Sector 2018.'"

LOCATION

More than half of China's commercial space companies are concentrated in Beijing.²¹⁶ The remaining companies are distributed among a handful of provinces and municipalities in Shaanxi, Hubei, Hunan, Jiangsu, Shanghai, Sichuan, and Zhejiang.²¹⁷

Beijing is the location of choice for private commercial space companies for a number of reasons. For one, CASIC and CASC, China's traditional state-owned space industrial conglomerates, are based in Beijing. Private companies headquartered in Beijing are close to the decision-makers of the defense industrial conglomerates and can also leverage the large pool of aerospace personnel who work in the capital region.²¹⁸

Beijing is also a major site for capital investment. In 2018, 29 of the 36 major domestic investment and finance deals for commercial space took place in Beijing.²¹⁹ Finally, in a regulatory environment in which certain commercial space activities must be approved on a case-by-case basis, Beijing-based companies can take advantage of their proximity to government agencies overseeing the commercial space industry.²²⁰

FINANCING

Xi's focus on the state-led sectors has resulted in the majority of lending going to SOEs. According to economist Nicholas Lardy, bank lending to the private sector in China has declined by 80 percent, despite the private-sector economy being the source of most of China's economic growth.²²¹

The Chinese government’s overall policy of prioritizing credit for SOEs appears to be reflected in funding amounts for China’s commercial space sector. The advantaged position of state- owned commercial space companies can be seen through their access to relatively large amounts of capital during early stages of financing. For example, Expace, the state-owned commercial launch subsidiary of CASIC, brought in 1.2 billion yuan (\$180 million) during the company’s Series A round of financing in December 2017.²²² In comparison, private Chinese commercial launch companies such as iSpace, Onespace, and Landspace on average brought in only several hundred million yuan (about \$40 million) over multiple rounds of early-stage financing (see Table 1).²²³

Table 3. Comparison of early-stage financing between state-owned and private Chinese commercial launch companies

Organization	Ownership	Financing time	Round	Amount (RMB)
Expace	SOE	December 2017	A	1.2 billion
iSpace	Private	November 2017	Angel	~100 million
		March 2018	Pre-A	[No data]
		June 2018	A	[No data]
OneSpace	Private	December 2015	Angel	> 10 million
		October 2016	A	> 100 million
		May 2017	[No data]	79.84 million
		January 2018	A+	> 200 million
		August 2018	B	~300 million
LandSpace	Private	March 2015	Seed/Angel	> 10 million
		June 2016	Pre-A	100 million
		November 2016	A	~20 million
		April 2018	B	200 million

Source: Adapted from “Prospects for the Chinese Commercial Space Development Situation in 2019,” 554-555.

LEADERSHIP

The background of China’s commercial space corporate leadership may differ depending on whether a company is SOE-controlled or private. An examination of the leadership of three commercial space launch companies—Expace, Landspace and OneSpace—suggests that state- owned commercial space companies are usually led by career SOE employees with strong technical backgrounds. For example, Expace is partially owned by CASIC and its leadership reflects that relationship. Before becoming chairman of Expace, Zhang Di was on the design team of the Long March 3A launch vehicle and previously served as director of CASIC’s Space Projects Department.²²⁴ Chairman Zhang Di also served concurrently as vice president of CASIC’s Fourth Academy.²²⁵

In contrast, private company founders appear to be relative outsiders to the space industry. The CEOs of LandSpace and OneSpace, for example, have backgrounds in finance and have no apparent technological or entrepreneurial background. Nor have they made their wealth running billion dollar companies. Although Onespace founder Shu Chang has an academic background in space technology, he spent his early career in an investment company.²²⁶ Landspace founder Zhang Changwu previously worked in China’s finance industry, with no clear background in the space industry.²²⁷

Moreover, there is no information to suggest that these individuals have special qualifications to establish, operate, and understand a commercially and technologically risky business venture such as commercial launch. Both LandSpace and OneSpace are led by Chief Technology Officers (CTOs) that have experience working in the space industry, which may ameliorate some of these concerns, but it is unclear how much authority they have in determining the direction of the company. The practice by both companies of pairing CEOs with a finance

background with CTOs with a space industry background suggests that both companies were founded by a common organizing entity.

WORK FORCE

A large proportion of the engineers employed by Chinese commercial space companies are likely former employees of CASIC and CASC, as well as other SOEs involved in China’s space program.²²⁸ One report from a Ministry of Industry and Information Technology (MIIT)-affiliated think tank suggests that a large number of SOE employees have left for positions in commercial space companies in recent years. The report identified 2015–2016 as the “peak period” of rocket system designers from CASC’s China Academy of Launch Vehicle Technology leaving for jobs in commercial space companies.²²⁹ Furthermore, the 2016–2017 period was identified as the high point of liquid rocket engine designers leaving CASC subsidiaries for positions at commercial space companies.²³⁰

The report did not indicate the number or seniority level of the CASC employees who left their former jobs during these periods, but the sheer numbers of workers (300,000) employed by China’s space industry conglomerates suggests that it has an excess of workers, some of whom may not be employed in positions they consider promising. In comparison, in 2018 the United States space industry as a whole employed 173,000 workers, 128,163 of whom worked for industry.²³¹

An examination of the workforce of LandSpace and One Space, however, raises questions about the real nature of these companies. SpaceX, for example, has 7,000 employees. LandSpace and One Space, on the other hand, have just 50 and between 100 to 200 employees, respectively. The low numbers of employees suggests that these companies are not engaged in much R&D and instead may be resellers or minor players in the commercial launch market.

Table 4. Selected U.S. and Chinese commercial launch companies

	SpaceX	ExPace	LandSpace	One Space
Origins	Elon Musk	Subsidiary of CASIC AKA “CASIC Rocket Company”	Founded by Tsinghua University	Private, working with NORINCO and CASIC
Date est.	2002	2016	2015	2015
Leadership	Elon Musk, PayPal, Tesla	Zhang Di, Deputy Director of CASIC 4th Academy	Zhang Changwu, previously at HSBC CTO Wu Shufan, previously at ESA	CEO Shu Chang, VP of Legend Holding CTO Chen Xiaojun, China Academy of Launch Vehicle Technology
Staff	7,000	Unknown	50	100–200
Products	Falcon 9 22.8 MT Partially reusable	Kuaizhou-1A Based on DF-21 200 kg payload First launch 2017 5 launches	Zhuque-1 300 kg into LEO No successful launches	OSM-1 205 kg into LEO No successful orbital launches
Financing	Musk. Investment firms	?	Multiple investment firms	Multiple investment firms

Problems with China's commercial space sector

Chinese authors observe that China's commercial space market is fraught with risks.²³² Some of the risks are the product of a government that has yet to make significant changes to the legal environment and governance structure for domestic space activities. China does not have a single, overarching space law, for example, and the set of institutions responsible for overseeing commercial space activities are dispersed among various government and military bodies.

Other problems reside in industry. A wave of Chinese entrepreneurs, capitalizing on the government's shift to allowing private investment in the space industry, are attracting funds from investors first and worrying about profit models later. Many of these companies lack the technical capabilities or plans to offer advantages in price or quality over domestic state-owned competitors, let alone international companies.

The remainder of this section examines these problems in detail.

GOVERNMENT

LACK OF LAWS, POLICIES, AND STANDARDS

China lacks an overarching space law that delineates the rights and responsibilities of stakeholders in its space enterprise. This legislative gap creates a number of problems for market growth and business development. As analysts from one CASC-affiliated research institute observe, the lack of national-level space legislation increases uncertainties for investors who are already taking risks by investing in an emerging market.²³³ Another Chinese scholar observes that commercial investment requires legal “certainty, stability, and predictability.”²³⁴ The absence of a space law also leaves domestic commercial space entrepreneurs without a clear framework for business development.²³⁵

The absence of a Chinese space law can be attributed to the dominance of non-commercial actors in domestic space affairs. Prior to 2000, Chinese space activities were conducted primarily by government and military organizations.²³⁶ For decades, it was possible to manage these actors with departmental regulations rather than a national law.²³⁷ As one Chinese scholar argues, the formulation of a space law took a backseat to more pressing concerns, since the space domain appeared to be “barely connected to daily life or related to economic development.”²³⁸

The National People's Congress (NPC), China's national legislature, has been working on drafting a space law for years. In 2013, the 12th NPC incorporated the drafting of a space law into its five-year legislative plan (2013–2018).²³⁹ The initial drafting work was undertaken by a leading small group led by the State Administration for Science, Technology, and Industry for National Defense (SASTIND) under the direction of the PRC State Council. In 2017, a chief engineer from SASTIND announced that the leading small group had “basically completed” a preliminary draft of the law.²⁴⁰ An article published a year later by Chinese space SMEs speculated that the law would be released “sometime around 2020.”²⁴¹ However, the five-year legislation plan of the 13th NPC (2018–2023) suggests that these SMEs' forecast might be overly optimistic. In the 13th NPC's legislation plan, the draft space law is included under a category of draft laws that still need significant work (Class II), not the category of draft laws that are expected to be submitted for review prior to 2023 (Class I).²⁴²

Chinese experts also contend that China lacks other policies and guidelines critical for commercial space development. Notably in the area of rocket launch, China does not have a clear, publicly releasable version of the critical stages in the course of launch review and approval.²⁴³ This could lead to difficulties for companies in the planning and development stages of related technologies and services.

Some domestic space regulations do exist for areas such as registering civil space objects²⁴⁴ and licensing regimes for civil launches,²⁴⁵ export control,²⁴⁶ and telecommunications applicable to space activities.²⁴⁷ Yet as one Chinese

scholar contends, this patchwork of regulations is “fragmented,” has “obvious loopholes,” and has overlapping measures at different levels of legislative hierarchy.²⁴⁸

NO TOP-LEVEL BODY TASKED WITH COMMERCIAL SPACE

Another shortcoming pointed out by Chinese experts is the lack of a top-level administrative body tasked with commercial space affairs. Chinese commercial space activities appear to be managed on an ad hoc basis by numerous agencies. The PLA exercises control over launch infrastructure and monitoring facilities, while SASTIND and its subordinate organization CNSA are responsible for overseeing the space-related defense industry and providing policy guidance.²⁴⁹ Analysts from an MIIT think tank have pointed out that no permanent coordination mechanism exists between military and civilian space-related departments and warn that the lack of regular coordination between the two sides could easily lead to bureaucratic stove piping and a waste of resources.²⁵⁰

OBSTACLES TO PRIVATE COMPANIES ACCESSING SPACE INFRASTRUCTURE

Another barrier to entry for Chinese commercial space companies, particularly private companies, is access to the country’s space infrastructure. In recent years, multiple PRC policy documents have called for increasing the joint construction and use of space infrastructure between military and civilian organizations. Yet, as authors affiliated with the MIIT think tank attest, the tangible results of these policies have been “far from apparent.”²⁵¹

Chinese authors also point out that China’s four existing launch sites have “reached saturation” due to the increasing number of government and military launches, leaving little room for commercial launches.²⁵² To date, most Chinese commercial space companies’ suborbital and orbital launch attempts have taken place from the Jiuquan Satellite Launch Center. One suborbital launch was carried out from the Wenchang Satellite Launch Center in Hainan Province. In contrast, the United States faces no such limitations on its launch infrastructure and leases launch pads to commercial space launch companies at Kennedy Space Center and Vandenberg Air Force Base and to the U.S. Commonwealth of Virginia at the Wallops Flight Facility.

The PLA also has a monopoly on China’s telemetry, tracking, and control system. One pair of authors contends that it is difficult for the PLA to support commercial launches, since it does not receive compensation for services.²⁵³

One potential solution to resolve the lack of access to space infrastructure is for commercial space companies to build their own space facilities, but there appears to be some ambiguity over whether this is legally feasible. According to CASC-affiliated authors, the PRC government has yet to permit private entities to build their own commercial launch sites and systems.²⁵⁴ The commercial launch regulations released in June 2019 stated that commercial space companies must use “nationally recognized launch sites,” but did not specify whether companies could gain approval to build their own launch sites.²⁵⁵

INDUSTRY PROBLEMS

Chinese analysts assess that recent entrants into China’s commercial space market generally lack transparent and sustainable profit models. According to one report from a PRC government-sponsored think tank, no Chinese commercial space company has a clearly articulated business model.²⁵⁶ Related concerns range from inadequate funding, the small size of the domestic Chinese market, and high prices.

FUNDING

The majority of private Chinese commercial space companies rely on venture capital, local government funding, and the companies' own funds to increase their valuation.²⁵⁷ According to one report, the Chinese domestic commercial space sector enjoyed a "golden age" of investment during the latter half of 2016, but since then investors have been more focused on the sustainability of companies' profit models.²⁵⁸ This new focus may be warranted. An employee of one commercial launch company has stated that some opportunistic entrepreneurs were using "commercial space" in startup names simply to "bamboozle" investors.²⁵⁹

The situation appears to be different for state-owned commercial space companies such as Expace and ChinaRocket that are owned by CASIC and CASC, respectively. Both these companies probably rely mostly on funding from their parent companies. Speaking to reporters in 2016, the former president of ChinaRocket drew a comparison between his company and SpaceX, stating that while Elon Musk's company had "limited funds," the Chinese state had "ample capital."²⁶⁰

MARKET SIZE

Some Chinese authors point out that the small size of China's commercial space market limits the ability of companies to achieve economies of scale.²⁶¹ According to authors affiliated with CASC, Chinese commercial remote sensing and satellite communications companies lack sufficient customers.²⁶² Another report from China Daily claims that the producers of Chinese commercial microsatellites have been unable to make a profit.²⁶³

PRICING

Another criticism of China's commercial space companies is a lack of competitive pricing for products and services.²⁶⁴ One report by a PRC government-sponsored think tank argued that the cost structure of these companies made lowering prices difficult.²⁶⁵

MANUFACTURING ISSUES

According to Chinese analysts, private Chinese companies have a limited ability to source rocket engines, and domestic SOEs have a limited capacity to produce engines for commercial launch providers.²⁶⁶ The inability of Chinese commercial launch providers to build their own engines suggests that they simply assemble engines provided by China's state-owned space industry and possibly even act as marketers of launch services rather than true developers. Expace's technology was previously developed by another CASIC subsidiary, for example. Furthermore, LandSpace's ability to launch rockets within two years of the company's founding appears to belie an external source for their rocket technology. OneSpace, on the other hand, conducted a test launch of its OS-1 rocket in 2018 just three years after the company's founding. The successful launch of the Hyberbola-1 rocket in 2019 by iSpace, a company with just 200 employees, also suggests a role as marketer rather than as a genuine developer.

Chinese authors also suggest that China's expanding commercial space sector is focused more on lowering prices and increasing production capacity rather than offering advanced products and services. CASC-affiliated authors, for example, point out that even though the number of Chinese companies manufacturing satellites and satellite components has increased greatly in recent years, their products are relatively unsophisticated.²⁶⁷

Chinese views of the U.S. commercial space industry

Chinese writings portray the United States as an established leader in commercial space and China as a latecomer struggling to catch up. Chinese analysts characterize their country's efforts in space commercialization as an act of "following and imitating" the decades-long developmental lead of Western companies.²⁶⁸ They see a difficult road ahead in which China must double down and make smart investments in order to be competitive in the international market.²⁶⁹

The majority of Chinese commercial space startups—especially commercial launch companies—have emerged only in the past five years. They generally lack experience designing, manufacturing, and marketing products and services to domestic and international clients. As these startups seek ways to catch up to global industry leaders, Chinese analysts look for role models from whom they can emulate best practices in commercial space development.

Many Chinese writings on commercial space analyze the experiences of U.S. companies, with a particular focus on SpaceX. Chinese space experts call SpaceX the "major representative company" for commercial space worldwide.²⁷⁰ A report from Hong Kong media claims that Chinese investors view SpaceX as the "benchmark company" for emerging commercial space companies in the mainland.²⁷¹

Chinese authors also follow developments in other U.S. commercial space companies, such as Digital Globe and Rocket Lab.²⁷² Yet the coverage these companies receive in Chinese academic writings and media reporting pales in comparison to that of SpaceX.

Chinese authors also pay attention to the ways in which the U.S. government uses various policies and incentives to create a favorable ecosystem for the growth of new commercial space companies. Chinese writings analyze ways in which NASA has supported private companies with funding, technology transfer, consulting, and infrastructure leasing. Although their specific recommendations vary, Chinese authors view strong government oversight and intervention as crucial toward the success of the domestic commercial space industry.

INNOVATION IN U.S. COMPANIES

Chinese authors observe that innovation has been critical to the success of U.S. commercial space companies. Innovation comes in different forms, from small incremental adjustments (such as cutting time and costs) to major disruptive changes. Chinese writings indicate two main types of innovation—technological and process—that have been hallmarks of U.S. commercial space companies.

TECHNOLOGICAL INNOVATION

BREAKTHROUGH TECHNOLOGY

A number of technical breakthroughs achieved by U.S. commercial space companies have attracted the attention of Chinese authors. One well-covered breakthrough in Chinese writings was SpaceX's first successful retrieval of two Falcon 9 thrusters. Following launch at sea, these two thrusters landed vertically on an unmanned barge in April 2016.²⁷³ To make sea retrieval a success, SpaceX had to overcome a number of difficulties. According to Chinese analysts, these difficulties included developing a stable and dependable maritime platform, achieving high accuracy in rocket control technology, and overcoming the effects of sea and weather conditions.²⁷⁴

Although Chinese researchers praised SpaceX's vertical retrieval at sea of the Falcon 9 thrusters, some were skeptical about its actual commercial benefits. For example, one Chinese author, pointing to the costs of post-retrieval maintenance and preparations for the next launch, questioned the actual savings of reusable first stages.²⁷⁵

INTEGRATING OFF-THE-SHELF TECHNOLOGY

Chinese writings observe that SpaceX's use of off-the-shelf technologies allowed the company to drastically lower launch costs in comparison to traditional players in the space industry. One article by Chinese analysts described a recent SpaceX launch quote of \$54 million as having rattled the "relatively closed-off global space launch ecosystem."²⁷⁶ Another article mentions SpaceX's Dragon capsule as an effective use of off-the-shelf technology.²⁷⁷

INNOVATION IN BUSINESS PROCESSES

Chinese authors note several ways in which U.S. commercial space companies take innovative approaches to running their businesses. These novel approaches include both how the company is organized and the way that it interacts with and markets itself to the outside world.

MANAGEMENT STRUCTURE

Chinese analysts see SpaceX's relatively flat management structure as an advantage. The company has a small number of department chiefs who all report directly to the company's CEO Elon Musk.²⁷⁸ The simplified structure, Chinese analysts observe, allows for quick decision-making and facilitates the flow of information, thereby accelerating the production process and overall efficiency.²⁷⁹

KEEPING THINGS IN-HOUSE

Another advantage Chinese authors see in SpaceX is the company's capability for in-house manufacturing. SpaceX broke from the traditional space industry model of outsourcing the R&D for aerospace engines, electronic components, navigation systems, and ground support equipment.²⁸⁰ Chinese analysts argue that although SpaceX's in-house approach would appear to run counter to the modern trend of company specialization, it is in fact critical for keeping costs down.²⁸¹

MEDIA OUTREACH

Another observed advantage of U.S. commercial space companies is their ability to connect to potential investors and employees through social media and other communications. According to one account in *China Space News*, SpaceX's strong media outreach has allowed it to effectively publicize its development aspirations and thereby attract top talent.²⁸² One particularly well publicized SpaceX activity was the Falcon Heavy test that launched a Tesla Roadster into space. According to an article in a Chinese industry newspaper, this test launch was one of multiple times that SpaceX "shocked the world."²⁸³

THE ROLE OF THE U.S. GOVERNMENT

Chinese authors see the U.S. government as playing an indispensable role in creating beneficial market conditions. Government assistance comes in various forms, from the creation of preferential policies to the direct provision of development funds and contracts. Chinese writings see benefits in the U.S. government's efforts in commercial space, including the breakup of United Launch Alliance's (ULA, a joint venture between Lockheed Martin Space Systems and Boeing Defense, Space, and Security) traditional monopoly over launch missions and the increased competitiveness of the U.S. space industry. At the same time, Chinese writings argue that U.S. government support for commercial space companies could lead to a hollowing out of NASA.

POLICY SUPPORT

Chinese authors see the U.S. government as providing indispensable support for commercial space through the formulation of preferential policies that advance the commercial sector's development. One area of government policy support identified by Chinese analysts has been the creation of commercial contracts. Analysts from CASC state that it was NASA that "sustained" SpaceX's development through troubled times under the Commercial Orbit Transportation Services (COTS) plan,²⁸⁴ which allocated \$788 million dollars over eight years to incentivize private industry to develop spacecraft to deliver cargo and crew to the International Space Station.²⁸⁵

TECHNOLOGY TRANSFER

According to Chinese writings, another area in which NASA has provided assistance to commercial space companies is the transfer of technologies. Chinese authors note that the rocket engine is traditionally one of the most challenging aspects in launch vehicle design. According to multiple Chinese authors, SpaceX's Falcon 9 made "direct use" of technologies from the Saturn V rocket to develop the Merlin engine.²⁸⁶ It is unclear what evidence Chinese sources are using to make this claim. SpaceX's website states that the Merlin engine was "developed and manufactured in-house" and that the Falcon 9's engine architecture is "an improved version of the design employed by the Saturn I and Saturn V rockets."²⁸⁷

CONSULTING ASSISTANCE

Another area of NASA support for commercial space companies is allocating its own employees to provide professional consulting services. Chinese authors have observed that NASA has at times embedded its own personnel at SpaceX facilities to provide consulting services for project development.²⁸⁸ Another set of authors argues that NASA's direct provision of technical guidance to SpaceX allowed the company to greatly reduce the difficulty of launch vehicle development.²⁸⁹

INFRASTRUCTURE ACCESS

Another area of support is access to infrastructure that a commercial enterprise would have difficulty developing on its own.²⁹⁰ The U.S. government, for example, leases launch pads to commercial space launch companies.

INCREASING COMPETITION

Chinese analysts observe that commercial space entrants can be used to break up inefficient monopolies. They note that prior to the emergence of SpaceX, the domestic market in the United States for large satellite launches was controlled entirely by ULA, a company they see as prone to cost overruns.²⁹¹

BRAIN DRAIN

Chinese observers argue that the benefits of increased competition from commercial space companies may have a detrimental effect on NASA's ability to retain talent. One Chinese newspaper article, for example, incorrectly notes that after the incursion of commercial space entrants into NASA's "territory," the organization's personnel numbers dropped from about 30,000 employees to around 20,000 employees.²⁹² In fact, NASA's current workforce stands at a little over 17,000.²⁹³ NASA was required by executive order to reduce its workforce in the 1990s in order to meet overall federal workforce reduction levels.²⁹⁴

LESSONS FOR CHINA

Chinese analysts view the United States as a leader in commercial space and the experiences of companies such as SpaceX as helpful for developing China's own commercial space industry. Through analysis of domestic and foreign companies, Chinese analysts have identified best practices and areas for improvement in China's own commercial space sector. This section identifies main themes in Chinese authors' recommendations for improving the growth of the commercial space sector in China.

CREATE A POSITIVE BUSINESS ENVIRONMENT

Chinese analysts see a strong government hand behind the success of U.S. commercial space companies. The U.S. government is seen as setting up guidelines for commercial space companies and indicating which activities can be undertaken and the kinds of permissions that need to be obtained. The U.S. government has also provided financial support, seen through the extension of commercial contracts to startups.²⁹⁵

Chinese authors recommend an across-the-board strengthening of laws, policies, and standards for the domestic commercial space industry. Chinese authors argue that the Chinese government should tell commercial space companies not only what they should not do, but also what they should do. In other words, commercial space companies should receive clear direction concerning the government's priority development areas and what funding and support commercial space companies can expect to receive for work in these priority areas.²⁹⁶ Chinese authors also call for legislation to increase the transparency of regulatory processes. Portions of the approval system for commercial launch, for example, are not publicly available.²⁹⁷

A critical question is whether the government will open up existing launch sites and control systems to private companies, or whether these companies will be permitted to build their own launch infrastructure.²⁹⁸ Export controls—which determine what types of launch vehicles and satellite technologies companies will be prohibited from marketing abroad—is also a consideration.²⁹⁹

Other areas for improvement in the legal realm pertain to how China will handle commercial space activities that impact or infringe upon the rights of other countries. For example, Chinese authors question what China would do if one of its commercial launch vehicles experienced failure and parts from the vehicle caused damage in a third-party country. One article by CASC-affiliated individuals advises that China should use “relevant UN space law” as a basis and provide assurances that damages incurred from launch accidents will be compensated by the Chinese government.³⁰⁰ Under the international Outer Space Treaty, to which China is a signatory, states are liable for damages caused by launch activities to another state party to the treaty.

Part of the push for improved top-level planning appears to be a desire to deconflict the actions of the traditional space industry and emerging commercial space companies. One of the concerns voiced by Chinese authors is that the commercial space sector is overcrowded with too many players.³⁰¹ In turn, they suggest that China's top-level planners should promote the development of a variegated system of commercial space products.³⁰² They also recommend that the government organize the activities of commercial space enterprises in a way that minimizes harm to SOEs' interests. One proposal is to establish a commercial space industry alliance, in which traditional players form a “price alliance” that minimizes “disorderly competition” among state-owned and private entities.³⁰³ In December 2019, it was reported that a commercial space alliance was established by six entities. The alliance, to be overseen by the China National Space Administration, is intended to advocate for the commercial space industry, carry out research, promote innovation, assist in developing regulations, and promote international cooperation.³⁰⁴

Authors in a leading Chinese space journal argue the alternative view that the Chinese government should transition from its traditional role of directing resources to one in which it serves as a “referee” in a competitive business environment. They view the Chinese government as traditionally making all decisions about the space

economy: what to develop, by when, and by whom. The U.S. space economy, in contrast, is depicted as allowing commercial actors to independently develop technologies and services outside of government contracts.³⁰⁵

Other Chinese authors argue that the state should do more to incentivize private companies and private capital to invest in commercial space activities. Suggestions for achieving this end include preferential policies for private actors and slating certain space products for commercial space enterprises.³⁰⁶ They recommend that state and industry funding should be provided to young commercial space companies.³⁰⁷

Another article by CASC-affiliated researchers suggests that commercial space companies should focus on “highly profitable” and relatively simple business ventures such as satellite applications and the construction of ground systems. They argue against commercial investment in “highly complex” aspects of the space industry such as launch vehicle and satellite design.³⁰⁸

While suggesting that the Chinese government play an initially strong role in supporting domestic commercial space companies, they do not contend that this should continue throughout the full course of a company’s life cycle. Furthermore, some Chinese authors argue that getting too close to a specific part of government could be damaging for a company over the long term. Chinese authors conclude that too much dependence on a government client can constrain a company’s growth.³⁰⁹

ACCELERATE MIXED-OWNERSHIP REFORM OF SOES

Chinese authors argue that a number of problems in China’s space industry SOEs—including poor market responsiveness, cost control, and personnel incentives—can be improved through mixed-ownership reform. Through this reform, private capital would shape SOE planning and resource allocation and make them more responsive to market demand. They also recommend reorganization, mergers, and acquisitions within the traditional SOE sector to optimize the layout of the space industry.³¹⁰

LEVERAGE TECHNOLOGIES FROM OUTSIDE THE SPACE INDUSTRY

Chinese authors observe that SpaceX lowered its rocket R&D costs and reduced development times by integrating commercially available off-the-shelf technologies and equipment. CASC-affiliated researchers claim that unlike SpaceX, Chinese space contractors tend to develop specialized products for satellites and rockets within their subordinate companies.³¹¹ The researchers argue that embracing more off-the-shelf technologies and equipment will lower costs and allow Chinese commercial space companies to become more competitive.³¹²

USE COMMERCIAL COMPANIES TO PROVIDE MORE OPTIONS

One of the lessons from SpaceX’s participation in U.S. national security contracting is that commercial players can provide useful redundancy for space launch. China has traditionally relied on two main space contractors whose products and services do not typically overlap. Nevertheless, CASC and CASIC constitute a duopoly for launch and satellite manufacturing. CASC-affiliated authors argue that the main purpose of SpaceX was to lower costs and break the launch monopoly of ULA rather than become the backbone of the domestic space industry.³¹³ (According to SpaceX’s website, the company’s purpose is to “revolutionize space technology, with the ultimate goal of enabling people to live on other planets”).³¹⁴ Private commercial space companies could help provide alternatives when the traditional players fail to deliver on time or on budget.³¹⁵

AIM FOR AN EFFICIENT, FLAT STRUCTURE

Company organization is another area in which SpaceX provides a role model for Chinese commercial space companies. Chinese writings observe that SpaceX’s business model has a highly effective cost control and flat management structure that can be run more efficiently.³¹⁶

EXPECT FAILURE

Commercial space companies often experience failure. Designing satellites and rockets is difficult, and getting them into space is even more challenging. A number of setbacks can get in the way, from regulatory issues to lack of funding to launch failure. Chinese authors point to SpaceX founder Elon Musk, who experienced multiple launch failures and was on the brink of bankruptcy before finally experiencing launch success. Chinese authors recommend that China's commercial space actors follow Musk's example. According to CASC-affiliated researchers, China's commercial space companies should be able to persist through challenges and continue to innovate.³¹⁷

Chinese views of space natural resource extraction

A second rationale of China's vision to exploit space for economic purposes is the extraction of natural resources in space. The use of space resources promises to open up lucrative new markets and increase the reach of future space missions. Space has the potential for vast amounts of minerals, metals, and energy to be used, mined, or otherwise collected in ways that could dramatically change space exploration and revolutionize energy production on earth.

The use of space resources is commonly known as *space mining*, which is defined as the extraction, collection, and utilization of natural resources located on the surface or subsurface of a celestial body. Celestial bodies contain different kinds of minerals, such as iron, platinum, and aluminum as well as water. Mined resources can be used either "in situ" or transported to the Earth.³¹⁸ Space mining, however, has significant technical and economic challenges to overcome in both the extraction and transport phase before its potential can be realized.

The most commonly discussed types of space mining in Chinese articles are collecting water ice from the poles of the Moon to be converted into fuel for spacecraft, creating orbiting space-based solar power (SBSP) stations to send energy back to Earth, and mining asteroids. All of these processes have technological challenges. Other challenges, such as economic feasibility, will be largely driven by market forces. Although this may change in the next 10–20 years with advancements in technology and public-private partnerships seeking to create platforms for the commodification of space resources, space resource extraction is currently in the theoretical and experimental stages of development.

Statements by Chinese scientists and engineers indicate that China's space experts view the extraction of natural resources in space as part of its plan to become a global leader in space. Chinese sources view the use of space resources as a long-term strategic means to further develop its space program and achieve resource security. According to its 2016 white paper on space, China "develops and utilizes space resources in a prudent manner."³¹⁹

Statements by Chinese space personnel indicate that Chinese space proponents view cislunar missions as a potential source of economic revenue. Lt Gen. Zhang Yulin, the deputy commander of the CMC Equipment Development Department, stated in a 2019 forum that "the limited capacity of Earth resources is the root cause of current global problems" and that cis-lunar space "will become another broad field for the expansion of human living space." Zhang proposed that China should build technologies to "form a sustainable economic cycle" made up of consumers on Earth, industrial facilities located in geostationary orbit, and raw materials mainly extracted from the Moon.³²⁰ China, he said, will "exploit the space between earth and the Moon for solar power and other resources after it builds a space station in 2020," further explaining that "the Earth-Moon [cislunar] space will be strategically important for the great rejuvenation of the Chinese nation."³²¹

According to Bao Weimin, director of CASC's Science and Technology Committee, China's development of a cislunar space economy will follow a three-stage process. In the first stage, China will improve its fundamental space capabilities and reduce costs. In the second stage, it will build a cislunar transport system between the Earth

and Moon to establish a space economic zone. In the third stage, China will complete the building of a space economic zone by the year 2045.³²²

Speaking in October 2019, Bao elaborated on the proposal. According to the proposal, by 2030 China will develop the basic technologies and achieve breakthroughs in key technologies to carry out the plan. By 2040, China will have reliable and inexpensive access to space. By mid-century, China will have the capabilities to develop cislunar space. According to Bao, China's exploitation of cislunar space would involve space resource exploration and development and the necessary supporting infrastructure that he estimates is valued at an annual return of more than \$10 trillion.³²³ News reports covering Bao's comments did not reveal the source of his \$10 trillion estimate. If accurate, the amount would be equivalent to one-eighth of the world's GDP.

A slightly different version of this vision is laid out in the China Academy of Launch Vehicle Technology's "Aerospace Transportation System Development Roadmap 2017-2045." The roadmap proposes developing a space transportation system capable of supporting large-scale space mining and the return of resources to Earth. The Roadmap states that by 2040 China hopes "asteroid mining and space solar power plants will be made a reality."³²⁴

Chinese writings focus on three main natural resource objectives: Moon mining, space-based solar power (SBSP), and asteroid mining.

MINING RESOURCES FROM THE MOON

Mining the Moon for natural resources has been an ambition of China's lunar exploration program. One of China's earliest proponents of lunar exploration, geochemist Ouyang Ziyuan, is the director of China's lunar exploration program and appears to have played a central role in arguing for the study of Moon mining. In 2000, lunar exploration proponents submitted a final report to the Chinese leadership entitled *The Scientific Objectives of a Chinese Lunar Resources Orbiter*, which, in part, justified the program on the basis of discovering and extracting helium-3, an isotope of helium that could theoretically be used in fusion reactions (see the section on helium-3 below).³²⁵ In 2006, a report posted on the Central Government of the People's Republic of China website identified the goal of "economic development and prosperity" for China's lunar exploration program, indicating that China has long viewed the potential economic return on lunar exploration.³²⁶

LUNAR ICE

NASA's confirmation of ice at the lunar poles in 2018 opened up a new era in the possibilities for both manned and unmanned space exploration.³²⁷ Water from lunar ice can theoretically be used for human consumption on crewed space missions. Water is extremely scarce in the space environment and is costly and impractical to transport in large quantities from earth—it is estimated to cost between \$9,000 and \$43,000 to send a water bottle into space.³²⁸ The ability to use water found on the Moon, however, would reduce the need to transport large quantities from Earth.

Lunar ice could also be broken down into its elemental forms through electrolysis, producing oxygen needed for life support along with hydrogen for use as spacecraft propellant. Once the hydrogen propellant is extracted, a network of orbiting fueling stations could be set up to fuel reusable landers going from the lunar surface to lunar orbit or could be placed in Low Earth Orbit (LEO) and used to refuel rockets in LEO to improve the efficiency and capability of missions to GEO. If the infrastructure were created for space fueling stations, interplanetary vehicles could be refueled in cislunar space, making travel to Mars less expensive.³²⁹

Additionally, once extraction systems are developed and space-based fueling stations built, lunar water could become a lucrative economic opportunity. According to Angel Abboud Madrid, director of the Space Resources Center at the Colorado School of Mines, extracting ice from the Moon would be "the first step in building a space economy."³³⁰

China has also been studying the use of lunar ice, and proposed missions to the Moon are aimed at further exploring the presence of lunar ice. According to Lt Gen. Zhang Yulin, with the use of lunar ice-derived propellant, “the current manned space program could lay the foundation for a manned Mars program and other deep-space exploration.”³³¹ China’s lunar exploration missions have moved toward this goal in a pragmatic way, initially creating a detailed understanding of the lunar surface and composition, and each subsequent iteration of the Chang’e lunar mission have further tested and mapped the lunar surface in order to achieve a proposed goal of building a robotic lunar base on the south pole of the Moon capable of exploiting lunar resources by 2030.³³²

The launch of the Chang’e-1 mission in 2007 produced the highest resolution lunar surface images ever made, surveyed the lunar soil for the helium-3, and determined the distribution of other potentially useful resources. The Chang’e-2 mission continued to produce even more detailed images of the lunar surface. In 2013, the Chang’e-3 mission conducted the first soft landing on the Moon in nearly 40 years, a feat last accomplished by the Soviet Union in 1976.³³³ Future missions for the Chang’e lunar probes, such as the Chang’e-5 scheduled for launch in 2020 and Chang’e-6 scheduled for the 2023–2024 timeframe, have the goal of returning lunar soil samples in order to better understand the composition of lunar regolith. The Chang’e-7 and 8 missions, with launch dates yet to be determined, will focus on more detailed surveys of the south polar region of the Moon and finding locations and quantities of water ice.³³⁴

After the announcement by NASA regarding the confirmation of lunar ice, reports in Chinese state media outlets highlighted the discovery, including commentary by experts in China’s space industry who pointed out the significance of lunar ice for China’s space industry. According to one report, Yang Yuguang, a researcher at the CASIC Second Research Institute and secretary of the International Astronautical Space Transportation Committee, stated that “oxygen is relatively easy to find on other planets in space, because many rocks are metal oxides, but finding hydrogen is much harder.” Yang goes on to say that hydrogen that is separated through electrolysis from lunar ice can be used to prepare high-efficiency rocket fuel, which greatly reduces the cost of space missions.³³⁵

In January 2019, the China Academy of Sciences (CAS) announced that Chinese and Russian scientists will work together in a two-year research project to explore water ice on the Moon. Vladimir Khmelyov, a professor at the Altai State Technical University in Russia, stated that an ultrasonic drilling project for lunar ice detection has won financing from Russia’s Fundamental Research Fund and China’s National Natural Science Fund. According to a press release on the CAS website describing the project, “The scientists will explore and develop the physical principles of the ultrasonic drilling of extraterrestrial surfaces to discover water and ice, including on the far side of the Moon and on Mars, which will help develop lunar and Martian research in the future.” The development and use of ultrasonic drilling will be critical to harvesting water ice because standard mechanical drilling devices create heat which evaporates the water.³³⁶

HELIUM-3

In addition to water resources on the Moon, China’s scientific exploration of the Moon has also centered on understanding the composition of the lunar surface and searching for other exploitable resources. Chinese analysis concludes that the Moon contains large amounts of 14 elements that could be useful to industry, including iron, titanium, uranium, thorium, and potassium. Chinese researchers are particularly interested in helium-3, a rare non-radioactive isotope of helium that could be used in a fusion reactor. Chinese analysts write that 100 tons of helium-3 could power all of the Earth’s energy needs for one year and estimate there are 1 million to 5 million tons of helium-3 on the Moon.³³⁷

During the 2015 Chang’e-3 lunar rover mission, Chinese scientists for the first time used data gathered from the rover to estimate a measurement of lunar regolith in order to estimate possible helium-3 deposits. The January

2019 soft landing of the robotic lunar rover Chang'e-4 on the Von Kármán Crater furthered China's exploration goals for identifying helium-3 deposits on the surface of the Moon. According to an article in the state-run publication of the China Meteorological Association, one of the goals of the Chang'e-4 mission was to accurately measure the thickness of lunar soil in order to better estimate the amount of helium-3 deposits.³³⁸

Yet mining helium-3 is a controversial proposal. Western experts point out several fundamental problems with the concept. Sustainable cold fusion, the type of power generation helium-3 would fuel, has not been invented yet.³³⁹ In addition, the technological hurdles that need to be overcome to mine the Moon are substantial in terms of complexity and cost. Some Chinese analysts acknowledge the technical difficulties of extracting helium-3 from lunar rocks and the high cost of returning large amounts of lunar soil to be processed,³⁴⁰ however, at an estimated value of \$4 billion to \$10 billion per ton,³⁴¹ they also conclude that the revenue derived from mining helium-3 could make Moon mining economically viable while simultaneously solving China's energy needs.³⁴²

SPACE-BASED SOLAR POWER

China is seeking to become a global leader in space solar technology and the first nation in the world to build a solar power station in space. Chinese space analysts believe the first tests to make this a reality could be 10 to 15 years away and that by 2050, China could have a functioning commercial SBSP station.³⁴³ Articles in Chinese media liken the building of a SBSP to a "Manhattan Project for the space and energy sector,"³⁴⁴ since the technology could revolutionize the energy industry and become a major strategic advantage for the nation that succeeds first. Wang Xiji, an academic from the Chinese Academy of Sciences (CAS) and a member of the International Academy of Astronautics, states: "Whoever obtains the technology [for SBSP] first could occupy the future energy market. So it's of great strategic significance."³⁴⁵

Articles in the Chinese media describe solar power beamed from space as a clean energy source to deal with energy shortages in heavily populated urban areas that could also be beamed to remote locations which currently do not have power plants. SBSP could have significant military application as well, in powering remote forward operating bases or other military facilities where the cost of bringing in fuel for generators is high. Solar power generation, including SBSP, is identified by Chinese military analysts as a viable source for battlefield energy needs.³⁴⁶ An article in the *People's Daily* quoted Xie Xin, the vice president of the Chongqing military-civil fusion and Innovation Research Institute, discussing work that will be done at the SBSP experimental base in Chongqing, indicating the likelihood that China is also exploring SBSP for military applications.³⁴⁷

The idea behind space-based solar power is not new. Originally conceived as science fiction in the 1940s, the idea of transmitting solar-collected energy from space was later introduced as a serious scientific concept in a NASA-funded proposal during the 1970s. The project was shelved by subsequent U.S. administrations due to significant cost and technological barriers, and was not given serious thought again until the late 1990s under the Clinton administration. In 1999, NASA's solar power exploratory research and technology program received a federal grant to study the issue of SBSP, but the research project was again dropped by NASA due to cost.³⁴⁸

Building an SBSP station involves launching satellites potentially as long as a kilometer containing a solar panel array, or conducting a series of rocket launches with multiple components to be assembled in space to create a station, typically orbiting in GEO. Once a station is assembled, the energy collected from the sun is converted into electromagnetic waves and transmitted back to earth to a receiving station using either microwave or laser electromagnetic wave frequencies. Each stage of this process has technical challenges that critics believe make SBSP economically unrealistic.

Both laser and microwave transmission, for example, have issues that have been stumbling blocks for the advancement of SBSP. Although lasers use a highly focused beam that is only a few meters wide and requires

only a small receiver on the ground, they cannot be effectively transmitted through cloud cover or rain. There are also safety concerns for objects in space and people on the ground moving through the path of a laser beam.³⁴⁹ Microwave transmission, with its longer particle wavelength, can easily pass through cloud cover but requires a receiver the size of several football fields, making construction and maintenance difficult and costly.

Another significant hurdle for SBSP has been the cost. Launch costs, combined with the efficiency losses of the energy conversions and the building of massive receiving stations on Earth has made SBSP financially unrealistic. According to John Mankins, president of aerospace technology firm Artemis Innovation Management Solutions, the cost of building and operating SBSP systems historically has been the biggest barrier to making it a reality. Mankins states, “In 1981, a major review conducted by the federal government concluded that it would have cost up to \$1 trillion in today’s dollars to deliver the first kilowatt/hour of solar from space, effectively killing the whole program in the United States.”³⁵⁰ A prominent critic of SBSP, Olivier L de Weck, professor of aeronautics, astronautics and engineering systems at the Massachusetts Institute of Technology, stated that “the energy we need to put in to launch the mass required for the SBSP station is so enormous that we may never recoup it.”³⁵¹

With advancements in robotics technology, cheaper heavy lift revolutionized through the commercial space industry, and advancements in material design leading to much lighter and durable components, SBSP may become more economically viable. Instead of sending a giant SBSP station on one rocket, a series of smaller, lighter rockets could be sent up with components to be assembled in space using robotics.

In addition, the components for lasers and solar panels are getting smaller, lighter, and cheaper to send into orbit. Lawrence Livermore National Laboratory (LLNL) is designing a relatively small SBSP laser with an aperture of only about two meters in diameter. This laser beam design weighs about 10 metric tons, a fraction of the weight of a microwave design. LLNL researchers estimate a cost of \$500 million to create and deploy the system into space using a Falcon 9 rocket.³⁵² Artemis Innovation Management Solutions has designed a microwave that would use a smaller receiving aperture on Earth and smaller parts.³⁵³ This approach also has significant drawbacks, however, including the robotic assembly of hundreds of thousands of components in GEO.³⁵⁴

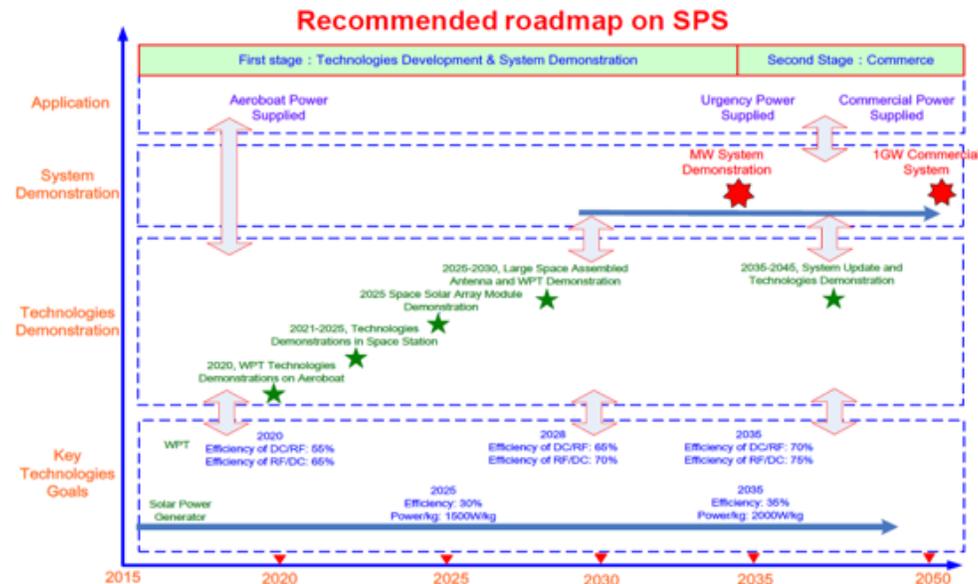
Currently NASA does not have a SBSP mission,³⁵⁵ while the space agencies of Japan, the European Union, and India are exploring SBSP. China is also advancing its own SBSP research. According to Li Ming, the director of the China Academy of Space Technology’s (CAST) Science and Technology Committee, “If we can maintain and further increase research and development (R&D) efforts, China is expected to become the first country in the world to build a space solar power station with practical value.”³⁵⁶

In 2006, CAST, China’s largest satellite manufacturer, held its first forum to examine the feasibility of SBSP. Two years later, in 2008 Beijing included R&D of space solar power plants into its national-level research plans.³⁵⁷ By 2014, CAST’s Qian Xuesen Laboratory had become a leader in SBSP technology in China, holding forums across the country and leading SBSP research projects.³⁵⁸



Conceptual image of space-based solar power:
Source: Spacelegalissues.com

Figure 8. Proposed timeline for China's development of SPS



Source: Promotional materials for 2nd Space Solar Power Satellite (SSPS) Workshop 2019 Seoul, Korea

Discussing China's ambitions to become a global leader in SBSP, Wang Li, a researcher at CASC, stated that dozens of research institutes, universities, and enterprises in China are researching key technologies such as space ultra-high voltage power transmission, high-efficiency wireless energy transmission, and super-large spatial structure on-orbit assembly. This research is intended to enable China to build a megawatt-scale space solar power plant in 2030 and the ability to build a gigawatt commercial space solar power plant by 2050.³⁶¹ Several PRC government institutes have since identified research plans for supporting the goals of achieving SBSP, including the following:

- The China National Space Administration (CNSA) will support SPS system technology research from 2016 to 2020.
- The National Natural Science Foundation of China (NSFC) will support fundamental research on large-scale space structures and control from 2017 to 2020.
- The Ministry of Science and Technology of the PRC will support research on wireless power transmission and its application from 2019 to 2022.³⁶²

ASTEROID MINING

At the farthest end of the near-term feasibility spectrum—and the space resource least likely to be exploited by China or any other spacefaring nation within the next 20 years—is mining precious metals from an asteroid.

The premise sounds enticing: identifying and locating asteroids with high concentrations of valuable minerals, metals, and water that could be extracted and brought back to Earth, or even returning an entire asteroid to Earth to harvest the minerals. Asteroids have the potential to contain an almost incomprehensible amount of wealth. According to one article, "The most valuable known asteroid is estimated to be worth \$15 quintillion."³⁶³ The technical capability and financial investments needed to even begin achieving the goal of bringing back metals from asteroids, however, is still at least 20 years away, according to space experts.³⁶⁴

Mining asteroids for natural resources is theoretical at present. According to one expert interviewed for this report, “The technology needed to mine asteroids is not in the realm of science fiction, but more in the realm of economic fiction.”³⁶⁵ A similar perspective on the economic viability of asteroid mining is offered by Yang Yuguang, a researcher at the Second Academy of China Aerospace Science and Industry Corporation, “I don’t believe the demand [for metals mined from asteroids] is there yet.” Yang goes on to state, “There are no elements or minerals that can’t be found on Earth. Even the rare minerals on the planet are definitely much cheaper to mine than on asteroids.”³⁶⁶

Buttressing these arguments, U.S. commercial asteroid mining efforts have experienced difficulties. The first asteroid mining company, U.S.-based Planetary Resources, was founded in 2012 but was acquired and disbanded by Blockchain developer Consensus in 2018.³⁶⁷

Another space mining company, Deep Space Industries, also founded in 2012, was acquired in 2019 by Bradford Space.³⁶⁸ Neither Consensus nor Bradford Space are pursuing space mining.

NASA is planning or conducting two asteroid exploration missions. NASA is currently conducting the Osiris Rex mission to explore the asteroid Bennu. The mission’s ultimate goal is to take a sample of the asteroid for return to the Earth in 2020.³⁶⁹ NASA also plans to send a robotic mission in July 2022 to explore the metallic asteroid known as 16 Psyche.³⁷⁰ The asteroid is thought to be comprised mostly of metallic iron and nickel and is estimated by some to be worth up to \$10,000 quadrillion—for comparison, the entire global economy is worth \$74 trillion.³⁷¹

China is also looking at the possibility of mining asteroids. The 2016 space white paper outlines China’s intent to find and explore asteroids, identifying that China will conduct further studies and key technological research on asteroid exploration.³⁷² According to CASC’s “Aerospace Transportation System Development Roadmap, 2017–2045,” by 2045 China envisions to have developed the sophisticated heavy lift rockets and robotic rover technology necessary to explore asteroids and comets within the solar system on a regular basis by 2045.³⁷³

Chinese researchers have also proposed an idea for capturing a small near-Earth asteroid and bringing it back to Earth. According to Li Mingtao, a researcher at the National Space Science Center at the Chinese Academy of Sciences, the idea of returning an asteroid to Earth by redirecting its orbit “sounds like science-fiction, but I believe it can be realized.”³⁷⁴ Li and his team were awarded a grant by the CAST to study the return of an asteroid to Earth. Li is currently working with space engineers at CASC’s Qian Xuesen Laboratory of Space Technology to design a satellite constellation to first locate and identify suitable asteroids with a diameter of around 10 meters for study, with the eventual goal of capturing it and then shifting its orbit to return to Earth.³⁷⁵

According to an announcement by the Chinese Academy of Sciences in May 2019, China has plans to explore an asteroid and a comet by 2025. According to Huang Jiangchuan, a researcher from CAST and chief designer of the Chang’e-2 probe, “China’s asteroid probe is expected to be launched before 2025.” Huang goes on to say that this type of exploration “could help us prevent a threat from [asteroids] to the earth, as well as exploit their resources.”³⁷⁶

CHAPTER 5: MAKING CHINA STRONG: CHINESE VIEWS ON MILITARY SPACE

Making China strong is the third rationale for China's space program. Space plays a central role in China's plans to project power far from its shores and in its abilities to defeat high-tech adversaries, such as the U.S. military. China's military has designated outer space as a warfighting domain—described as a “new commanding height of war”—that China must fight for and seize if it is to win future wars. PLA officers and analysts assert that space is the ultimate high ground and that whoever controls space controls the Earth.³⁷⁷ These analysts describe space-based C4ISR systems as a critical part of a modern military sensor-to-shooter network.³⁷⁸ At the same time, Chinese military analysts regard space as a critical vulnerability that can debilitate an enemy if denied.³⁷⁹ To further integrate space into military operations, the PLA created the Strategic Support Force (SSF), an organization that is, in part, responsible for elements of the PLA's space program.

China depicts its own military space activities as promoting the peaceful use of space and publicly minimizes the military role its space program. China's 2019 defense white paper, for example, states that China's space program promotes the peaceful use of space by:

Actively participat[ing] in international space cooperation, develop[ing] relevant technologies and capabilities, advanc[ing] holistic management of space-based information resources, strengthen[ing] space situation awareness, safeguard[ing] space assets, and enhance[ing] the capacity to safely enter, exit and openly use outer space.

In keeping with this narrative, the white paper provides no specific information on the space, cyber, and electronic warfare roles and missions of the Strategic Support Force. The white paper merely states that the SSF is “a new type of combat force for safeguarding national security” that is involved in “supporting forces for battlefield environment, information, communications, information security, and new technology testing.”

In contrast to its depiction of its own military intentions in space, China depicts the United States as intent on making outer space a battlefield. The 2015 defense white paper warns that “countries concerned are developing their space forces and instruments, and the first signs of weaponization of outer space have appeared.” Similarly, the 2019 defense white paper declares that “international strategic competition is on the rise” and claims that the United States has “provoked and intensified competition among major countries” to such an extent that threats to outer space security are characterized as “looming large.” Consequently, the PLA is required to “safeguard China's security interests in outer space.”

Chinese views on military space are shaped by three factors: their perception of the importance of space to military operations, the PLA's concept of operations, and the PLA's perceptions of U.S. military space developments.

The importance of space to military operations

Space operations play a critical role in the PLA's ability to conduct anti-access/area denial (A2/AD) operations by enabling long-range precision strikes against land, air, and naval targets and in denying adversaries the use of their own space assets. In its 2015 defense white paper, *China's Military Strategy*, China for the first time officially designated outer space not just a military domain, but a critical military domain. According to the white paper, the PLA must be able to deal with “a wide variety of emergencies and military threats” and “prepare for military

struggle in all directions and domains.”³⁸⁰ As a result, the PLA is required to “safeguard China’s security and interests in new domains” and that “threats from such new security domains as outer space and cyber space will be dealt with to maintain the common security of the world community.”³⁸¹ As a result, “China will keep abreast of the dynamics of outer space, deal with security threats and challenges in that domain, and secure its space assets to serve its national economic and social development, and maintain outer space security.”³⁸²

Since the early 2000s, Chinese military writings have characterized space as the new high ground and concluded that without space superiority China would be at a disadvantage in all other domains.³⁸³ The authors of the 2013 *Study of Space Operations*, for example, predict that future wars will likely begin in outer space and that “achieving space superiority and cyber superiority are critical for achieving overall superiority and being victorious over an enemy.”³⁸⁴ They argue that China must prepare for an enemy to attack from all domains, including space, and identified outer space as one of five major military threats facing the PLA, along with nuclear, conventional, cyber, and nuclear-conventional threats and included space operations as one of nine “main operational activities” along with information operations, joint strike operations, air and missile defense, air and sea blockades, island seizure operations, area denial operations, border defense operations, and cyber operations.³⁸⁵

The authors conclude, “Whoever is the strongman of military space will be the ruler of the battlefield; whoever has the advantage of space has the power of the initiative; having ‘space’ support enables victory, lacking ‘space’ ensures defeat.”³⁸⁶ Consequently, the authors of *Study of Space Operations* assert that space warfare is inherently offensive in nature and that “active offense is the only method for achieving victory in war.”³⁸⁷

These assessments are based on PLA analysts’ assessments of U.S. military operations. Chinese writers continue to view space as essential to modern war and see the United States as heavily dependent upon space-based systems. According to Chinese sources, U.S. military operations since 1999 have relied on space for more than 70 percent of its communications needs, 80–95 percent of its intelligence collection needs, 100 percent of meteorological forecasting, and 90 percent of precision guidance for munitions.³⁸⁸

The reliance of the U.S. military on space is also viewed by PLA analysts as a critical vulnerability. Counterspace operations can deny, degrade, disable, or destroy an opposing side’s space capabilities. These can include attacks against both ground-based and space-based space assets through the use of kinetic and non-kinetic means.³⁸⁹ Articles in China’s military media on U.S. satellite capabilities highlight the U.S. military’s reliance on satellites for its military operations.³⁹⁰ One article from the *Winged Missiles Journal*, a monthly periodical from the China Aerospace Science and Industry Corporation (CASIC), described U.S. satellites as an “indispensable means for direct support of battlefield operations,” and that the United States would “lose its military advantage” if its satellites were destroyed.³⁹¹

Chinese concept of operations

A second factor driving Chinese perceptions of space is the Chinese military’s concept of operations and its characterization of modern war. The PLA characterizes modern war as “informatized local wars” that take information superiority—the ability to use information and deny its use to an adversary—as the key determiner of battlefield success.³⁹²

SYSTEM-VS.-SYSTEM OPERATIONS

A major component of the PLA’s modernization focus has been the development of networked C4ISR systems.³⁹³ The PLA has been guided by the U.S. concept of network-centric warfare, a concept first popularized in the late 1990s. Network-centric warfare involved translating an information advantage characterized by a shift in focus from platforms to networks, information sharing, and shared situational awareness into a warfighting

advantage characterized by knowledge of commander's intent, self-synchronization, and increased combat power.³⁹⁴ Network-centric warfare is intended to "enable a shift from attrition-style warfare to a much faster and more effective warfighting style" characterized by speed of command. The resulting increase in the speed of command is intended to foreclose enemy courses of action and disrupt the enemy's strategy.³⁹⁵

The PLA's adoption of network-centric principles is reflected in the concept of system-vs- systems (SvS) operations.³⁹⁶ Similar to network-centric warfare, SvS operations are intended to "accelerate operational response times to enhance firepower and maneuver, particularly by shortening and streamlining decision-making and sensor-to-shooter times to get inside an opponent's decision cycle." Units participating in SvS operations "operate with greater independence in dispersed deployment in a nonlinear battlespace, yet synchronize operations within a centralized command structure with some allowance for initiative."³⁹⁷

Chinese analysts portray space as a critical component of SvS operations due to the ability of space technologies to better enable ground, air, and naval operations and the necessity to deny other countries the use of space. A robust, space-based C4ISR system is often described as a critical component of a future networked PLA.³⁹⁸ For example, a PLA Navy Senior Captain writes that "modern joint campaigns are inseparable from space information systems support; whoever controls space has space information supremacy, and thus has the initiative in war."³⁹⁹

The need to develop space-based C4ISR systems is based on the requirement to develop power-projection and precision-strike capabilities. The development of long-range cruise missiles and ballistic missiles for over-the-horizon attacks against land and naval targets requires the ability to locate, track, and target enemy installations and ships hundreds of kilometers away from China's shores, as well as the ability to coordinate these operations with units from multiple services. In doing so, remote sensing satellites can provide intelligence on the disposition of enemy forces, provide strategic intelligence before a conflict begins, and help provide post-strike battle damage assessments. Communication satellites can provide global connectivity and can facilitate communications between far-flung forces. Navigation and positioning satellites can provide critical information on location and can improve the accuracy of strikes. These capabilities will also better integrate disparate services into a joint force by allowing one service to better support other services through better communications and by helping integrate intelligence functions through a shared battlefield picture.

Information is not just to be collected and utilized, however, but also to be denied to an adversary. PLA writings on information warfare emphasize striking first. According to PLA sources, the decisive nature of information and the faster operational tempo brought about by its use will lead to "the first battle being the decisive battle" and "a single battle determining the outcome" of a war.⁴⁰⁰ As a result, PLA writings state that the Chinese military should attempt to achieve information superiority at the outbreak of a conflict and before operations in other physical domains.⁴⁰¹ Gaining information superiority at a conflict's outset should enable successful joint operations during the rest of the conflict, while the lack of information superiority could jeopardize victory.⁴⁰²

Chinese perceptions of U.S. military space developments

The third factor influencing Chinese perceptions of military space is the view that the United States is trying to dominate space. PLA analysis of the U.S. military's intentions in space focus on the proposal and eventual establishment of the U.S. military's Space Force, the development of space technologies by the U.S. military, and the publication of U.S. military doctrinal and strategic writings that have been perceived as evidence that the United States is determined to develop offensive counterspace capabilities. According to the PRC Ministry of Defense, "It is known to all that the U.S., in pursuit of space hegemony, has formed the Space Force, spent enormous amounts of money on enhancing space combat readiness and unilaterally initiated an arms race in the space."⁴⁰³

CHINESE VIEWS ON THE ESTABLISHMENT OF A U.S. SPACE FORCE

On December 20, 2019, President Trump officially signed the Space Force into law. PRC government and media reactions to the proposal to create the Space Force and its eventual establishment have been overwhelmingly negative, arguing that the United States is “cooking up” threats to militarize a peaceful domain, an effort that threatens peace and will likely lead to an arms race.

An MND spokesperson stated that the establishment of the U.S. Space Force “will only intensify militarization and arms race in the space, and greatly undermine peace, security and global strategic stability.”⁴⁰⁴ The Chinese Foreign Ministry stated that “such moves seriously violate the international consensus on the peaceful use of outer space, undermine the global strategic balance and stability, and pose a direct threat to peace and security of outer space.”⁴⁰⁵

In previous statements before the founding of the Space Force, an MND spokesperson argued that “outer space is the common property of human kind” and that China is “opposed to the use of force or threat of the use of force in outer space.”⁴⁰⁶ The PRC MFA echoed this sentiment, contrasting China’s belief that space belongs to “all mankind” with the U.S. view of space as a “new war-fighting domain.”⁴⁰⁷

Reporting in PRC media frequently argued that the United States is exaggerating the space threat posed by China and Russia in order to justify the establishment of the Space Force.⁴⁰⁸ A report from *China Daily* described China as a “latecomer” to space that “still lags far behind” the United States in space technology and that it is both “ridiculous” and “ill-intentioned” to depict China as a “rapidly growing space threat.” The report continued by arguing that these beliefs are a “pretext for hawks in the U.S.” used to “seek military expansion into space.”⁴⁰⁹ This notion was also reflected in official PRC responses to the Space Force. For example, an MFA spokesperson contended that the United States is “cooking up” threats from China in outer space in order to “pursue unilateral military advantage and develop advanced weapons.”⁴¹⁰

PRC media also frequently portrayed the establishment of a Space Force as out of step with international efforts to keep space peaceful.⁴¹¹ For example, China’s official English language newspaper, *China Daily*, argued that the “professed zeal” of the United States to turn space into a “potential war front” deals a “heavy blow” to decades of international efforts to keep space peaceful.⁴¹² Another report from *People’s Daily* contended that despite being a signatory to an international treaty that bans the militarization of space (a possible reference to the Outer Space Treaty), the United States is “hell-bent on trying to dominate all domains,” a goal the report describes as a “threat to world peace.”⁴¹³

PRC media reports also highlighted efforts by China to prevent the weaponization of space and portrayed U.S. actions as leading to an unwanted arms race in space.⁴¹⁴ A report on China’s state-owned *CGTN* cited remarks from MFA spokesperson Lu Kang, arguing that the United States has “thwarted” Chinese and Russian attempts to create a treaty preventing an arms race in space.⁴¹⁵ Another report from *China Daily* described the Space Force as “morally unacceptable” and “counterproductive,” contending that it will lead to an arms race that other powers will use to justify their own “space military projection.”⁴¹⁶

Other reports in PRC media emphasized that the establishment of the Space Force was not unanimously accepted across the U.S. government, frequently arguing that it faces both administrative and budget obstacles.⁴¹⁷ *China Daily* argued that former Secretary of Defense Mattis “openly opposed” the establishment of a space force on budgetary grounds.⁴¹⁸ *People’s Daily* contended that the U.S. Air Force would be the “largest resistance” to the Space Force, as its establishment would “strip a portion” of the U.S. Air Force’s budget.⁴¹⁹ In spite of this debate, a report from *Beijing Daily*, the official newspaper Beijing Municipal Committee, argued that “Cold War thinking,



Seal of the U.S. Space Force

great power politics, and national chauvinism” would ensure that this opposition would not lead the United States to “easily abandon” plans for a Space Force.⁴²⁰

PRC portrayals of U.S. space technologies

PRC descriptions of U.S. counterspace capabilities closely follow the narrative that the United States is the main force in the weaponization of space, while China continues to advocate for its peaceful use. PRC writings underscored that the United States is creating an arms race in its efforts to develop its space military capabilities, including offensive space-based weapons.⁴²¹ A report from the state-run China News Service cited Fan Gaoyue, a researcher with the Chinese Academy of Military Sciences, in asserting that the space arms race is being “driven by the U.S.” The report then argued that the United States “has spared no efforts” in its development of space weapons in order to increase its “overall space defense and attack capacity.”⁴²² Following a familiar narrative, PRC journal articles and media reports on U.S. offensive capabilities contended that the United States is exaggerating claims of Chinese space capabilities in order to justify its development of space weapons.⁴²³ Professor Zhou Derong of the PLA Logistics Academy argued that if China were developing ASAT weapons, they would be “no more than self-defense measures,” and that the United States is depicting itself as a “victim” to “provide an excuse for the development of its own space forces.”⁴²⁴

These themes not only appear in PRC discussion of U.S. counterspace capabilities in general, but also in PRC media and journal article descriptions of U.S. space-related technologies that they describe as having counterspace applications.

X-37B ORBITAL TEST VEHICLE

The X-37B Orbital Test Vehicle is a U.S. Air Force unmanned spacecraft that has been operational since 2010. Much is unknown about the X-37B. According to a U.S. Air Force fact sheet, the X-37B’s primary objectives are “reusable spacecraft technologies for America’s future in space and operating experiments which can be returned to, and examined, on Earth.”⁴²⁵ PRC depictions of the X-37B frequently emphasized its potential offensive counterspace applications.⁴²⁶ An article in *Aerospace Electronic Warfare*, a



X-37B

bimonthly periodical affiliated with CASIC, labelled the X-37B a “space fighter” that “can carry various weapons, or capture a satellite with its mechanical manipulators.”⁴²⁷ Another report from the official People’s Daily described the vehicle as a “multipurpose space fighter” that “can break through any ground defense systems within one to two hours and deliver precision strikes from space at ground, sea, and air targets.”⁴²⁸

PRC writings on the X-37B highlighted the potential military application and secretive nature of the vehicle to portray it as both a serious international concern and a direct threat to China and the world.⁴²⁹ A report from the *PLA Daily* argued that the “secretive attitude” of the X-37B test flights “increased the concern of the international community,” which was “full of concerns about the actual capability and future impact” of the vehicle.⁴³⁰ The CASIC-sponsored *Military Digest* described the spacecraft as a “weapon without rival” and emphasized that the X-37B’s can “strike any location on earth within two hours.” The article also argued that even though the vehicle is not yet commonplace technology, the “psychological edge” it gives to the United States “could make it difficult for other nations to sleep or eat in peace.”⁴³¹

OPERATION BURNT FROST

In 2008, one year after China shot down one of its own satellites, the U.S. Navy fired a Standard Missile-3 from USS *Lake Erie* to destroy an errant U.S. satellite in order to destroy the satellite's toxic hydrazine propellant before it crashed to Earth. In response to criticism from the PRC government, Air Force General Kevin Chilton, then commander of U.S. Strategic Command, stated that unlike the 2007 Chinese operation, Burnt Frost was carried out with "full transparency," and that countries around the world were notified of the strike.⁴³²

PRC media reporting portrayed Operation Burnt Frost as a test of U.S. ASAT capabilities that threatened the peaceful use of space.⁴³³ *China Daily* described the operation as a "thinly disguised" test of U.S. ASAT capabilities that could "take out" other countries' "orbiting communications and spy spacecraft." Hong Yuan, then secretary general of the Arms Control and Proliferation Prevention Center of the Chinese Academy of Social Sciences, contended that the operation proves the United States has the ability to "blockade outer space and has officially begun the process of weaponizing outer space." Hong Yuan continued by arguing that the operation will lead other nations to join the United States in an "uncertain and largely irregular new period of strategic weapons contest."⁴³⁴



SM-3

XSS-11

In April 2005 the U.S. Air Force launched the XSS-11 rendezvous spacecraft to perform "up-close inspections of inactive satellites and spent rocket stages" in order "to pave the way for making on-orbit inspections for diagnostic purposes."⁴³⁵ PRC media reports depicted the XSS-11 as another indicator of the U.S. intention to weaponize space.⁴³⁶ For example, *People's Daily* argued in two separate reports that the U.S. views the weaponization of space as "unavoidable," and that the successful test of the XSS-11 proves that the United States now has the capability to "disrupt and attack other countries' satellites."⁴³⁷



XSS-11

GEOSYNCHRONOUS SPACE SITUATIONAL AWARENESS PROGRAM

Geosynchronous Space Situational Awareness Program (GSSAP) satellites operate in the Earth's geosynchronous orbit as part of U.S. Strategic Command's Space Surveillance Network. The satellites are able "to collect space situational awareness data allowing for more accurate tracking and characterization of man-made orbiting objects" and are also capable of operating "near a resident space object of interest, enabling characterization for anomaly resolution and enhanced surveillance."⁴³⁸

PRC reporting on the GSSAP emphasized the surveillance capabilities of the program's satellites, especially their ability to monitor the satellites of other countries.⁴³⁹ China's official news agency, *Xinhua*, argued that the U.S. is already "substantially ahead" in space military technology, but it is still increasing its deployments. *Xinhua* highlighted the 2014 launch of two GSSAP satellites, along with comments by the head of the U.S. Air Force Space Command stating that the satellites will monitor the "nefarious capability other nations might try to place in that critical orbital regime."⁴⁴⁰ Another report from the Shanghai-based publication *The Paper* cited language from

the Pentagon's 2011 *National Space Security Strategy* that the United States will increase its intelligence capabilities, and argued that the United States will use its space situational awareness capabilities as a means to both lead and restrict other countries in space.⁴⁴¹

PRC PORTRAYALS OF U.S. MILITARY SPACE PUBLICATIONS

Although Chinese sources portray U.S. technology developments as practical demonstrations of the U.S. commitment to space weaponization, they also describe U.S. publications going back decades as developing the doctrinal basis for space war.

The foundational source for U.S. space warfare planners, according to numerous Chinese sources, is *High Frontier: A New National Strategy*, a 1981 report by the Heritage Foundation. The report's purpose was to promote missile defense, but it also addressed the strategic importance of space, including the exploitation of space for economic gain. Many Chinese analysts describe *High Frontier* as the U.S. strategy to achieve space supremacy and control space.⁴⁴² According to one source:

*After the Cold War, even though the United States no longer frequently uses the “high frontier” strategy, the essence of the strategy continues and it is to a great extent proposing a new “high frontier” strategy. It is bent on deploying missile defense systems and its lasting goal is achieving space supremacy. The U.S. “high frontier” strategy in the new century reduces the security environment on China’s periphery and seriously hinders China’s efforts at unification.*⁴⁴³

Chinese sources also point to other publications as signaling the U.S. intent to weaponize space. For example, *Joint Vision 2010*, published by the U.S. Joint Chiefs of Staff in 1996, provided a concept for the fusion of C4ISR capabilities, and many Chinese articles referencing this publication concern C4ISR systems development. Chinese authors, however, also assessed that the document's call for “full spectrum dominance” included space superiority and that the United States was intent on developing a space force.⁴⁴⁴

Chinese sources have also assessed the 1996 U.S. Air Force document, *Global Engagement: A Vision of the 21st Century Air Force*, which stated that the U.S. Air Force was “transitioning from an *air and space force* on an evolutionary path to a *space and air force*.”⁴⁴⁵ One Chinese analyst stated that *Global Engagement* was the first time that the United States officially declared an intention to establish a space force.⁴⁴⁶ Articles reviewing the U.S. Space Command's 1997 *Vision 2020* note that the report states the U.S. military “is very dependent on space capability today and will be even more dependent on space capability by 2020”⁴⁴⁷ and that the document advocated controlling space.⁴⁴⁸ Another analyst wrote that *Vision 2020* concluded that space will become a method for countries to become militarily and economically strong.⁴⁴⁹ According to one Hong Kong academic, “The U.S. is the leader in the militarization of space. It was the first country that established a dedicated command, the U.S. Space Command, to unify military operations in space. In fact, as its *Vision for 2020* proclaims, the Space Command sought to achieve “full spectrum dominance” in space.”⁴⁵⁰ The authors of the *Study of Space Operations* also note that the taxonomy of space operations provided by the USAF's *AFDD-1 Air Force Basic Doctrine and AFDD-2 Operations and Organization* includes references to space control missions.⁴⁵¹

PRC PORTRAYALS OF SCHRIEVER WARGAMES

The Schriever Wargame is a series of space war games first conducted in 2001.⁴⁵² That first war game was viewed by Chinese sources as concerning China in that it involved a large, space-capable “near-peer” country that massed its forces near the border of a neighboring nation.⁴⁵³ According to a 2005 Chinese article, the Schriever

series of war games demonstrates that “space warfare is not far away” and concluded that China “must develop a new national security concept that places space security within national security strategy.”⁴⁵⁴ Other authors asserted that the Schriever Wargames illustrate the U.S. willingness to develop space weapons and that China must prepare for an arms race in space.⁴⁵⁵ Other Chinese sources view the Schriever Wargames as a deterrence measure by the United States taken to try to prevent China from developing its own space weapons.⁴⁵⁶

The 2018 iteration of the war game played out a scenario in which a hypothetical competitor attempted to exploit cyberspace and space to accomplish strategic objectives in the Indo Pacific. The objective of the exercise was to examine the use of space and cyberspace in a combat scenario, and to explore various means of deterring adversaries from pushing conflict into space.⁴⁵⁷ PRC reporting on the Schriever Wargame used the event to illustrate that future conflicts will inevitably involve space, and that the United States is testing its capabilities for such a conflict.⁴⁵⁸ Mu Xiaoming of the PLA’s Xi’an Political College argued that the United States is the biggest investor in military space and described the United States as “having almost all of the technologies for attacking targets in space.” He contended that the United States holds the Schriever Wargames in order to “inspect and verify the effectiveness of its space combat plans and weapons systems.”⁴⁵⁹ Commenting on Schriever 2012, Xia Yu, deputy director of the Beijing Institute of Space Science and Technology Information, remarked that “space is no longer tranquil, and future competition for superiority and battle for strength will become even more intense.”⁴⁶⁰

Chinese academic writings also portrayed the Schriever Wargames as a reflection of the United States’ changing use of space, and its evolving offensive capabilities. For example, a 2017 article published in the journal *Aerodynamic Missile Journal* claimed that a study of the Schriever Wargame allows for a better understanding of developments in U.S. space warfare and space technologies. The authors argued that earlier developments of U.S. space forces were mainly in using space as a means to support combat capabilities in other domains, while an increase in the ability to control space has led the U.S. military to increase the tactical use of space, including prompt global strike. In addition, the article claimed that the U.S. military’s application of its space forces has a “hegemonic hue,” and that the Schriever Wargame is not only conducting space defense, but also a means for the United States to gain the initiative in space. The authors argued that this shift in the exercise illustrates the offensive nature of the U.S. military’s space strategy.⁴⁶¹

CHINA AND SPACE ARMS CONTROL

China’s narrative stressing the peaceful uses of space while condemning U.S. actions as militaristic is also evident in China’s stance on space arms control. China stresses that it “always adheres to the principle of the peaceful use of outer space and opposes the weaponization of space and an arms race in space and guarantees that its space activities benefit the whole of mankind.” China maintains that “outer space is common heritage of all mankind, and the benefits of space development should be enjoyed by all,” and that “for any country, to maximize the military and security value of outer space, or even seek to place weapons there, would yield no benefit to the security of its own or the world.”⁴⁶²

Before China’s 2007 ASAT test, PRC policy was widely regarded as unconditionally opposed to all types of ASAT weapons. According to China’s 2005 white paper on arms control and disarmament: “Taking weapons into outer space will lead to an arms race there and make it a new arena for military confrontation. Such a prospect is not in the interest of any country.” The white paper noted that “China has all along stood for peaceful use of outer space” and that “the existing international legal instruments on outer space cannot effectively prevent weaponization of and an arms race in outer space.” The white paper also urged the international community to “take effective preventive measures, negotiate and conclude relevant international legal instrument to prohibit

deployment of weapons in outer space and the threat or use of force against objects in outer space so as to ensure that outer space is used purely for peaceful purposes.”⁴⁶³

China has continued to maintain this stance since the 2007 ASAT test and has jointly, with Russia, proposed draft treaty language on space arms control at the UN Conference on Disarmament. Despite this effort, China and Russia have opposed a space code of conduct proposed by the European Union that would establish non-binding guidelines for space activities, including those related to offensive counterspace activities.

DRAFT TREATY LANGUAGE ON THE “PREVENTION OF THE PLACEMENT OF WEAPONS IN OUTER SPACE, THE THREAT OR USE OF FORCE AGAINST OUTER SPACE OBJECTS”

In 2008 and 2014 China and Russia jointly presented draft treaty language on the “Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects” (PPWT). The 2014 draft treaty proposed that countries agree “not to place any weapons in outer space” and to “not resort to the threat or use of force against outer space objects of States Parties.”⁴⁶⁴

The United States has opposed both proposals and regards the effort by China and Russia as a restriction on U.S. space-based missile defense capabilities. Ambassador Robert Wood, the U.S. representative to the United Nations Conference on Disarmament, has called the draft proposal “fundamentally flawed.”⁴⁶⁵ The proposed treaty would neither prohibit the development, testing, and deployment of terrestrial-based counterspace weapons, such as the type of direct- ascent kinetic-kill vehicle used in China’s 2007 ASAT test, nor the research, development, and storage of space-based counterspace systems. The proposed treaty would not prohibit “use of force” or the “threat of force” against objects in space during armed conflict. It also lacks a verification mechanism. Importantly, the 2014 draft does not prohibit the use of counterspace capabilities in acts of “self-defense” in accordance with Article 51 of the United Nations Charter.⁴⁶⁶

CHINA’S POSITION ON A SPACE CODE OF CONDUCT

The lack of international agreement on the regulation of space weapons led the European Union to pursue a code of conduct for outer space activities (hereafter referred to as the “Code”) that was intended to act as a “non-legally binding, voluntary international instrument aimed at building norms of responsible behavior in space activities.”⁴⁶⁷ The Code was first introduced in 2008; the latest draft of the Code was released on March 31, 2014.⁴⁶⁸

The drafting of a proposed Code is based on the difficulty, if not impossibility, of reaching a legally binding treaty governing conduct in space, especially in regards to offensive counterspace activities. The intent of the Code’s drafters was to establish “rules of the road” that would guide signatory states in their space activities, but not legally bind them to constrain their actions in space. The Code seeks to enhance the “safety, security, and sustainability of outer space activities” through the establishment of transparency and confidence building measures.”⁴⁶⁹ Among its many provisions, the draft Code proposes that states should:⁴⁷⁰

- avoid harmful interference with outer space activities;
- promote the peaceful exploration and use of outer space;
- minimize the risk of accidents in space and collisions between space objects;
- refrain from any actions to damage or destroy space objects, unless in self-defense or to mitigate debris; and
- resolve to limit actions which may generate long-lived space debris.

China is opposed to the adoption of the Code and some regard China's (and Russia's) objections to the Codes' provisions as tactics to prevent the adoption of any form of restrictions on the military use of space, especially in regard to counterspace activities.⁴⁷¹ China and Russia view the United Nations as the appropriate venue for discussing international agreements limiting space activities, and both countries prefer their 2014 draft of the PPWT, discussed above, as an alternative to the Code. China and Russia have also stated that they would like to limit the Code's provisions to civil and commercial space activities. Interestingly, China and Russia also object to the reference in the Code to the right of self-defense, despite such a provision being included in their draft PPWT language. The two countries state that transparency and confidence-building measures, such as the Code, should not govern use of force provisions. China is also critical of the information-sharing provisions of the Code, especially in regards to military space activities.⁴⁷²

CHAPTER 6: CONCLUSIONS AND IMPLICATIONS

The Chinese leadership values space power. It better enables China to defend itself, influence international affairs, and develop its economy. It is one element of Xi Jinping’s drive to achieve the “national rejuvenation of the great Chinese people.” China’s space industry plans for China to become the world’s leading space power, surpassing the United States by mid-century.

China’s space narrative parallels its larger narrative of the U.S.-China relationship. Chinese sources portray the United States as a malevolent actor while depicting China as committed to peaceful solutions, economic development, and cooperation with all countries regardless of political system and level of economic development. Similarly, China portrays space as the heritage of all humankind and its space program as committed to the peaceful use of outer space. China states that it is open to cooperation with all UN-member states and is working to provide the benefits of space to the world community, especially developing countries. At the same time, China publicly minimizes the military role of its space program and officially states that it eschews space weapons.

China portrays the United States as the leading space power with a strong legacy of innovativeness and success. It explicitly portrays the United States as trying to restrict China’s access to space, weaponizing space with the establishment of a space force, and the development of counterspace weapons and a space warfighting doctrine. It implicitly portrays the United States as less open to international space cooperation, especially with developing countries, and less committed to bringing the benefits of space to the broader international community.

The dynamic between the United States and China in space reflects the overall strategic competition that characterizes the relationship. The United States and China are in a long-term competition, in which China is attempting to become a global power—in part through the use of space. China’s primary motivation for developing space technologies is national security. However, as China’s space program advances, its commercial and scientific activities will become more prominent and will extend the competition to encompass economics and diplomacy, challenging U.S. leadership in space just as China challenges the United States across the full range of diplomatic, military, and economic power. In this respect, China’s space program is one element of its efforts to transition the current U.S.-dominated international system to a multipolar world.

To date, China’s success in space can be attributed, in large part, to top-level leadership recognition of the benefits of space power, consistent planning, and stable and ample funding. US. success in competing with China will need to rely on the same fundamentals.

China intends to surpass the United States as the leading space power

Chinese space industry officials depict their country as a major space power behind Russia and the United States. These space industry officials state that China intends to surpass Russia as a leading space power by 2030 and replace the United States as the leading space power by 2045.

By 2030, China plans to have a broad range of space capabilities:

- A complete line of light, medium, and heavy lift launch vehicles using solid and liquid fuel rocket engines, potentially including reusable launch vehicles

- A ground-space information network intended to integrate the collection, transmittal, and processing of information derived from global space-based remote sensing, navigation, and communication systems
- An ability to conduct in-orbit servicing and maintenance of spacecraft
- A fully functioning long-term crewed space station
- A robust deep space exploration program consisting of the following:
 - Mars missions, possibly including a Mars sample return mission
 - An asteroid probe
 - A Jupiter probe
- A counterspace architecture consisting of cyber, electronic warfare, kinetic kill, directed energy, and co-orbital capabilities

The primary motivation for China's space program is national security

China's space program since its inception in the 1950s has been focused on protecting China's national security. Space is characterized as an essential component of modern warfare that plays a role in meeting many of its national security needs. Its C4ISR components provide critical capabilities necessary to fight "informatized local wars," and its counterspace components threaten the ability of adversaries to conduct space operations. China's plans to build a global, 24-hour, all-weather remote sensing system and a global satellite navigation system by 2020; an integrated space-ground information network by 2030; and a counterspace architecture designed to threaten an adversary's space capabilities from the ground to geosynchronous orbit also reflect this emphasis on national security.

As China's space capabilities improve and as China's space program expands to include more missions beyond LEO, China's space program is transitioning to better provide economic and scientific benefits. As a result, economic, commercial, and scientific motivations for China's space program will figure more prominently, even as national security remains the primary motivation.

China's space proponents envision an expansive role for China's space program

China's space proponents come from industry, the military, government organizations, and academia. Most fall into what the U.S.-based Aerospace Corporation has called the "Galactic Battle Fleet" school of space power focusing "on scenarios requiring yet-to-be developed technology and applications."⁴⁷³

This school of thought is best expressed by Lt. General Zhang Yulin, the deputy director of the CMC Equipment Development Department, who foresees China developing an enduring cislunar presence to industrialize the extraction of space resources. Zhang and others envision a space program that by mid-century exploits cislunar space through space-based remote sensing, navigation, and communications capabilities; a human presence in space through the operation of a space station and human exploration of the Moon; and natural resource extraction through asteroid and Moon mining and space-based solar power.

It is unknown to what extent China's top leadership has accepted this vision of space, however. Research for this report found no evidence that the Chinese government has officially approved many aspects of this expansive vision for space natural resource extraction as well as the "Roadmaps" issued by CASC and CALT that outline space industry plans for technology development to 2045. For example, the megaproject and mega-engineering projects discussed in the 13th FYP and scheduled for completion by 2030 do not include a majority of the projects listed in these Roadmaps.

It is possible that statements by personnel involved in China's space program as well as the goals set forth in industry "Roadmaps" are vision statements that do not reflect approved goals. Statements by Lt. General Zhang

on cislunar space, for example, are reported in English-language sources as official statements, whereas Chinese-language reporting presents them as personal opinions.⁴⁷⁴

Such statements could also be lobbying efforts. The 14th Five-Year Plan will begin in 2021, and the run up to any new five-year plan involves debates over which projects will be funded. This process will necessarily result in winners and losers, with some projects being funded and others not. Public discussions of expansive plans to exploit the economic benefits of cislunar space and claims of an \$11 trillion dollar cislunar market could be examples of attempts by China's space enterprise to advocate a maximalist approach to China's space program through the over-hyping of its purported benefits.

Discussions of many of these programs in Chinese sources, such as human exploration of the Moon, Moon mining, and asteroid mining, may also indicate ongoing feasibility studies. Traditionally, proposed space missions undergo a long period of feasibility study before a formal decision is made. China's leadership would need to balance the assessed benefits of these proposals against the technological and economic capacity to support them. This is not unprecedented in the history of China's space program. Both the human spaceflight program and the lunar exploration program underwent a period of lobbying and feasibility studies before they were approved. This process took six years in the case of the human spaceflight program and 10 years in the case of the lunar exploration program.⁴⁷⁵

If the vision of an enduring cislunar presence is approved, China would need to devote significantly more financial and human resources to its space program. Many of these proposed projects, such as human exploration of the Moon, Moon and asteroid mining, and space-based solar power, are complex and costly. Moreover, the allocation of these resources would come at the same time that China's economic growth is slowing and its population aging, increasing the opportunity costs for the pursuit of expensive and risky projects.

Completing all of these projects concurrently by 2045 would be an immense undertaking for any country. All of the projects proposed in Chinese sources present technological challenges for China's space industry. In order to accomplish them, China would need to transition from its traditional role of being a "fast follower" by leveraging foreign experience and technology to become the world's technological leader across a broad swath of space technologies. In doing so, China would need to concurrently solve many technical challenges unprecedented in the history of spaceflight. It is uncertain to what extent China's space program can overcome these challenges, especially by mid-century. Table 5 lists many of these proposed projects.

Table 5. Space projects proposed in Chinese writings

	Projects	Final Approval?	Proposed timeline	Done before?
Launch	Super heavy lift launch vehicle	No	2030	U.S. Saturn V, 1967
	Partially reusable rocket launcher	Unknown	2030	SpaceX Falcon 9, 2015
	Fully reusable launch vehicle	Unknown		No
	Suborbital space tourism vehicle	Unknown		No
	Combined cycle launch vehicle	Unknown		No
Lunar exploration	Human lunar exploration	No	2031–2036	US Apollo program, 1969
	Moon mining	Unknown	2050	No
Asteroid exploration	Asteroid exploration	Yes	2030	Near Earth Asteroid Renedezvous- Shoemaker, 1996
	Asteroid mining	Unknown	2050	No
Mars exploration	Mars orbiter	Yes	2020	US Marine 9, 1971
	Mars Lander	Yes	Unknown	US Viking 1, 1976
	Martian sample return mission	Unknown	2050	No
Jupiter exploration		Yes	2030	US Pioneer 10, 1973
In-orbit servicing and maintenance		Yes	2030	Yes

China’s focus on space leads to success

Although much attention has been placed on the role of intellectual property theft and forced technology transfer in advancing China’s technology programs, two other factors have played a role in the success of China’s space program. The first is a shared recognition among the nation’s top leadership of the importance of space to China. Chinese leaders from Jiang Zemin to Xi Jinping have sought to associate themselves publicly with the space program. The top-level focus on space in particular and science and technology in general demonstrates the CCP’s commitment to making technology a central component of China’s modernization effort.

China’s space program has also benefited from consistent goals and funding. China’s space program has enjoyed the stability of long-term planning. China’s space industry is given five-year and fifteen-year goals and it works to achieve them. Indeed, China’s space program has a strong record of achieving the goals set out for it in the 2006 MLP.

Table 6. Space program missions

Program	Goal	Completion date	Comments
Human spaceflight	Orbit 60-ton space station	2020	New completion date is 2022.
Earth observation	Build global, all-weather, 24-hour earth remote sensing	2020	Expected to be achieved.
Lunar exploration	Orbit Moon, land rovers on Moon, return lunar sample	2020	Lunar sample return mission delayed due to LM-5 failure. Launch scheduled for 2020.
Satellite navigation	Build regional system; build global satellite navigation system	2020	Last satellite of constellation to be launched in May 2020.
Launch vehicles	Develop new generation of Long March launch vehicles	2020	Achieved by Northrop Grumman and Intelsat 2020.

Source: Li Wei, "China to launch last satellite for BeiDou navigation system in May," *Xinhua*, April 6, 2020 http://eng.chinamil.com.cn/view/2020-04/06/content_9785700.htm and Wang Yamei, "China Improves Space-based Observation of Earth," *Xinhua*, December 10, 2019, http://www.xinhuanet.com/english/2019-12/10/c_138620146.htm

The United States remains the leading space power

Although China's space program is advancing rapidly, the United States remains the leading space power and will retain that position for decades. A number of examples illustrate the United States' commanding lead in space.

Number of satellites in space. The United States has 901 satellites in orbit. China has 299.

Lunar exploration. The United States remains the only country to have landed humans on the Moon—first in 1969.

Human spaceflight. The United States has continuously operated the International Space Station (ISS), with its partners, since 1998. The ISS has hosted astronauts from 18 countries and facilitated research from 83 countries and regions. The ISS is the largest space station ever constructed and is much larger than China's planned space station. The ISS weighs over 419 tons. China's space station will weigh around 60 tons.

Heavy lift. The United States has operated United Launch Alliance's Delta IV Heavy since 2004, and, with the exception of one test launch, it has operated flawlessly. Falcon Heavy, a privately developed launcher by SpaceX, has been in operation since 2018. China's heavy lift launcher, the Long March 5, was built by China's traditional space industry and was first launched in 2016; its second launch in 2017 failed and it has not flown since.

Mars exploration. The United States has conducted 11 successful robotic missions to Mars. China has not conducted any.

Remote sensing. U.S. commercial satellite remote sensing provider DigitalGlobe offers 30 centimeter resolution satellite imagery. China's SuperView satellite has a resolution of 50 centimeters.

In-orbit servicing and maintenance. In February 2020, the Northrop Grumman Mission Extension Vehicle-1 (MEV-1) docked with the Intelsat 901 satellite to conduct servicing and maintenance. This was the first time that docking had been performed with a satellite that had not been originally designed to dock.⁴⁷⁶ China plans to acquire a similar capability by 2030.

But the United States can lose this lead

The United States can lose its position as the leading space power if it does not invest in its space program sufficiently and effectively. Scott Pace, the Executive Secretary of the National Space Council, wrote in a 2011 *Space Policy* article, “The most important implication for the USA from Chinese civil space capabilities is not that the Chinese will be in space, but that the USA may not be....It is a longstanding truism that the rules of international relations in new domains are created by those who show up and not by those who stay home.”⁴⁷⁷

Events since 2001 bear this out. Although the United States has concentrated on fighting counterinsurgencies in Iraq and Afghanistan, China has developed a comprehensive counterspace capability intended to deny the United States its valuable space capabilities and has lost its advantage in hypersonics to China.⁴⁷⁸ By the mid-2020s, China could be the only country operating a space station. Chinese leadership in space would not only have military implications, but also potential political and economic consequences.

Implications for the United States

MILITARY IMPLICATIONS

SPACE ENHANCES PLA A2/AD CAPABILITIES

The acquisition of space-based intelligence and navigation information to enable long-range strikes and the use of offensive space control measures against U.S. satellites demonstrates the prominent role of space in China’s efforts to establish an effective A2/AD capability. The denial of critical space-based C4ISR capabilities integrated with cyber and kinetic attacks against ground-based C4ISR nodes could complicate the ability of the U.S. military to flow forces to the region and conduct operations effectively.

The PLA can use space-based capabilities to identify land- and sea-based targets globally and to provide intelligence for PLA naval, aviation, and missile forces to adjust fire, restrike targets, or verify a target’s destruction. With space-based ISR capabilities in combination with the 1,500-kilometer range DF-21D ballistic missile, CJ-10 ground launched cruise missile, and 4,000-kilometer range DF-26 ballistic missile, China could attack both land and naval targets in the western Pacific and Indian Oceans and the South China Sea.⁴⁷⁹ Despite its growing reliance on space, however, no PLA source reviewed for this study acknowledged the potential vulnerabilities the PLA may take on as its depends on space more.

CHINA’S GROWING POLITICAL AND ECONOMIC TIES FACILITATE THE EXPANSION OF ITS MILITARY SPACE PROGRAM

China’s growing political and economic influences have enabled China to set up space telemetry, tracking, and control (TT&C) centers more globally, allowing it to better operate its spacecraft and monitor the spacecraft of other countries. In 2019, the Republic of Kiribati and China reestablished formal ties. The move will likely allow China to restart operations of a TT&C station that had to be abandoned when Kiribati switched formal recognition to the Republic of China in 2003.⁴⁸⁰ China has also established a TT&C station in Argentina that U.S. Southern Command commander Admiral Craig Faller described as “concerning.” According to Admiral Faller, “Beijing could be in violation of the terms of its agreement with Argentina to only conduct civilian activities, and may have the ability to monitor and potentially target U.S., Allied, and partner space activities.”⁴⁸¹ In 2011, the *South China Morning Post* reported that China had leased a space tracking facility in Dongara, Australia, built by the Swedish Space Corporation.⁴⁸² In 2016, China began operation of the China Remote Sensing Satellite North Polar Ground Station based in Kiruna, Sweden, that is designed to receive data from China’s remote sensing satellites.⁴⁸³

CHINESE SPACE TECHNOLOGIES AND SERVICES COULD BE USED BY POTENTIAL ADVERSARIES

China could offer space technologies and services to countries that currently lack access to space, enabling them to counter U.S. presence and operations the world over. For example, Chinese remote sensing data provided to potential U.S. adversaries would make it more difficult for the U.S. military to hide its intentions and provide security to U.S. forces. Satellite communications could enable U.S. adversaries to conduct longer-range operations. The Beidou satellite navigation system could provide an alternative to GPS and allow foreign militaries to be more independent of U.S. weapon systems.

CHINA'S COMMERCIAL SPACE SECTOR COULD PROVIDE ADDITIONAL MILITARY CAPABILITIES

If it continues to grow and advance in capabilities, China's commercial space sector could supplement the PLA with additional launch, remote sensing, navigation, and communication capabilities. PLA sourcing of commercial space capabilities could also provide initial market demand for China's nascent commercial space sector, which could sustain companies until a true commercial space market is developed.

POLITICAL IMPLICATIONS

CHINA'S SPACE NARRATIVE PRESENTS DIPLOMATIC CHALLENGES TO THE UNITED STATES

The Chinese government uses its space program for international political gain. China's "shared future vision for humanity in space" narrative is intended to increase China's influence in space-related diplomacy and build relationships with foreign partners. China's narrative of using space for peaceful purposes and working to bring the benefits of space to all countries is one element of its larger endeavor to reduce U.S. power and influence. China uses its international space cooperative activities to demonstrate that it is an enlightened, benevolent hegemon able and willing to fulfill other countries' security and economic needs through the application of space-based capabilities.

As in other domains, as Chinese capabilities and interests increase, China will likely try to shape international space governance by courting developing countries and proactively interacting with the United Nations. China could use its influence to promote its agenda to shape international efforts on space arms control, space sustainability, the commercial uses of space, and natural resource extraction. Chinese influence could also be used to stymie U.S. or Western approaches to space governance, such as its opposition to the European Union's proposed International Code of Conduct for Outer Space Activities.

MORE COUNTRIES WITH SPACE AGENCIES INCREASES OPPORTUNITIES FOR CHINESE LEADERSHIP

The increasing ability of China's space program to provide opportunities for leadership will be aided by the growing number of countries with space programs. Since 2014, six countries have established space agencies, and 15 countries have become members of the United Nations Committee on the Peaceful Uses of Outer Space. New entrants in space will provide more opportunities for China to expand its space collaboration and serve as a mentor to countries with little or no experience running a space program or developing space technologies.

COMMERCIAL AND ECONOMIC IMPLICATIONS

U.S. COMMERCIAL LAUNCH COMPANIES WILL LIKELY CONTINUE TO DRIVE FUTURE INNOVATION

China's commercial space launch companies differ in significant ways from their commercial launch counterparts in the United States. Chinese commercial launch companies were founded by space industry or finance professionals with no apparent entrepreneurial backgrounds or means to self-fund their companies. "New space" companies on the other hand, including SpaceX, Blue Origin, and Virgin Galactic, were founded by technology-oriented billionaire entrepreneurs with experience running large, complex organizations in a true commercial environment.

Several indicators suggest that Chinese commercial space companies are not innovative. Truly private companies building rockets from scratch need time to establish a headquarters, seek and receive funding, hire a team, begin R&D, and then manufacture the rockets. iSpace was the first Chinese commercial space company to achieve orbital launch despite the fact that it has only existed since 2015 and has a team of less than 100 personnel. For Expace, a subsidiary of CASIC, the transfer CASIC rocket technology to Expace appears to have jumpstarted this process. The same can probably be said for LandSpace, whose LS-1 appears to have been derived from CASC's Long March-11. OneSpace and iSpace have also received support from SOEs in the course of product development and rocket launch.

In addition, the number of staff employed by China's commercial space launch companies suggests that most companies do not have the staff to successfully conduct launch vehicle R&D. The number of workers employed by Expace is unknown, but LandSpace, OneSpace, and iSpace appear to employ between several dozen to just over 100 employees. On the other hand, U.S. companies employ hundreds, if not thousands, of staff who are responsible for research, development, and manufacturing of spacecraft. SpaceX employs 7,000 people. Blue Origin employs more than 1,000.⁴⁸⁴ The smallest of these companies, Virgin Galactic, employs 360 personnel.⁴⁸⁵

Moreover, the ability of Expace and iSpace to conduct launches within several years of their founding suggests that they have received assistance from China's state-owned space industry. In contrast, U.S. companies have had longer lead times. SpaceX was founded in 2002 and did not launch its first rocket, the Falcon-1, until 2006 and did not make its first commercial launch until 2012 with the Falcon-9. Blue Origin was founded in 2000 but did not make a test flight of its New Shepard-1 reusable launch system until 2015. Virgin Galactic was founded in 2004, and its first powered test flight of SpaceShip Two was in 2013.

Finally, the spacecraft manufactured or planned by these U.S. companies are more technologically advanced than their Chinese counterparts. The most technologically demanding rocket manufactured by these Chinese companies is Expace's Kuaizhou-11, which can transfer a 1,500 kilogram payload into LEO. In contrast, SpaceX's Falcon-9 can lift 22,800 kilograms into orbit and is partially reusable. Moreover, unlike China's commercial space launch providers, all the U.S. companies mentioned here are working on human-rated spacecraft that add a significant level of complexity that heretofore have been successfully developed only with the full governmental backing.

DEMAND FOR SMALLER SATELLITES LOWERS THE BAR FOR ENTRY INTO THE COMMERCIAL SPACE MARKET

The growing market demand for smaller, less sophisticated, and less expensive satellites may lower customer requirements and expectations for functionality and reliability, thereby lowering the bar and evening the playing field for market entry for Chinese satellite developers. A focus on smaller satellites would also be more suitable for Chinese commercial launch providers, which to date have focused on launch vehicles capable of carrying smaller payloads.

In addition, although U.S. export control laws prohibit the export of satellites with U.S.- manufactured components to China, the proliferation of smaller, less sophisticated, and less expensive satellites using non-regulated, commercial off-the-shelf technologies will provide opportunities for non-Chinese satellite manufacturers to legally launch their satellites on Chinese launchers.

CHINESE MERCANTILIST POLICIES COULD HARM THE U.S. COMMERCIAL SPACE SECTOR

The rapid expansion of Chinese commercial space companies, the lowering of technological hurdles to space, and Chinese mercantilist industrial policies could result in China flooding markets with cheap alternatives to U.S. space products and services. Chinese export policies— as seen in sectors such as solar panels and steel—could be

applied to the commercial space sector. Such actions would undermine the profitability of the U.S. commercial space sector and render it less able to achieve U.S. policy goals.

China devotes more than 3 percent of its gross domestic product to business subsidies.⁴⁸⁶ If applied to the commercial space sector, these mercantilist policies would exacerbate an already saturated international space launch market. U.S. and European panelists speaking at the Satellite 2019 conference doubted the ability of the international commercial space market to support the current number of commercial launch providers and estimated that the international commercial launch market could support only three to seven companies.⁴⁸⁷

China's entry into commercial space may lead to "regulation shopping" China's commercial space industry remains in regulatory limbo, and Chinese sources describe many factors that complicate the launch of commercial satellites. Depending on the type of regulatory regime China ultimately chooses, China's entry into the commercial space market could lead to "regulation shopping" in which companies from around the world seek the most business-friendly environments. Such canvassing could lead to competition among spacefaring countries to offer the most business-friendly environment.

CHINESE COMMERCIAL SPACE COMPANIES MAY CHALLENGE SPACE SUSTAINABILITY PRACTICES

The rapidly rising number of new commercial space companies in China suggests the possibility that many of them will be unfamiliar with or unconcerned about operating their spacecraft in ways that preserve the usability of space. Practices such as not deorbiting satellites as they near the end of their service life or insufficient reliability that prevents satellites from being deorbited (or that leads to catastrophic malfunction) will proliferate space debris.

CHINA'S COMMERCIAL SPACE SECTOR COULD PROMOTE INTERNATIONAL ACQUISITIONS

Chinese commercial space companies could seek or be used to acquire foreign companies to access better technologies. Such activities would require increased vigilance through the Committee on Foreign Investment in the United States (CFIUS) process to protect U.S. intellectual property as well as monitor efforts to acquire non-U.S. companies.

A SPACE RESOURCE EXTRACTION PROGRAM COULD ESTABLISH CHINA AS DOMINANT SPACE POWER

China's ambitions to extract natural resources from space could have profound consequences for the world—if they are approved and successful. China's development of a technologically capable and economically viable space resource program would require the development of advanced launch, spacecraft, and space mining technologies that would likely make China the dominant space power, if the United States chose not to develop similar technologies. Natural resource extraction in space, including space-based solar power, would also limit the environmental impact of the Chinese government's efforts to improve the living standards of its 1.4 billion-plus population by lessening the need for terrestrial resources.

In its effort to achieve resource security, China could depress the price of natural resources through its successful mining of asteroids and the Moon by flooding the market with an overabundance of metals and minerals. Today, no shortage of metals and minerals exists. Even rare earth metals are made rare only because the means to extract them have high environmental costs. The Chinese government may disregard such an outcome, however, preferring instead the access to natural resources that space provides over its economic costs.

Finally, a Chinese space resource extraction program could lead to Chinese efforts to shape international governance of the space environment in favor of Chinese interests or unilateral efforts to occupy favorable locations in space or on the Moon. The Outer Space Treaty, for example, which both the United States and China have

signed, prohibits countries from claiming asteroids or other celestial bodies, but does not address private claims. The Moon Treaty, on the other hand, does ban private claims, but neither the United States nor China has signed it. The absence of an international governance system for space resource extraction could lead to space remaining a largely ungoverned commons subject to the unrestrained actions of individual countries prone to making the space equivalent of land grabs.

U.S. and China appear to be on the cusp of a security dilemma

The United States and China appear to be heading into a security dilemma in space. A security dilemma is produced when one state's efforts to increase its security are perceived by another state as weakening its security.⁴⁸⁸ It is rooted in the anarchic, "self-help" nature of the international system in which states are compelled to rely on themselves for survival and see other states as potential threats.⁴⁸⁹ As a result, the security dilemma is based on the notion that "one state's gain in security often inadvertently threatens others."⁴⁹⁰

Chinese analysts cite U.S. military technology development and doctrinal publications and the proposal to establish a U.S. Space Force to demonstrate the ability and intent of the U.S. military to deny space to its adversaries. These analysts argue that U.S. actions necessitate the need for the PLA to develop its own technological and organizational capabilities to use and defend its interests in space. At the same time, U.S. analysis of China's space program cite that country's development of counterspace technologies, doctrinal studies and official government publications, along with the establishment of the Strategic Support Force, as evidence that China is developing the capability to deny the U.S. its space capabilities.

A security dilemma in space between the United States and China can cause arms racing and increase instability by incentivizing first strikes.⁴⁹¹ Indeed, Columbia University's Robert Jervis concludes that during a time of crisis between two countries involved in a security dilemma, the deployment of offensive weapons will increase the chance of war and create incentives for preemption.⁴⁹²

This dynamic could play out in space between the United States and China. Both countries have an incentive to strike first in space during the initial stages of a conflict. For the PLA, this would achieve an asymmetric advantage against a superior U.S. force by delaying its entry and keeping it away from the conflict zone. For the U.S. military, the incentive would be to defeat China's ability to locate, track, and target U.S. bases and naval ships with long-range precision strike platforms in order to create a permissive environment for U.S. forces to operate within or close to the conflict zone.

APPENDIX A: CHINA'S MILITARY, GOVERNMENT, AND INDUSTRIAL SPACE ORGANIZATIONS

In order to provide the reader with background of China's space program, this appendix discusses some of its important organizations.

Military organizations

STRATEGIC SUPPORT FORCE

The PLA's primary space organization is the Strategic Support Force (SSF), a functional command that conducts strategic-level space, cyber, and electronic warfare operations.⁴⁹³ China's 2019 defense white paper describes the SSF as "a new type operational force to maintain national security" and "an important growth point" for the PLA's "new quality operational capability."⁴⁹⁴ A major mission of the SSF is to improve the PLA's joint operational capability by integrating strategic-level C4ISR and counter-C4ISR capabilities with service and theater command capabilities.⁴⁹⁵

The SSF has two subordinate operational departments: a Network Systems Department responsible for conducting strategic cyber and EW operations and a Space Systems Department responsible for space operations.⁴⁹⁶ The Space Systems Department is responsible for the operation of China's launch sites, satellite control centers, and the remaining portion of China's telemetry, tracking and control architecture. It may also be responsible for launch vehicle and satellite research and development.

Governmental organizations

The PRC has numerous space-related governmental organizations located in various ministries and scientific organizations. For the purposes of this report, we focus on just two of those organizations: the State Administration for Science, Technology, and Industry for National Defense (SASTIND) and the China National Space Administration (CNSA).

STATE ADMINISTRATION FOR SCIENCE, TECHNOLOGY, AND INDUSTRY FOR NATIONAL DEFENSE

The State Administration for Science, Technology, and Industry for National Defense (*Guojia Guofang Keji Gongye Ju*; 国家国防科技工业局) is a regulatory and policy-making body that oversees the work and personnel management of the state-owned nuclear, space, aviation, armament, shipbuilding, and electronics industries; it is a subordinate entity to the Ministry of Industry and Information Technology (MIIT). In this role, it is the main organization for overseeing the performance of China's defense industry and ensuring that each industry meets its performance goals and the requirements of the military, while also remaining commercially competitive. SASTIND is also responsible for international cooperation in nuclear power and space through the China Atomic Energy Authority and CNSA.

CHINA NATIONAL SPACE ADMINISTRATION

The China National Space Administration (*Zhongguo Hangtian Ju*; 中国航天局) is subordinate to SASTIND and oversees the work of the space industry by providing policy and regulatory guidance and promoting the commercialization of space technologies. The director of CNSA is also a vice minister of MIIT and the director of SASTIND. In addition to its policy and regulatory role, CNSA is responsible for promoting international collaboration on civilian space programs and technologies. CNSA also leads China's lunar exploration program.

Defense industry

China's traditional state-run space industry is made up of two large defense conglomerates – the China Aerospace Science and Technology Corporation (CASC) and the China Aerospace Science and Industry Corporation (CASIC). These two conglomerates together employ a relatively young workforce of around 300,000 people⁴⁹⁷ – 55 percent of CASC's workforce is 35 or younger.⁴⁹⁸ This relatively young workforce suggests that China's space program could become more capable as the workforce matures and gains more experience in managing technological challenges.

CHINA AEROSPACE SCIENCE AND TECHNOLOGY CORPORATION

The China Aerospace Science and Technology Corporation (*Zhongguo Hangtian Keji Jituan*; 中国航天科技集团) is China's main industrial entity for the R&D in launch vehicles, spacecraft, and strategic missiles. It also conducts R&D on satellite applications technologies, information technologies, new energy and new material products, auto parts, and space biology products.⁴⁹⁹

CASC is composed of eight research and production academies, 14 specialized firms, and nine publicly listed firms. Its development and production bases are located in Beijing, Shanghai, Xi'an, Chengdu, Tianjin, Inner Mongolia, Shenzhen, and Hainan. It is also home to 11 defense S&T key laboratories, one national engineering laboratory, and five national engineering research centers. CASC is reported to employ 170,000 individuals.⁵⁰⁰

CHINA AEROSPACE SCIENCE AND INDUSTRY CORP.

The China Aerospace Science and Industry Corporation (*Zhongguo Hangtian Kegong Jituan Gongsi*; 中国航天科工集团公司) was established in 1956 as the Fifth Academy of the Ministry of Defense. CASIC now has five academies, two scientific research and production bases, six publicly listed companies, and over 570 enterprises and institutes, with more than 137,000 employees. As the largest missile designer and manufacturer in China, CASIC is engaged in the development, research and manufacture of air defense missile systems, cruise missile systems, solid rockets, and space products.⁵⁰¹

APPENDIX B: PROFILES OF SELECT CHINESE COMMERCIAL SPACE COMPANIES

This appendix provides short profiles of some of the leading Chinese commercial space companies.

Commercial launch companies

EXPACE

Expace Technology Co. (*Hangtian Kegong Huojian Jishu Youxian Gongsi*; 航天科工火箭技术有限公司), a subsidiary of CASIC, was established in Wuhan in February 2016.⁵⁰² Expace markets the Kuaizhou (快舟) series of solid-fuel launch vehicles, which CASIC began developing in 2009 as a “low-cost, quick-response rocket family for the commercial space market.”⁵⁰³ Expace launch services are priced at around \$10,000 per kg of payload.⁵⁰⁴

PRODUCTS

Expace offers the Kuaizhou 1A, which was first launched in 2013 in Jiuquan.⁵⁰⁵ This solid-fuel launch vehicle is capable of putting a 200-kg payload into sun-synchronous orbit or a 300-kg payload into low Earth orbit. Rather than a fixed launch pad, the Kuaizhou 1A uses a transporter-erector-launcher (TEL) vehicle.⁵⁰⁶

Expace’s first commercial launch took place from the Jiuquan Launch Center on January 9, 2017 when a Kuaizhou 1A lifted three small satellites into SSO. The launch contract for this mission was worth over 100 million CNY.⁵⁰⁷ Expace successfully launched another Kuaizhou 1A in September 2018, which carried the Centispace-1-s1 satellite, an experimental satellite developed by the Chinese Academy of Sciences.⁵⁰⁸

Aside from the Kuaizhou 1A, Expace plans to offer a number of other launch vehicle solutions. The Kuaizhou 11, currently under development, will be capable of putting a 1-metric-ton payload into SSO at an altitude of 700 kilometers or a 1.5-metric-ton payload into LEO at an altitude of 400 kilometers. Like the Kuaizhou 1A, the Kuaizhou 11 is a road-mobile, solid-fuel rocket.⁵⁰⁹

Other Kuaizhou variants are in the planning stages. The Kuaizhou 16, targeted at commercial satellite makers, will have a diameter of 3.5 meters and be able to send satellites weighing up to five tons into low Earth orbit. The Kuaizhou 21 will have a diameter of 4.5 meters, a liftoff thrust of more than 1,000 metric tons, and be capable of sending a 20-metric-ton spacecraft into low Earth orbit. The Kuaizhou 21 will be used primarily to support Chinese space programs, including China’s planned space station. A longer-term planning goal is the Kuaizhou 31, which may be capable of sending a 70-ton payload into LEO.⁵¹⁰

PERSONNEL

Expace is led by Chairman Zhang Di (张镝), who serves concurrently as deputy director of CASIC’s 4th Academy. Zhang’s earlier career focused on various rocket development programs, including the design of the Long March 3A.⁵¹¹

No numbers on the total number of personnel at Expace have been observed at the time of writing.

FACILITIES

In September 2016, Expace signed an agreement with the governments of Hubei and Wuhan to build the Wuhan National Aerospace Industry Base (*Wuhan Guojia Hangtian Changye Jidi*; 武汉国家航天产业基地). The

base, which will be structured around Expace, will focus on manufacturing carrier rockets and satellites and on applications using satellite data. By 2020, the base may have an annual production capacity of up to 50 carrier rockets and 140 commercial satellites.⁵¹²

Construction on the base began in Wuhan's Xinzhou District on 24 April 2017. In a statement, Expace said it would invest 1.7 billion yuan into the base to build production and assembly plants for commercial launch vehicles. Additionally, CASIC's Second Academy would invest 300 million yuan into an R&D and manufacturing complex for small satellites.⁵¹³ Since then, new CASIC subsidiaries have registered at the base. These include Aerospace Xingyun S&T Co. (*Hangtian Xingyun Keji Gongsi*; 航天行云科技公司), which is affiliated with CASIC's 4th Academy, and Space Engineering Development Co. (*Hangtian Kegong Kongjian Gongcheng Fazhan Gongsi*; 航天科工空间工程发展公司) affiliated with CASIC's 2nd Academy.⁵¹⁴

According to Wuhan Mayor Wan Yong, the Wuhan National Aerospace Industry Base will be China's third national-level aerospace industry base after Xi'an and Shanghai. Aside from aerospace enterprises, the base will also contain clusters focused on new materials and high-tech equipment such as industrial robots.⁵¹⁵

Capital. In April 2016, two months after its establishment, Expace reported that it had registered capital of 300 million yuan (\$46 million).⁵¹⁶ The company reported an additional 1.2 billion CNY (\$180 million) acquired via A round financing in December 2017.⁵¹⁷ The sources of related capital is unknown.

CHINAROCKET

ChinaRocket (*Zhongguo Changzheng Huojian Youxian Gongsi*; 中国长征火箭有限公司), a subsidiary of CASC and directly subordinate to CALT, was established in Beijing in October 2016.⁵¹⁸ The company plans to begin carrying cargo into space and offering upper-atmosphere passenger services by "as early as 2020."⁵¹⁹ ChinaRocket has yet to complete an orbital launch at the time of writing, despite previous media reporting suggesting the company would attempt a launch in the first half of 2019.⁵²⁰

PRODUCTS

ChinaRocket plans to offer four types of commercial rockets in its "Dragon series," three of which are "off-the-shelf models" based on existing Long March launch vehicles.⁵²¹ The fourth is to be a "liquid-fueled, medium-lift rocket specifically for the commercial launch market."⁵²²

ChinaRocket currently offers the Smart Dragon 1 (*Jielong Yihao*; 捷龙一号), a "fast, agile, and flexible" micro-launcher designed by CALT capable of putting a 150-kg payload into 700-km SSO. The Smart Dragon 1 has a total length of 19.5 meters, a diameter of 1.2 meter, and a takeoff weight of about 23.1 tons.⁵²³ Based on these specifications, it appears that this launch vehicle is based on the Long March 11.

ChinaRocket has publicized a number of plans for future products. These include several variants of reusable spacecraft for passenger services, new launch facilities, and "space-themed parks."⁵²⁴ The company is also exploring vertical takeoff/landing and horizontal takeoff/landing, with hopes to adopt related technologies around 2021 or 2022.⁵²⁵

PERSONNEL

The current president of ChinaRocket is Tang Yagang, who was previously identified as deputy director of carrier rocket development at CALT.⁵²⁶

No numbers on the total number of personnel at ChinaRocket have been observed at the time of writing.

FACILITIES

ChinaRocket is based in Beijing.⁵²⁷

CAPITAL

No information related to investment and financing at ChinaRocket have been observed at the time of writing.

LANDSPACE

LandSpace (*Beijing Lanjian Kongjian Keji Youxian Gongsi*; 北京蓝箭空间科技有限公司) is a private company established in Beijing in 2015. The company has the goal of becoming a “world-class Chinese launch enterprise” and links itself directly with China’s Military-Civil Fusion strategy.⁵²⁸

PRODUCTS

LandSpace initially offered the LandSpace 1, a solid-fuel rocket designed to carry payloads up to 400kg to 500-km SSO.⁵²⁹ This rocket was 20.7 meters tall with a diameter of 2 meters.⁵³⁰

However, in 2018 the company scrapped LandSpace and changed its offering to the Zhuque 1. This rocket’s reported launch capacity is 200kg to 500-km SSO, with a length of 19 meters and diameter of 1.35 meters.⁵³¹ LandSpace unsuccessfully launched a Zhuque 1 on October 27, 2018. The rocket failed to reach orbit reportedly as a result of a third-stage launch failure.⁵³²

LandSpace is also in the process of developing the Zhuque 2, a larger, liquid-propellant rocket which the company claims will have a launch capacity of 4.0 tons to 200-km LEO, 1.8 tons to 500-km SSO, 1.5 tons to 700-km SSO.⁵³³

In January 2017, LandSpace signed a contract with the Danish satellite company Gomspace to use the LS-1 rocket to launch Gomspace satellites in 2018.⁵³⁴ However, the deal appears to have been canceled, perhaps in light of LandSpace’s transition to the Zhuque 1. If the deal had gone through, this would have been the first time that a private Chinese company provided launch services to a foreign client.⁵³⁵

PERSONNEL

LandSpace founder Zhang Changwu previously worked in China’s finance industry.⁵³⁶

As of 2017, LandSpace had over 50 technicians on payroll.⁵³⁷ According to Zhang Changwu, LandSpace initially experienced hiring difficulties. Nearly all of the skilled workers his company needed were in the state aerospace contracting sector, where they had highly competitive salaries and benefits.⁵³⁸

FACILITIES

LandSpace has three facilities. It has two R&D centers, one in Beijing and the other in Xi’an, Shaanxi Province. The company also has an “intelligent manufacturing base” located in Huzhou, Zhejiang Province.⁵³⁹

CAPITAL

Since 2015, LandSpace has attracted over 300 million CNY in investment, including 200 million CNY via Round A financing in April 2018.⁵⁴⁰

ONESPACE

OneSpace (*Lingyi Kongjian Keji Youxian Gongsi*; 零壹空间科技有限公司) is a private company that established in Beijing in August 2015.⁵⁴¹ The company has been working with CASIC and NORINCO to develop a line of reliable, low-cost launch vehicles for the commercial market.⁵⁴²

PRODUCTS

OneSpace is developing two series of launch vehicles: the solid-fuel OS-X series and the liquid-fuel OS-M series.

OneSpace performed a successful suborbital launch of its OS X1 test rocket on September 7, 2018 from Jiuquan. The company claims that this rocket is capable of reaching an altitude of 500 kilometers, though it only reached an altitude of 35 kilometers during the test flight.⁵⁴³

The company failed a launch attempt of its liquid-fuel OS M1 on March 27, 2019. Control of the 19-meter-tall, 20 metric ton rocket was lost about a minute after launch.⁵⁴⁴ The OS-M1 is designed to carry a 205-kilogram payload to 300-kilometer LEO or 73 kilograms to 800- kilometer SSO.⁵⁴⁵

PERSONNEL

OneSpace is led by Shu Chang, who started the company in his early 30s. He is a graduate of Beihang University and former vice president of Legend Holdings, an investment company founded by members of the Chinese Academy of Sciences.⁵⁴⁶ The company's CTO, Chen Xiaojun, came from CALT. Other members of the company's senior leadership came from CASC, CASIC, AVIC, and CAS.⁵⁴⁷

In an April 2018 interview, Shu Chang said that his company had between 100 and 200 employees—a larger staff than any of China's other commercial launch companies at the time.⁵⁴⁸

FACILITIES

OneSpace is headquartered in Beijing. In February 2017, the company added an R&D center and intelligent manufacturing facility in Chongqing.⁵⁴⁹

CAPITAL

As of late 2018, OneSpace has attracted investment totaling over 600 million CNY, including about 300 million CNY acquired through Round B financing in August 2018.⁵⁵⁰ The company's website listed a number of investors, including Hongtai Fund, China Merchants Venture, Qianhai Mergers and Acquisitions Fund, Tongkang Investment Group, Legend Star, Chunxiao Capital, Harbin Institute of Technology Robot Group, and AIIG.

iSPACE

iSpace (*Beijing Xingji Rongyao Kongjian Keji Youxian Gongsi*; 北京星际荣耀空间科技有限公司) also known as Beijing Interstellar Space Technology Ltd., is a private company established in Beijing in October 2016.⁵⁵¹ The company has the stated goal of building high-quality, low-cost, quick-response commercial launch vehicles for the global small satellite launch market.⁵⁵²

Significantly, iSpace was the first of China's private launch companies to conduct a successful orbital launch. On July 24, 2019, iSpace launched its solid-propellant Hyberbola-1 launch vehicle from Jiuquan, sending payloads that included an amateur radio satellite into space.⁵⁵³

PRODUCTS

iSpace has completed suborbital launches with two small solid-fuel test rockets. On April 5, 2018, the Hyperbola 1S performed a successful suborbital launch from the Hainan launch center.⁵⁵⁴ A second suborbital flight was carried out from the Jiuquan Launch Center on September 5, 2018, during which the Hyperbola 1Z carried three small payloads, one of which parachuted back to earth.⁵⁵⁵

iSpace's Hyperbola 1, a small solid-fuel launch vehicle, is designed to send a 300-kg payload into 200-km LEO.⁵⁵⁶ The Hyperbola 1 has a total length of 20 meters, a diameter of 1.4 meters, and a liftoff weight of 31 tons.⁵⁵⁷

iSpace's plans for future products include the Hyperbola 2, described as a "green, reusable small liquid rocket," and a "suborbital space tourism concept vehicle."⁵⁵⁸ The Hyperbola 2 is designed to send a 1.9-ton payload into 200-km LEO.⁵⁵⁹ The liquid rocket has a total length of 38 meters, a diameter of 2.5 meters, and a liftoff weight of 95 tons.⁵⁶⁰ iSpace expects to conduct a first launch of the Hyperbola 2 sometime in 2021.⁵⁶¹ No dates have been set for the space tourism vehicle.

PERSONNEL

Little information is available about the leadership of iSpace. According to one report, the company was founded by "a group of senior Chinese rocket scientists."⁵⁶² Another report states that the founder of iSpace was the former director of the R&D Center of CASC's First Academy.⁵⁶³

According to the company's promotional materials, iSpace has "over 100" employees.⁵⁶⁴ iSpace's core group of personnel have experience spanning the full design process of domestic carrier vehicles as well as strategic and tactical missiles.⁵⁶⁵ On average, employees at the company have 12 years of experience in the aerospace industry.⁵⁶⁶

FACILITIES

iSpace has two main facilities: a headquarters and an R&D center. The company's headquarters is located in Beijing and consists of six departments: overall management, project management, overall design, dynamic design, attribute/orbit control and engine operations, and military trade.⁵⁶⁷ The company's R&D center is located in Xi'an.⁵⁶⁸

CAPITAL

iSpace's early financing consisted of "close to 100 million RMB" from SASTIND and CITIC Group.⁵⁶⁹ iSpace received additional capital through pre-A and A rounds of financing in March and June 2018, respectively, though no data is available regarding the amounts received during those rounds.⁵⁷⁰ Additional A++ series financing received in July 2019 pushed iSpace's capital over the \$100 million mark.⁵⁷¹

Shunwei Capital, an investment firm affiliated Lei Jun—chairman of the Chinese electronics company Xiaomi—has been involved in iSpace fundraising.⁵⁷² Other investors that have participated in iSpace's series A financing include Matrix Partners China, CDH Investments, and Baidu.⁵⁷³

Other commercial space companies

CHANG GUANG SATELLITE TECHNOLOGY CO., LTD

Chang Guang (*Changguang Weixing Jishu Youxian Gongsì*; 长光卫星技术有限公司) describes itself as “the first commercial remote sensing company in China.” It was founded in 2014 in Changchun, Jilin Province.⁵⁷⁴ The company is a commercial spinoff of the Chinese Academy of Sciences’ Changchun Institute of Optics, Fine Mechanics and Physics (CIOMP).⁵⁷⁵ Chang Guang is a vertically integrated company that builds, operates, and sells data applications from commercial remote sensing satellites as well as unmanned aerial vehicles (UAVs).⁵⁷⁶ Its main clients are Chinese government organizations and the PLA, though the company has stated that it wishes to orient itself more toward the consumer market.⁵⁷⁷

PRODUCTS

Chang Guang’s main commercial offering is data services derived from the Jilin-1 constellation of remote-sensing satellites in Sun synchronous orbit (SSO). The data from these typically 200-kg satellites, which achieve roughly 1-meter resolution, can be used for applications such as surveying, environmental protection, and military reconnaissance and surveillance.⁵⁷⁸

As of early June 2019, 13 Jilin-1 satellites were in orbit.⁵⁷⁹ The company intends to launch 60 satellites by 2020 and have 138 in service by 2030.⁵⁸⁰ According to Chang Guang, having 138 satellites in orbit would give the company a 10-minute revisit capability anywhere in the world.⁵⁸¹

In May 2016, Chinese websites showed images of U.S. military ships at the Navy Yard in Philadelphia that were taken by a Jilin-1 Optical A satellite.⁵⁸² According to one article in China’s media, the satellite has a resolution of 0.72 meters, which is “high enough to catch aircraft carriers.”⁵⁸³

PERSONNEL

As of March 2018, Chang Guang reported having 366 employees, more than 80 percent of whose educational credentials were at the master’s degree level or higher.⁵⁸⁴

FACILITIES

The headquarters of Chang Guang are located in Changchun.⁵⁸⁵ The company invested 6 billion CNY in the Changchun Aerospace Information Industry Park, which opened in October 2018.⁵⁸⁶ Once it enters full production, the industrial park will be capable of producing 30 satellites and 200 UAVs per year.⁵⁸⁷ Chang Guang also has subsidiaries in Deqing County, Zhejiang Province and Haikou, Hainan Province.⁵⁸⁸

CAPITAL

According to the company’s website, Chang Guang has a total registered capital of 1.183 billion CNY.⁵⁸⁹ The company’s investors include CIOMP and the Jilin provincial government.⁵⁹⁰

ZHUHAI ORBITA

Zhuhai Orbita (*Zhuhai Oubite Yuhang Keji Gufen Youxian Gongsì*; 珠海欧比特宇航科技股份有限公司) is a publicly listed company founded in March 2000 in Zhuhai, Guangdong Province.⁵⁹¹ The company’s origins lay in the R&D, design, and manufacture of integrated circuits for aerospace and industry, and it has since moved into satellite operations and applications.⁵⁹² Chinese media have called the company “China’s first independent private operator of a satellite constellation.”⁵⁹³

PRODUCTS

Zhuhai Orbita's main commercial offering is data applications from the Zhuhai-1 constellation of remote-sensing satellites. By the end of 2020, the company plans to have 34 satellites in the constellation, including video, hyperspectral, synthetic aperture radar (SAR), and infrared satellites.⁵⁹⁴ In April 2018, seven of the constellation's satellites had been launched.⁵⁹⁵ An additional five satellites were launched in September 2019.⁵⁹⁶

PERSONNEL

The Chairman of Zhuhai Orbita is Dr. Yan Jun (颜军).⁵⁹⁷ The company reported that it had "more than 985 employees" as of May 2018.⁵⁹⁸

FACILITIES

Zhuhai Orbita's head office is located in Zhuhai, Guangdong Province.⁵⁹⁹ The company is also one of the lead investors in the Zhuhai Intelligent Industrial Park, which is scheduled to be completed by the end of 2019.⁶⁰⁰

Additionally, the company plans to operate seven ground stations in support of the Zhuhai-1 satellite constellation. Two of the ground stations have been completed: one in Mohe, Heilongjiang Province and one in Zhuhai, Guangdong Province.⁶⁰¹ The remaining five are under construction, four of which are in mainland China, while the fifth is in an unspecified location outside China.⁶⁰²

CAPITAL

According to the company's website, Zhuhai Orbita had a market capitalization of 10.1 billion CNY (about \$1.58 billion) as of May 22, 2018.⁶⁰³ Zhuhai Orbita became a listed company on the Shenzhen Stock Exchange on February 11, 2010.⁶⁰⁴

SPACEWILL INFO. CO., LTD

SpaceWill (formerly known as Space View/*Beijing Hangtian Shijing Xinxi Jishu Youxian Gongsi*; 北京航天世景信息技术有限公司) is a subsidiary of CASC established in January 2012.⁶⁰⁵ The company is an authorized domestic and international distributor of high-resolution Earth imagery.⁶⁰⁶ The majority of the company's clients appear to be PRC government agencies and state-owned firms.⁶⁰⁷ SpaceWill seeks to gain a greater share of the international market for 2.5-meter-and-better resolution Earth imagery.⁶⁰⁸

PRODUCTS

SpaceWill is the commercial operator and distributor of data from Earth observation satellites in the SuperView-1 constellation. This constellation consists of four identical 0.5-meter-resolution optical satellites as of January 2018.⁶⁰⁹ The company expects the Superview-1 constellation, which should contain at least 24 satellites (optical, SAR, hyperspectral, and video), to be completed by 2022.⁶¹⁰

SpaceWill is a commercial distributor of data from a number of other satellites. These include Gaofen (GF-1, GF-2, GF-3, GF-4), Ziyuan (ZY-3, ZY-3 02), and Huanjing (HJ-1A&B) satellites.⁶¹¹

PERSONNEL

The general manager of SpaceWill is Xu Liping (徐丽萍).⁶¹²

FACILITIES

SpaceWill is based in Beijing.⁶¹³

CAPITAL

SpaceWill's promotional materials claim that the company has provided "more than 1,400 commercial and government customers."⁶¹⁴ SpaceWill's top client has been the PRC State Bureau of Surveying and Mapping.⁶¹⁵ Other domestic clients include the former Ministry of Land and Resources and State Oceanic Administration, Sinopec, Petrochina, China Unicom, and ZTE.⁶¹⁶ SpaceWill has a number of foreign partners, including the U.S. company DigitalGlobe (now part of Maxar), South Korea's SI Imaging Service, and Canada's Urthecast.⁶¹⁷ SpaceWill has also provided data for the European Space Agency and Netherlands Space Office.⁶¹⁸

HEAD AEROSPACE

HEAD Aerospace (also known as China HEAD/*Beijing Hede Yuhang Jishu Youxian Gongsi*; 北京和德宇航技术有限公司) is a private company established in Beijing in 2007.⁶¹⁹ The company's business model focuses on facilitating the trade of space products between China and foreign countries and on marketing downstream applications and services derived from small satellites.⁶²⁰

PRODUCTS

In cooperation with CASC subsidiary Shanghai Aerospace Technology Research Institute, HEAD Aerospace is developing the multipurpose SkyWalker satellite constellation.⁶²¹ The constellation, which will be used and operated by HEAD Aerospace, will include different types of satellites focused on both communications and Earth observation, with an intended completion date of 2022.⁶²² Once completed, the SkyWalker constellation could have as many as 48 satellites in SSO and LEO orbits.⁶²³ The first satellite of the constellation, HEAD-1, was successfully launched from Taiyuan on November 15, 2017.⁶²⁴

Through strategic partnerships with other Chinese companies and government organizations, HEAD Aerospace offers data and services based on AIS, optical, radar, and video data from in-orbit satellites.⁶²⁵

In June 2018, HEAD Aerospace signed a strategic partnership agreement with Satlantis to be the Spanish company's exclusive partner in commercializing its small satellite optical camera in China.⁶²⁶

PERSONNEL

The president of HEAD Aerospace is Jason Chou (*Zhou Dachuang*; 周大创).⁶²⁷ The company's lead for international business development and general manager of HEAD Aerospace France is Kammy Brun, who is rather prominent in media generated by the company.⁶²⁸

FACILITIES

HEAD Aerospace is headquartered in Beijing.⁶²⁹ The company has subsidiaries located in Hong Kong, the Netherlands, and France.⁶³⁰ The Netherlands subsidiary (est. 2016) focuses on small satellites "from a mission and payload/subsystem approach."⁶³¹ The France subsidiary (est. 2017) is located in Paris and aims to foster international partnerships in support of the Skywalker constellation.⁶³²

HEAD Aerospace runs joint laboratories in Switzerland and Italy. The Sino-Italy Joint Laboratory of Electric Propulsion (*Zhongyi Diantuijin Lianhe Shiyanshi*; 中意电推进联合实验室) was founded in 2015 between the Lanzhou Institute of Physics (under CASC) and the Italian company Sitael.⁶³³ According to HEAD Aerospace's website, this Sino-Italy joint laboratory is aimed at sharing information between the two countries' governments to help accelerate research in electric propulsion.⁶³⁴

CAPITAL

HEAD Aerospace claims that it has a broad range of domestic and international partners. International partners listed on the company's website include Airbus Defence & Space, Hyperion Technologies, and Sitael.⁶³⁵

In January 2019, HEAD Aerospace and China Center for Resources Satellite Data and Applications were awarded a contract to build a ground station in Ethiopia.⁶³⁶ The contract has a training component and is reportedly aimed at enabling Ethiopia to receive satellite data and develop related applications.⁶³⁷

ZEROG LAB

ZeroG Lab (also known as Beijing Lingzhong Aerospace Technology Co. Ltd/*Beijing Lingzhong Kongjian Jishu Youxian Gongsì*; 北京零重空间技术有限公司) is a private company established in October 2016 and registered in Beijing in January 2017.⁶³⁸ The company's main business relates to the development and sale of micro- and nanosats and their core parts.⁶³⁹

PRODUCTS

In April 2018, ZeroG Lab unveiled its plan to build the "Lingque" (Spirit Magpie) satellite constellation.⁶⁴⁰ The constellation will be designed, developed, and constructed along with partner organizations Huaxun Fangzhou Co., Ltd. and the Rocket Force Engineering University.⁶⁴¹ The initial plan for Lingque is a constellation of 132 6U CubeSats that have a resolution better than 4 meters.⁶⁴² The CubeSats would operate in SSO and LEO and have a revisit time of 30 minutes for key regions.⁶⁴³ In the longer term, ZeroG Lab would like to see the constellation reach 378 satellites and have a 10-minute revisit time anywhere in the world.⁶⁴⁴

The Lingque-1A, the first test satellite for the Lingque constellation, was successfully launched into orbit on a Long March 11 on January 21, 2019.⁶⁴⁵ A second test satellite, the Lingque-1B, was lost in a failed orbital launch attempt by OneSpace on March 27, 2019.⁶⁴⁶

In a 2018 interview, ZeroG Labs' general manager clarified that selling core satellite parts was the main driver of the company's sales.⁶⁴⁷ One of the products sold by ZeroG Labs is an onboard computer that the company claims helps decrease Chinese satellite developers' reliance on foreign imports.⁶⁴⁸

PERSONNEL

The general manager of ZeroG Lab was identified as Zhang Bei (张北).⁶⁴⁹

FACILITIES

ZeroG Lab is based in Beijing.⁶⁵⁰ The company's headquarters in Beijing includes a ground control station, completed in March 2018.⁶⁵¹

In April 2018, the company stated that it would work with Huaxun Fangzhou Co., Ltd to establish a CubeSat production facility in Shenzhen.⁶⁵² ZeroG Lab said that the Shenzhen facility would have an annual production capacity of 50 CubeSats and associated components.⁶⁵³

CAPITAL

ZeroG Labs' investors include Huaxun Fangzhou Co., Ltd and Yinxinggu Capital.⁶⁵⁴

In 2017, ZeroG Lab took in more than 10 million CNY through sales of core satellite components.⁶⁵⁵ In early 2018, the company's general manager said that he expected ZeroG Lab to report an income of 30 million CNY or more that year.⁶⁵⁶

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ABBREVIATIONS

AFDD	U.S. Air Force Doctrine Document
ASAT	Antisatellite weapons
BRI	Belt and Road Initiative
C4ISR	Command, control, communications, computers, intelligence, surveillance, and reconnaissance
CALT	China Academy of Launch Vehicle Technology
CAS	Chinese Academy of Science
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science and Industry Corporation
CCP	Chinese Communist Party
CGWIC	China Great Wall Industry Corporation
CMC	Central Military Commission
CMI	Civil-military integratio
COPUOS	Committee on the Peaceful Uses of Outer Space
CNP	Comprehensive national powe
CNSA	China National Space Administration
CNY	Chinese yua
COPUOS	UN Committee on the Peaceful Uses of Outer Space
COTS	Commercial Orbital Transportation Services
CTO	Chief technology officer
DOD	U.S. Department of Defense
FYP	Five-Year Plan
GEO	Geosynchronous Earth orbit
GPS	Global Positioning System
HSAR	Hyperspectral SAR
ISS	International Space Station
KKV	Kinetic kill vehicle
LEO	Low Earth orbit
MCF	Military-Civil Fusion
MIIT	Ministry of Industry and Information Technology
MLP	Medium and Long-term Plan for Science and Technology Development
NASA	National Aeronautics and Space Administration
NDRC	National Development and Reform Commission
NDS	U.S. National Defense Strategy
NPC	National People's Congress
NSS	U.S. National Security Strategy
PLA	People's Liberation Army (PRC)
PRC	People's Republic of China

R&D	Research and development
S&T	Science and technology
SAR	Synthetic-aperture radar
SASTIND	State Administration for Science, Technology, and Industry for National Defense
SBSP	Space-based solar power
SOE	State-owned enterprise
SPD	Space Policy Directive
SSO	Sun-synchronous orbit
SSPS	Satellite solar-power station/system
ULA	United Launch Alliance
UNOOSA	UN Office for Outer Space Affairs

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