AMERICAN FOREIGN POLICY COUNCIL

Space Policy Initiative

Space Policy Review

China's Space Ambitions: Drivers, Goals, and Capabilities

By: Namrata Goswami

The Big Picture

- The mission of China's space program is to protect its national rights and interests and to build up its overall strength—the space program serves China's overall national strategy.
- China plans to establish itself as the world leader in space by 2049, the 100th anniversary of the establishment of the People's Republic of China.
- The key drivers are assuming leadership in space, regime legitimacy and internal national development, economic development of space and entrepreneurship, and national security.
- China's civilian space capacity is led by its independent space launch system, its BeiDou navigation system, its ability to maintain a human presence in low Earth orbit, and its missions to the Moon and Mars. The PRC is developing reusable space launch capability.
- China is developing space capabilities for countering adversaries, including kinetic kill, co-orbital, electronic warfare (satellite jammers), ground-based lasers, space robotic capacities with a robotic arm, reconnaissance, and surveillance. These capabilities are intended to create space access for China and to deny access to its adversaries in times of conflict.

Assessing China's space program is vital to understanding how investments in space add to a country's comprehensive national power. An analysis of China's space program drivers, goals, and capabilities makes it evident that the Chinese Communist Party (CCP) leadership has prioritized investments in space as a key area of innovation and technology. China has robust civilian and military space structures, inspired and institutionalized by a civil-military integration strategy, with the aim of emerging as a lead actor in space by 2049, the 100th anniversary of the establishment of the People's Republic of China (PRC). To better shape U.S. space policy, it is critical to understand the drivers that inform China's space program, its space goals, and its space capabilities in the civilian, military, and commercial arenas.

Chinese Space Strategy

China views space as part of its grand strategy for comprehensive national power and as critical for its national rejuvenation. First and foremost, China's space program is informed by lessons learned from the "century of humiliation," when China was caught off guard because it hadn't recognized the critical importance of defending its maritime and land borders against external invasion.[1] Consequently, China recognizes that maintaining freedom of access to its space lines of communication is vitally important for national security.

In a white paper titled "China's Space Program: A 2021 Perspective," the State Council of the PRC stated

Namrata Goswami, Ph.D. *is an author, professor and consultant on Great Power Politics, Space Policy and International Relations. She teaches at the Thunderbird School of Global Management, Arizona State University, and is a consultant for Spacefund Intelligence. She is co-author of the book Scramble for the Skies: The Great Power Competition to Control the Resources of Outer Space. All views are her own.*
Research for this paper was funded by the Nonproliferation Policy Education Center.

that "the space industry is a critical element of the overall national strategy"[2] and that the mission of China's space program is to "protect China's national rights and interests, and build up its overall strength." It stated further that the core principle of China's space program is that "China's space industry is subject to and serves the overall national strategy."[3] Critically, according to the white paper, China aimed to further develop its space infrastructure within the next five years (2021–2025) to include remote sensing satellites, the BeiDou navigation system, human spaceflight, dual-antenna X-band interferometric synthetic aperture radar (InSAR), lunar and asteroid probes, planetary defense, nuclear propulsion, in-orbit service and maintenance, and reusable space transport systems.[4] Since 2017, Chinese President Xi Jinping has incorporated his idea of a "Chinese Dream" of national rejuvenation into the CCP Constitution,[5] and space forms an integral part of that Chinese Dream.[6] In April 2020, the powerful National Development and Reform Commission identified space as "new infrastructure," thereby prioritizing investments in building space capability, propelled by Xi's innovation and Made in China 2025 policies.[7]

Funded with an annual budget of approximately $11 billion (based on open-source data, since China does not publish an official space budget),[8] China has had ambitions to establish a permanent space station by the end of 2022,[9] a Lunar research outpost by 2036,[10] and a solar power satellite transmission capacity from geosynchronous orbit (GEO) by 2050.[11] In addition, China plans to establish itself as the world leader in space by 2049, the 100th anniversary of the establishment of the PRC.[12] Beyond its civilian space ambitions, China has invested in developing its military space capability specifically to augment its information warfare capacity for military command, control, and communications; positioning, navigation, and timing for independent missile launch and tracking, as well as sea-based launch for avoiding detection. In the commercial sphere, Chinese private space companies, such as OneSpace, launched to orbital space in 2019 and plan to develop reusable rockets—a critical goal for the years 2021–2025, per the 2021 CNSA white paper. China has invested up to $3 billion in its private space sector annually since 2018.[13] According to a document released in 2015 by China's State Council, titled "Guiding Opinions of the State Council on Innovating the Investment and Financing Mechanisms in Key Areas and Encouraging Social Investment" (otherwise known as Document 60), a key goal for China is to encourage investments in the private space sector and help to subsidize innovation in key space technologies to gain strategic advantage.[14] Moreover, space has formed an integral part of China's Belt and Road Initiative (BRI) Spatial Information Corridor since 2018.[15] China has utilized policies to direct and rein in its own private space sector under its civil-military fusion strategy and its 2021 National Defense Law. This law is legally binding and states that

> All State bodies, armed forces, political parties, people's organizations, enterprises, public institutions, social organizations, and other organizations shall support and participate in accordance with the law in national defense development, and fulfill their national defense duties and tasks. … Any organization or individual who, in violation of this Law or other relevant laws, refuses to fulfill their national defense obligations or jeopardizes national defense interests shall be held legally responsible.[16]

Against this backdrop, Chinese leadership has been clear about its commitment to prioritizing space. The guiding framework for Chinese space policy is underpinned by several key drivers in the civilian, military, and commercial space arenas.

Key Drivers of China's Space Program

The key drivers of China's space program are assuming leadership in space, regime legitimacy and internal national development, economic development of space and entrepreneurship, and national security.

LEADERSHIP IN SPACE

Space-based solar power is applicable to a variety of in For China, leadership in space is critical as it grants China the ability to constitute the norms, rules, and regulations of space governance. It also guarantees that China's citizens will have the ability to access space for its economic prospects. In line with this driver, China's space behavior and strategy is informed by its historical texts, including Han Feizi and his focus on legalism, an assertive and strong leader, and a strong state;[17] Sun Tzu's *Art of War* and his focus on a comprehensive legitimate grand strategy;[18] and Mao Tse Tung's *On Guerilla Warfare* on how to gain the initiative by utilizing both engagement and disengagement of the adversary (space warfare).[19] President Xi has offered his concept of Chinese leadership in his Chinese Dream,[20] inscribed into the CCP Constitution in 2017.[21] In his communications with China's space scientists, Xi pointed out that China's dream was to become an aerospace power, with the space dream aimed at strengthening China's role in the world.[22] China has set itself a goal to exceed all others in space by 2049 in time for the 100th anniversary of the PRC. The driver for leadership is aimed at developing comprehensive power: industrial, logistic, diplomatic, and economic.[23] The goals, articulated by the China Academy of Launch Vehicle Technology, were published in November 2017 in the front pages of the *People's Daily*, the official newspaper of the CCP's Central Committee.[24] To classify China's space program as an exploration program is misleading. This is a program for industrial and economic dominance of Cislunar system (space between Earth and the Moon). As part of constituting leadership in space, China established the BRI Spatial Information Corridor in 2018, offering its BeiDou navigation system and other space infrastructure to the 151 partner nations of the BRI.[25] The BRI includes several U.S. allies, such as Greece, Italy, Saudi Arabia, the United Arab Emirates, New Zealand, and several NATO members, including Poland, Latvia, Lithuania, Estonia, Czech Republic, Bulgaria, Slovakia, and Romania. China has developed a concept termed 16+1 for Central and Eastern European countries that compliments the BRI.[26]

REGIME LEGITIMACY AND INTERNAL NATIONAL DEVELOPMENT

The CCP cares about regime legitimacy, both internally and internationally. Space plays an integral role in augmenting CCP regime legitimacy, by showcasing China's success under CCP guidance to explore and develop space. Adding to the CCP's legitimacy as a force for innovation in high-end technology are successful missions to the Moon and Mars; Lunar sample return; the successful launch of Tianhe; the cargo spaceship Tianzhou; the world's first quantum satellite, Micius; the Tiangong space station; and development of the BeiDou navigation system. Illustrating the centrality of Xi is the inclusion of his published thoughts as a manual that is now part of China's school curriculum, highlighting 14 principles and the centrality of the CCP in developing China into a first-rate power and a leader in science and technology.[27] During his speech to the 20th National Congress of the Chinese Communist Party, Xi specified the importance of China's investment in critical strategic technologies—such as artificial intelligence, space, and robotics—to China's emergence as a science and technology power.[28]

China's space program has been linked directly to internal national development since the space program began in 1956. Space is utilized for navigation, e-commerce, ATM transactions, disaster relief, weather prediction for agriculture, fishery, e-education, telemedicine, tele-education, satellite television, and satellite internet. Almost all of China's white papers on space highlight the vital connection between space and comprehensive national development.[29] China views space as an infrastructure, critical for internal national development and international recognition as a great power in space.

ECONOMIC DEVELOPMENT OF SPACE AND ENTREPRENEURSHIP

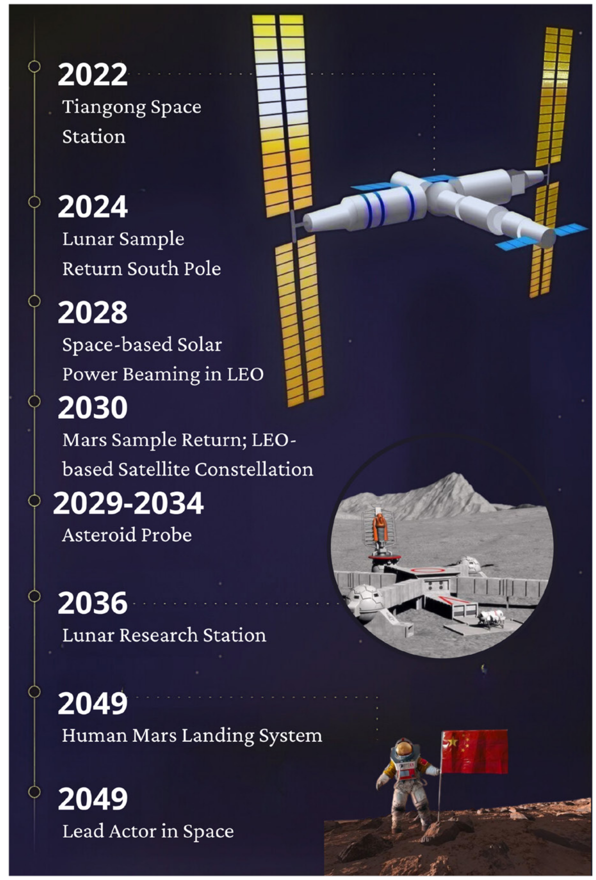
The economic dimension of space and its future potential is highlighted as crucial for China's space program. The Earth-Moon zone is predicted to generate around $10 trillion annually by 2050.[30] The BeiDou navigation system, established with an investment of $9 billion, is predicted to generate $59 billion in revenue for China annually.[31] Researcher Li Mingtao, with the National Space Science Center, indicates that China's investment in space mining might become a new engine for the global economy.[32]

Since 2016, China has been creating avenues for encouraging its private space sector and subsidizing entrepreneurship. As stated earlier, clear direction has been offered for the private space sector via China's Document 60. Moreover, subsidized rates for access to spaceports maintained by the People's Liberation Army (PLA) are offered for launches by Chinese private companies; in addition, China has made financial investments in developing 5G satellite networks as well as reusable launch systems. Chinese private space companies are building small satellites, working on creating a 5G satellite constellation in low Earth orbit (LEO), and investing in commercial space launch sites.

NATIONAL SECURITY

China awoke to the national security aspect of space during the Gulf War of 1991 as it watched U.S. space-based support "coordinate forces beyond 'line of sight', target and track integrated air defense system, and use its Global Positioning System (GPS) for precision strike, and anticipate when missiles were incoming."[33] China suddenly understood the inefficacy of its own surface-to-air missile defense system in light of U.S. space capacities. China saw the 1996 Taiwan Strait crisis as a humiliation when it lost sight of two of its missiles over the strait, allegedly due to the U.S. cutting off GPS signals over the Pacific.[34] Consequently, China developed its own version of GPS—the BeiDou navigation system. China has now strengthened the national security dimensions of space by focusing on developing overhead sensing, long-term over-the-horizon communication, missile warning and tracking, anti-satellite weapons, rendezvous and proximity operations, blinding and dazzling weapons, a dual-use robotic arm capacity, and an independent capacity to guide its own missiles. The Political Bureau of the CCP Central Committee established the Central Commission for Integrated Military and Civilian Development (CCIMCD) in January 2017, the first such body dedicated to civil-military integration to be established by the top CCP leadership.[35] In March 2018, Xi presided over a plenary session of the CCIMCD.[36] In this session, Xi urged private companies across sectors (including private space startups) to locate their work within this civil-military integration strategy, in order to build integrated national strategic systems and capabilities.

Figure 1. China's Space Goals



Source: American Foreign Policy Council

With these four drivers—leadership in space, regime legitimacy and internal national development, economic development of space and entrepreneurship, and national security—in mind, let us now assess China's space goals and its space capabilities.

China's Space Goals

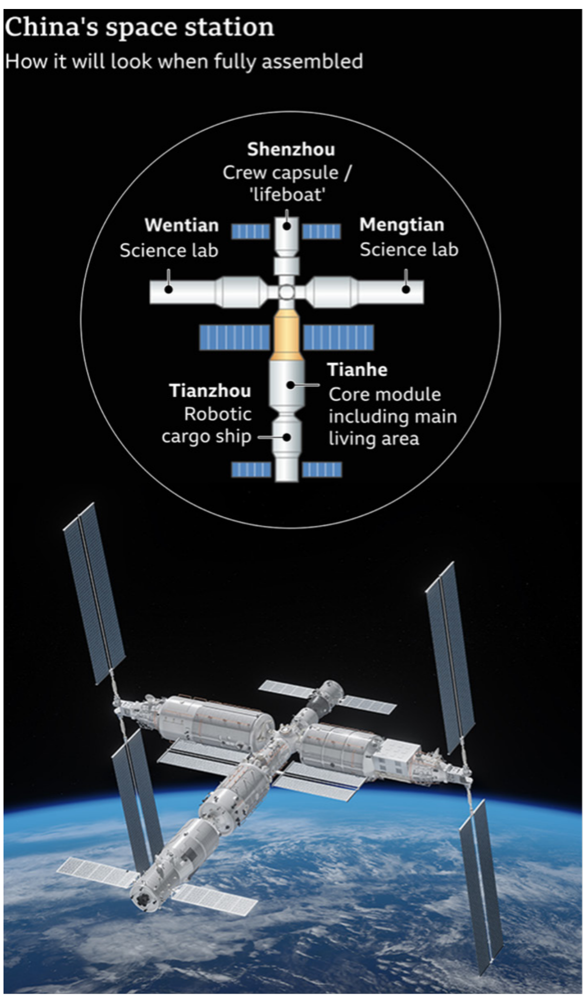
China supports and funds one of the world's most ambitious space programs. Viewing space investments as part of a larger infrastructure and logistical industrial development, China points out that its space investments will build resilient national systems that will help China to develop internally and internationally. Among China's foremost space goals are to build its own permanent space station (the Tiangong, which was completed in late 2022); build its Mars robotic missions, including Mars sample return, by 2030; develop its Lunar robotic mission program and establish a Lunar station on the Moon by 2036; develop a human landing system for Mars by 2049; construct space-based solar power satellites in GEO by 2050; construct asteroid probes (2029–2034); and develop planetary defense.[37] China also aims to assemble, by 2030, a resilient space support structure with a fleet of satellite constellations that includes both civilian and military satellites.

PERMANENT SPACE STATION

Foremost among China's goals for space logistics and infrastructure are its plans to build its own permanent space station called the Tiangong. On April 29, 2021, China launched the core lab of the Tiangong, called the Tianhe. The Tianhe, now in its orbital slot in LEO, 350–450 km above Earth, is the management module of the Tiangong, with the ability to dock three spacecraft for short periods of time. The Tianhe is designed for a lifespan of 10 years. The Tianhe is the largest spacecraft that China has launched to date. According to Bai Linhou, the deputy chief designer of Tiangong at the China Academy of Space Technology (CAST), "We will learn how to assemble, operate and maintain large spacecraft in orbit, and we aim to build Tiangong into a state-level space lab supporting the long stay of astronauts and large-scale scientific, technological and application experiments."[38] Bai elaborated that China's space station will build the capability to utilize space resources as well. In June 2021, China launched its first crewed mission of three astronauts to the Tianhe, for a period of three months, to help construct the space station.[39] The astronauts also tested the new extravehicular suits. Critically, China's cargo spacecraft, the Tianzhou-2, launched supplies to the Tianhe, as part of the logistical system. With its construction completed in November 2022, the Tiangong has a core module, the Tianhe, as well as two labs, the Wentian and the Mentiang. The Wentian will be used for scientific experiments as well as living space and will have a robotic arm to carry out extravehicular activities; the Mentiang will be similar in function and make. The Tiangong is a T-shaped space station with a maximum weight of about 66 tons, and it can support up to six astronauts for a period of up to six months, the longest such presence in space by Chinese astronauts.[40] The station is geared by electric propulsion and has two flexible solar panels. The main experiments that Chinese space scientists will conduct are related to how humans can survive for longer periods in space.

As part of China's 14th Five-Year Plan (2021–2025), the National Natural Science Foundation of China allocated $2.3 million for Chinese scientists to study the feasibility of in-orbit assembly of a kilometer-wide space station.[41] The thrust of this project is to reduce the cost of launching construction materials to space. In November 2022, Zhang Lu, a researcher at the Chinese Academy of Sciences (CAS) in Beijing, announced that China will be conducting a reproductive experiment using monkeys on the Wentian space module, which is expandable and can accommodate multiple life sciences experiments such as studies of algae, fish, and snails. These experiments are being conducted to assess an "organism's adaptation to microgravity and other space en-

Figure 2. China's Tiangong Space Station



Source: BBC

vironments." Kehkooi Kee, a professor with the School of Medicine at Tsinghua University, has led in-orbit stem cell experiments and argues that "as more nations plan for long-term settlements in orbit around the moon or Mars, 'these experiments will be necessary'."[42] China is launching a space telescope, called the Xuntian, that will orbit close to the space station and be used in observations of space.

CHINA'S LUNAR EXPLORATION PROGRAM

On January 14, 2019, a few days after China successfully landed humanity's first robotic probe on the far side of the Moon with its Chang'e 4 mission, Wu Yanhua, deputy head of the CNSA, announced that, by the end of 2019, China would launch Chang'e 5 to bring Lunar samples back to Earth. This would be followed by Chang'e 6 (2024-2025), aimed at bringing samples from the South Pole, and Chang'e 7 (2028), which will survey the South Pole to evaluate its composition. Chang'e 8 (2030) will test key technologies such as 3D printing to lay the groundwork for construction of a scientific base on the Moon (2036).[43] In March 2021, China signed a memorandum of understanding with Russia to build the International Lunar Research Station on the Moon.[44]

In December 2020, a year behind schedule but successfully, China brought back samples from the Moon via its Chang'e 5 mission and unfurled its first fabric flag on the Moon, a feat much lauded as establishing Chinese technology and leadership on the Lunar surface. Wu Yanhua, in a special press conference at the State Council Information Office in Beijing, stated that "the successful mission is a new milestone in the development of China's space industry, proving that China has mastered the technology for shuttling between Earth and the Moon."[45] China's Lunar program is propelled by visions of resource prospecting. Scientists at the Technology and Engineering Center for Space Utilization of the Chinese Academy of Sciences tested 3D printing technology in microgravity by successfully completing a ceramic testing technology in 2018.[46] According to Wang Gong, director of the CAS Key Laboratory of Space Manufacturing Technology, this evaluated Chinese capability to build bases on the Moon and Mars, as well as in situ resource utilization and space manufacturing with space-based resources.[47] The use of ceramics is instructive as it is similar in composition to Lunar silicate particles. As Wang put it, "Elon Musk and SpaceX are developing technologies to take people to other planets, and we are developing technologies to help them survive."[48]

Wu Weiren, the chief scientist of the China Lunar Exploration Mission, stated in 2005 that "our short-term goal is to orbit the Moon, and land on the Moon, and take samples back from the Moon. … [O]ur long-term goal is explore, land and settle. We want our manned lunar landing to stay for longer periods and establish a research base," [49] a goal now articulated with Russia. Wu believes that the critical step forward is to establish a Lunar palace especially on the South Pole by 2030, given the presence of sunlight and water-ice there. Beihang University in China experimented with a simulated Lunar module in 2018, in which eight students lived in a Moon lab for 370 days, to study how a regenerative life support system might work.[50] Significantly, the Chang'e 4 carried a 3 kg (0.8 L) aluminum alloy cylinder—containing seeds of cotton, potatoes, and *Arabidopsis* (a plant related to cabbage), as well as silk worm eggs.[51] The idea was to study whether potatoes (food for Moon settlers) and silk worms can flourish on the Moon in a simulated mini-biosphere. According to the mission chief, Liu Hanlong, the idea was to study the process of developing food for space travelers on the Lunar surface. Liu specified, "Our experiment might help accumulate knowledge for building a Lunar base and long-term residence on the Moon."[52] In May 2018, the Queqiao relay satellite, or Magpie Bridge, was placed in the Lagrange (L2) halo orbit to serve as a communication relay satellite from the Chang'e 4.[53] Queqiao can peer into the Lunar polar craters, identifying future landing zones for China's probes in the shadowed regions, as part of recognizing the critical importance of L2 in Cislunar space. In 2024, China will launch the Queqiao 2, to support the 2024–2025 Chang'e 6 Lunar South Pole mission, the first of a series of missions to the Lunar South Pole in support of establishing a Lunar research base.[54]

SPACE-BASED SOLAR POWER

In 2019, China became the first country to establish a state-funded space-based solar power (SBSP) base plant.[55] The plant, in Chongqing's Bishan district, is being constructed under the guidance of the Chongqing Collaborative Innovation Research Institute for Civil-Military Integration (CCIRICMI) in southwestern China in partnerships with researchers from Chongqing University, CAST's Xi'an Branch in Shaanxi province, and Xidian University. The initial $15 million investment for the

Figure 3. China Space-based Solar Power Timeline

Source: American Foreign Policy Council

SBSP plant was made by the Bishan district government. Technologies being tested include the construction of SBSP satellites in GEO using automated assembly and wireless power transmission.[56] Li Ming, senior vice president of CAST, asserted that China will lead the world in this critical renewable energy source.[57] The key challenges that the plant will be testing are microwave transmission of electricity and in-space manufacturing of SBSP satellites. Xie Gengxin, deputy head of CCIRICMI, stated:

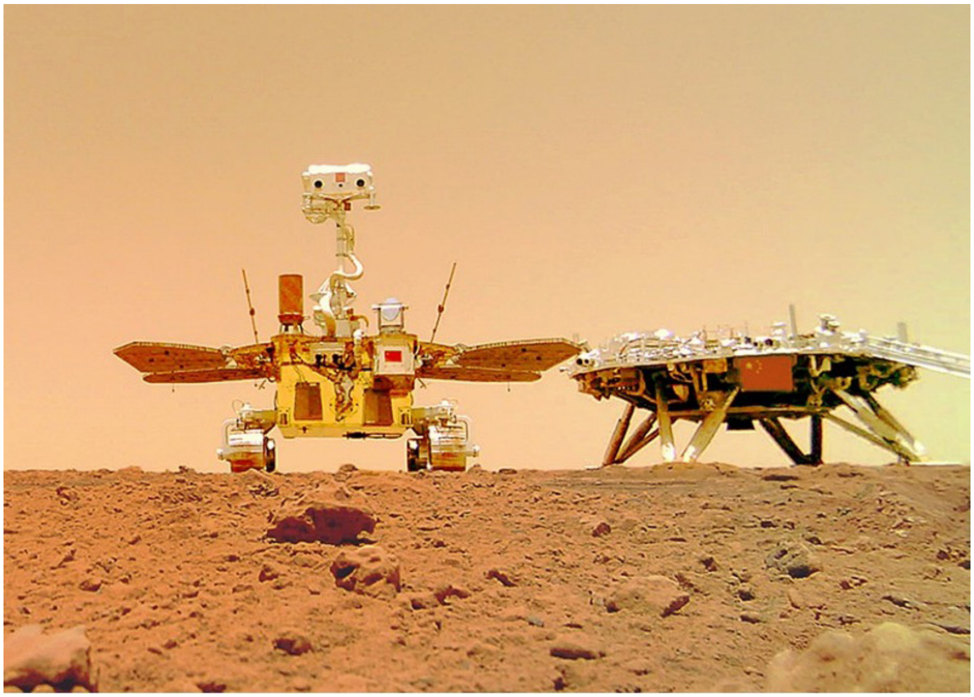
> We plan to launch four to six tethered balloons from the testing base and connect them with each other to set up a network at an altitude of around 1,000 meters…. [T]hese balloons will collect sunlight and convert solar energy to microwave before beaming it back to Earth. Receiving stations on the ground will convert such microwaves to electricity and distribute it to a grid. … [I]f everything goes well, a Chinese solar power station will be put into orbit about 36,000 kilometers above Earth and start generating power before 2040.[58]

Wang Xiji, the chief designer of China's first rocket, the Long March 1, advocates for SBSP in China. Wang believes that "the world will panic when the fossil fuels can no longer sustain human development. We must acquire space solar power technology before then…. Whoever obtains the technology first could occupy the future energy market. So it's of great strategic significance."[59] Wang further says that "once completed, the solar station, with a capacity of 100MW, would span at least one square kilometre, dwarfing the International Space Station and becoming the biggest man-made object in space."[60] Wang believes that China needs to act quickly on an SBSP program to ensure that it is ahead of the United States and Japan on this critical renewable technology and to occupy strategically important locations in space.[61] The timeline for China's SBSP ambition is to carry out the first 100 kW SBSP demonstration at LEO by 2025, a 1 mW SBSP demonstration in GEO by 2030, and a 100 mW SBSP demonstration by 2035; construct a SBSP satellite to orbit (36,000 km) above Earth and start generating power by 2040; and establish the first commercial SBSP satellite in operation in GEO by 2050.[62]

MARS MISSION

China officially announced its first independent Mars mission in 2016, with an aim to orbit, land, and send out a rover to the Mars surface. China's first attempt to send a Mars orbiter, atop the Russian rocket Phobos-Grunt in 2011, failed to leave LEO and fell back into the Pacific Ocean.[63] In July 2020, China launched the Tianwen 1, which landed on the Mars surface in February 2021, making China the second country after the United States to have a successful landing mission that communicated back to Earth. For China, the goal of the Mars mission

Figure 4. China's Mars Rover



Source: Space.com

is to build capacity to develop settlement on the most Earth-like planets. In 2019, China opened its first Mars simulation base (at 53,330 square meters, with a cost of $22.3 million) in Mangai, located in the arid desert region of Qaidam Basin in the Qinghai-Tibet plateau, aimed at introducing people to life in a Mars-like environment. This region's barren, rocky landscape closely resembles the topographic conditions found on Mars.

Similar to the relay technology developed for China's Lunar far-side mission, China has developed relay capability for Mars communication. The Mars landing also developed further China's automated landing as the Mars atmosphere required a heat shield as well as a parachute and thrusters to slow the descent of the lander. Jia Yang, the deputy chief designer of the Chang'e 3 probes, specified that "the Mars rover should be able to sense the environment, plan its route, conduct scientific exploration and detect faults autonomously. It should be a mobile intelligence."[64] In fact, after the lander made it to the Mars surface and sent out the rover in May 2021, the message from the orbiter was delayed by 17 minutes in reaching Earth due to the 320-million-km distance between Earth and Mars. By orbiting Mars, landing on the planet, and sending out the rover, China became the first country to successfully achieve all three goals in its first independent attempt.[65] China plans to execute a Mars sample return and establish a Mars human landing system and a Mars base by 2049. Wang Xiaojun, the head of the China Academy of Launch Vehicle Technology (CALT), in his presentation on "the Space Transportation System of Human Mars Exploration," highlighted some of the key technologies for

Figure 5. China's Mars Timeline

Source: American Foreign Policy Council

Mars under consideration. Besides Mars sample return (2030), there are plans to develop robotic exploration of a site for a Mars base (2035), the human mission (2037), the building of a Mars base (2041), and the establishment of an Earth-Mars cargo system (2043). The technology that China views as enabling these Mars logistics is nuclear propulsion, something that China is working toward building. Wang referred to the logistics as a "sky ladder" system.[66] The road map for Mars was revealed by CALT.[67]

ASTEROID PROBES AND SPACE MINING

China has announced that it plans to have an asteroid exploration mission by 2025.[68] The aim of this mission will be to collect samples from the near-Earth asteroid (NEA) Kamo'oalewa, and the same spacecraft, once it delivers the samples to Earth, will then be launched to the asteroid belt. This particular asteroid mission is being named after Zheng He, the 15th century Chinese explorer and admiral of China's famous treasure ships.[69] The mission will utilize nanotechnology to carry out exploration of the Comet 133P/Elst–Pizarro. Russia has joined China on this asteroid mission.[70] According to a CAST paper,

> ZhengHe flies an over ten-year mission, launching in 2022 to reach the NEA 2016HO3, return 200-1000g sample back to earth within 2-3 years, then continue its journey to rendezvous with the Main Belt comet 133P/Elst-Pizarro just before it reaches perihelion in 2030 and remain there for one year to carry on remote sensing and in-situ measurement.[71]

The second target would be Comet 311P, a main comet in the asteroid belt.[72] In its 2021 white paper on space, the CNSA identified planetary defense as a critical area of study and leadership for the years 2021–2025. Chinese space scientists are working on plans to capture a NEA and bring it to Earth to inspect and extract its resources. Li Mingtao, of the National Space Science Center, along with his research team, details that plan.[73] The idea is for a spacecraft to bag an asteroid and push it over Earth, followed by a heat shield that unfolds, reducing the velocity of the asteroid as it enters Earth's atmosphere. The landing must be carefully controlled so that the asteroid lands in an area far from human habitation. Li is working in collaboration with scientists from the Qian Xuesen Laboratory of Space Technology to place satellites in the heliocentric Venus orbit, in order to search and analyze NEAs with a diameter of 10 m. The challenge after capture would be to drop the speed of the asteroid from 12.5 km/s to 140 m/s before it touches down on Earth. The timeline for such a launch to capture an asteroid is 2029, and the aim is to bring the asteroid back to Earth around 2034. A NEA like 3554 Amun, approximately 2 km in diameter, contains nickel and iron (worth $8 trillion), cobalt ($6 trillion), and gold and other precious metals ($6 trillion), together totaling $20 trillion.[74] Based on such estimates, Li asserts that

> Space mining might become a new engine for the global economy…. Unlike missions to bring samples back, we aim to bring back a whole asteroid weighing several hundred tonnes, which could turn asteroids with a potential threat to Earth into usable resources…. Our analysis shows that maneuvering a small asteroid is feasible in principle, and could bring enormous economic and social benefits.[75]

CHINA'S NATIONAL SATELLITE CONSTELLATION

Under direction from the China National Development and Reform Commission, in which the development of satellite internet is identified as "new infrastructure," China has established a national plan to develop a national satellite mega-constellation of 12,992 satellites, as per filings with the International Telecommunications Union (ITU). The national satellite constellation is called the Guowang ("national network") satellite internet project.[76] Bao Weimin, a senior member of the National Committee of the Chinese People's Political Consultative Conference and director of the Science and Technology Committee of the Aerospace Science and Technology Group, specified that a national grid company (Guowang) will be established to maintain this mega-constellation.[77] This satellite internet project is supported by China's 14th Five-Year plan.

China's Space Capabilities

China's aspiration to become a dominant space power is not just a plan. China is far along its path to making this a reality. The aforementioned key drivers and space goals are cemented in a foundation of current capabilities. China is focused on developing its current and future capabilities in the civilian, military, and commercial space arenas.

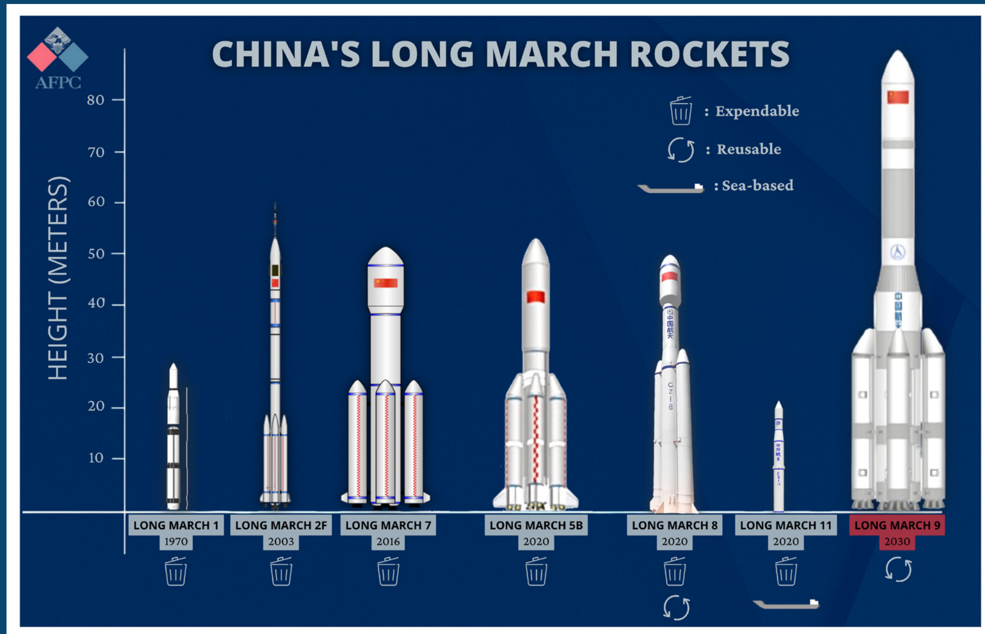
CIVILIAN SPACE CAPABILITIES

China's civilian space capacity is led by its independent space launch system, its independent BeiDou navigation system, its ability to maintain human presence in LEO, and its missions to the Moon and Mars.

Independent Launch Capability

China possesses an advanced independent space launch capability. Named the Long March (Chang Zheng) rocket series, Long March 1 was based on the Dong Feng 3 intermediate-range ballistic missile. The Long March 1 launched China's first satellite into orbit in 1970. The Long March 2 was based on the Dong Feng 5 intercontinental ballistic missile, and the Long March 2F launched China's first astronaut, Yang Liwei, to space in 2003. Since 2016, China has developed a new series of rockets called the Long March 5, 6, and 7. The Long March 5B has been developed specifically to launch the space station, as well as missions to the Moon. Wang Xiaojun, the head of CALT, stated that the Long March 5B will expand China's aerospace capabilities. Compared to 14 tonnes to LEO by the Long March 5, the Long March 5B, which took 10 years to build, can carry 22 tonnes to LEO and 14 tonnes to GEO. The rocket's chief designer, Li Dong, stated that "the development of the new carrier rocket also helps lay the foundation for the research and development of China's heavy-lift launch vehicle."[78]

Figure 6. China's Long March Rockets



Source: American Foreign Policy Council

The development of launch systems is critical for meeting China's stated space goals. For instance, the Long March 5B, which suffered two prior failed launched attempts,[79] was the rocket that launched China's Mars mission and its Chang'e 5 Lunar sample return mission. In June 2019, China also successfully launched the Long March 11 from a mobile launch platform in the Yellow Sea off the coast of China's Shandong province. This achievement is strategically important as it offers China a flexible platform to launch, brings down costs as the launch location is close to the Equator, enables rapid responses in times of conflict, helps in stealth capabilities for launch as mobile sea space launches are difficult to find, and provides a solid propellant rocket that can launch quickly. This solid propellant capability is similar to the DF-21 medium-range ballistic missile (MRBM) and the DF-26 intermediate-range ballistic missile (IRBM).[80]

Long Lehao, an academician of the Chinese Academy of Engineering and a chief designer at CALT, which builds the Long March rockets, specified China's launch goals by 2030: "The capacity of Chinese rockets would reach 140 tonnes for low-Earth orbit, 44 tonnes for Earth-Mars transfer orbit, 50 tonnes for Earth-Moon transfer orbit, and 66 tonnes for geosynchronous transfer orbit in 2030." By 2030, China will have the Long March 9, its super heavy lift rocket, whose version 22 is going to be reusable.[81] The Long March 9 is designed to carry a payload of 140 metric tons to LEO, a 50-tonne spacecraft to a Lunar transfer orbit, and a 44-tonne payload to Mars transfer orbit.[82] Importantly, in its justifications for the Long March 9, China listed the following four goals: (1) launch of a Mars robotic exploration mission, which requires 41-tonne payloads; (2) manned Mars missions; (3) deep space missions; and (4) "constructing orbital solar power plant with 10,000 MW capacity, massing some 50,000 tonnes, requiring 620+ launches."[83] Reusability is a key core space priority, as outlined in the 2021 CNSA white paper on space.[84] The Long March 8 is among the rockets

Figure 7. China's Space Launch Sites

Source: American Foreign Policy Council

considered for reusability—it launched in December 2020 with a capacity of 4.5 tonnes to Sun synchronous orbit.[85] The Long March 8 is viewed as a medium-sized rocket, and the first stage of the Long March 8 will become reusable by 2025. China Aerospace Science and Technology Corporation (CASC), the developer of the Long March 8, stated that the entire rocket will become reusable by 2035. The Long March 8 will be equipped to make changes to its flight path autonomously if it encounters a malfunction.[86]

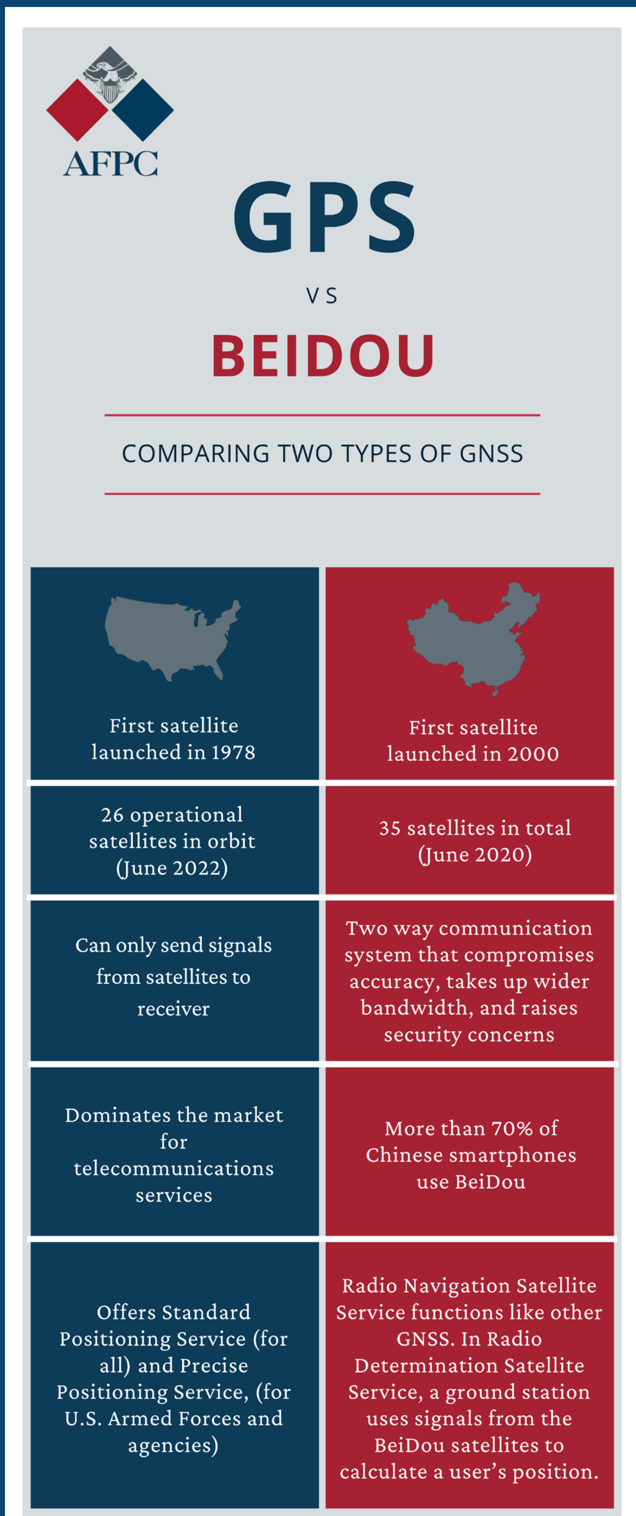
China has four spaceports. These include the Jiuquan Satellite Launch Center in the Gobi Desert, Inner Mongolia; the Taiyuan Satellite Launch Center in Kelan County, Xinzhou, Shanxi province; the Wenchang Space Launch Site in Wenchang, Hainan province; and the Xichang Satellite Launch Center in Xichang, Liangshan Yi Autonomous Prefecture in Sichuan. A fifth spaceport is under construction in Ningbo, Zhejiang province. The spaceport will be equipped to support 100 launches in a year.[87] China is also building a ship that is 162.5 m long and 40 m wide, termed a "new type rocket launching vessel."[88] The vessel is capable of launching the Long March 11 and other similar-sized commercial rockets called the Smart Dragon series, which are developed by China Rocket Co. in affiliation with CALT. In December 2022, the Smart Dragon 3 launched from a ship in the Yellow Sea and successfully put 14 satellites into orbit.[89] The ship was built in the city of Haiyang, in Shandong province.[90] This floating sea launch ship will be utilized in the recovery of rockets.

BeiDou Navigation System

As of May 2022, China had launched 541 satellites; by comparison, the U.S. had launched 3,433, Russia had launched 172, and others countries had launched a combined 1,319, for a total satellite count of 5,465.[91] According to March 2023 analysis by astronomer Jonathan McDowell, there were 7,300 active satellites (based on data from SpaceX and the U.S. Space Force).[92] Almost 50 percent of that count (3,660 satellites) were owned by SpaceX as part of its LEO satellite constellation, Starlink.[93]

On June 23, 2020, China launched the 55th satellite of its BeiDou navigation system (BDS), providing a fully independent Global Navigation Satellite System (GNSS) as an alternative to the Global Positioning System (GPS), which is maintained by the U.S. Space Force. With this launch, "China is now able to extend influence in a multidomain environment (land, sea and space) via its BeiDou space system, which provides navigation to aircraft, submarines, missiles, as well as commercial services dependent on such navigation."[94] This Chinese information infrastructure consists of undersea cables, where China is dominant; space-supported links; and other Earth-based links. As an alternative to GPS, BDS enables China to further consolidate its hold on global infrastructure and rulemaking, form partnerships and alliances, and control the standards for information technology, mobile devices, 5G, self-driving cars and drones, and the broader internet of things.[95] It offers China an influence mechanism whereby countries dependent on BeiDou would hesitate to criticize China on political issues such as Tibet, the South China Sea, or Taiwan. This increases China's ability to coerce and compel. Wang Jingang, the chief deputy designer of the BDS-3 satellites, says, "It's a rare chance to devote my intelligence to a symbolic national project. … [P]eople still mainly depend on navigation by GPS, supplemented by BDS. I hope that in a few years, people can be navigated mainly by BDS."[96] BeiDou is now part of the BRI Spatial Information Corridor. The development of BeiDou reflects China's clear policy goal of taking the lead in navigation and offering better services to countries that require it, especially in the Asia-Pacific, Africa, and Latin America.

Figure 8. GPS vs. Beidou



Source: American Foreign Policy Council

Lunar and Deep Space Capacity

As mentioned earlier, China's stated objective is not merely to visit the Moon, but to explore and establish settlements in space. Lieutenant General Zhang Yulin, former deputy commander of China's Manned Space Program and former deputy chief of the Armament Development Department of the Central Military Commission, now with the PLA Strategic Support Force, highlighted the significance of the Moon in 2016 when he stated, "The earth-moon space will be strategically important for the great rejuvenation of the Chinese nation."[97] In the same interview, Zhang indicated that China will be investing in building capacity to generate solar power in space. He was clear on what China's space program focus should be in the long term: "The future of China's manned space program is not a moon landing, which is quite simple, or even the manned Mars program which remains difficult, but continual exploration of the earth-moon space with ever developing technology."[98] Toward this end, China is developing the ability to conduct operations in Cislunar space as well as developing new spacecraft that could take crewed missions to the Moon.

In a recent interview, Wu Weiren, the chief designer of the China Lunar Exploration Program, said that China is now in Phase 4 of its Lunar mission. This includes several landings on the South Pole of the Moon, with the goal of establishing a research base. Phase 4 will consist of the Chang'e 6, 7, and 8. Specifically,

> Chang'e-6 will attempt to retrieve one to two kilograms of samples from lunar pole regions and return them to earth. Chang'e-7 will land on the south pole of the moon, with the goal of looking for water ice and surveying the region's environment and landform. Chang'e-8 the phase finale will scout how to exploit the resources on the lunar south pole.

The South Pole of the Moon is advantageous due to its peaks of eternal sunlight as well as the presence of water-ice. Wu noted, "As the gravity on [the] Moon is only one sixth of the Earth's, it is easier for probes to take off and the spacecraft can also solve the fuel supply issues on the moon."[99] China is building a crew module for its human Lunar missions and has been actively testing the unit—it launched an uncrewed test in May 2020.[100] A human landing on the Moon is now anticipated by 2030. As mentioned in the section on China's space goals, China is also developing a Mars human landing system, asteroid probes, and planetary defense.

MILITARY SPACE CAPACITIES

China views its space competence as a critical component of its national power and directly linked to national security—one of the drivers for China's space program, as previously identified. The State Administration on Science, Technology and Industry for National Defense (SASTIND), which functions under the direction of the Ministry of Industry and Information Technology (MIIT), is the institution that directs China's space program.[101] SASTIND is responsible for

> nuclear weapon, aerospace technology, aviation, armament, watercraft and electronic industries. It is established to strengthen military forces with additional personnel and more advanced equipment. Ensuring material supplies for the army is its top priority. Furthermore, it intends to contribute to the prosperity of the whole country by stimulating the manufacturing industry, gaining competitive edges through with superior production techniques. As the administrative and regulatory agency of science, technology and industry for national defense, SASTIND serves the needs of national defense, military forces, national economy, and military-related organizations. Meanwhile, it is also responsible for the coordination of communications and cooperation on the use of nuclear power and space activities with countries and international organizations.[102]

Under SASTIND is the CNSA, founded in 1993, and the other state-funded space institutions, such as CAST, CALT, and CASC. The PLA plays a critical role in developing China's space program, including its human spaceflight program.

Xi Jinping has offered a clear policy guidance on civil-military integration.[103] This last point is critical as Xi is clear about what he wants from such a policy: What Xi terms "China's space dream" (now a part of his signature Chinese Dream and enshrined in the CCP Constitution)[104] is to utilize China's space capabilities to create the economic resources needed to maintain China's leading position in the world. In short, China wants its space program to contribute to comprehensive national power and the rejuvenation of the Chinese nation.[105] In fact, Xi, who is the chairman of the Central Military Commission (CMC), has frequently urged China's space sector to take up a leading role in his civil-military integration strategy.[106] Xi also specifies that all space agencies (civilian and military)—including the PLA Strategic Support Force (PLASSF), which was established in 2015—owe complete loyalty and allegiance to the CCP.[107] In an article published August 1, 2021, in *Qiushi Journal*, the flagship journal of the CCP, Xi stressed the critical principle of PLA loyalty to the CCP:

> [T]the fundamental principle and system of the Party's absolute leadership over the armed forces are the political characteristics and rooted advantages of the PLA forces that completely distinguish them from all other old-style armed forces … realizing the centennial goal [of the CCP's founding] is a major decision made by the CCP Central Committee and the CMC in pursuing a stronger military. It is a major task relating to China's overall security and development, and a crucial step in the modernization of national defense and the armed forces.[108]

China has demonstrated a key capability with its Shijian-21 (SJ-21) satellite grabbing one of its defunct satellites in GEO and throwing it 300 km away into a graveyard orbit where satellites are unlikely to hit other functioning spacecraft. The commander of U.S. Space Command, General James Dickinson, stated in April 2021 that China's SJ-21 "could be used in a future system for grappling other satellites."[109] The dual use of satellites for something like debris clearing and grabbing an adversary satellite in times of conflict is a realistic scenario. An on-orbit servicing, assembly, and manufacturing (OSAM) satellite, which the SJ-21 is believed to be, has this dual capability.

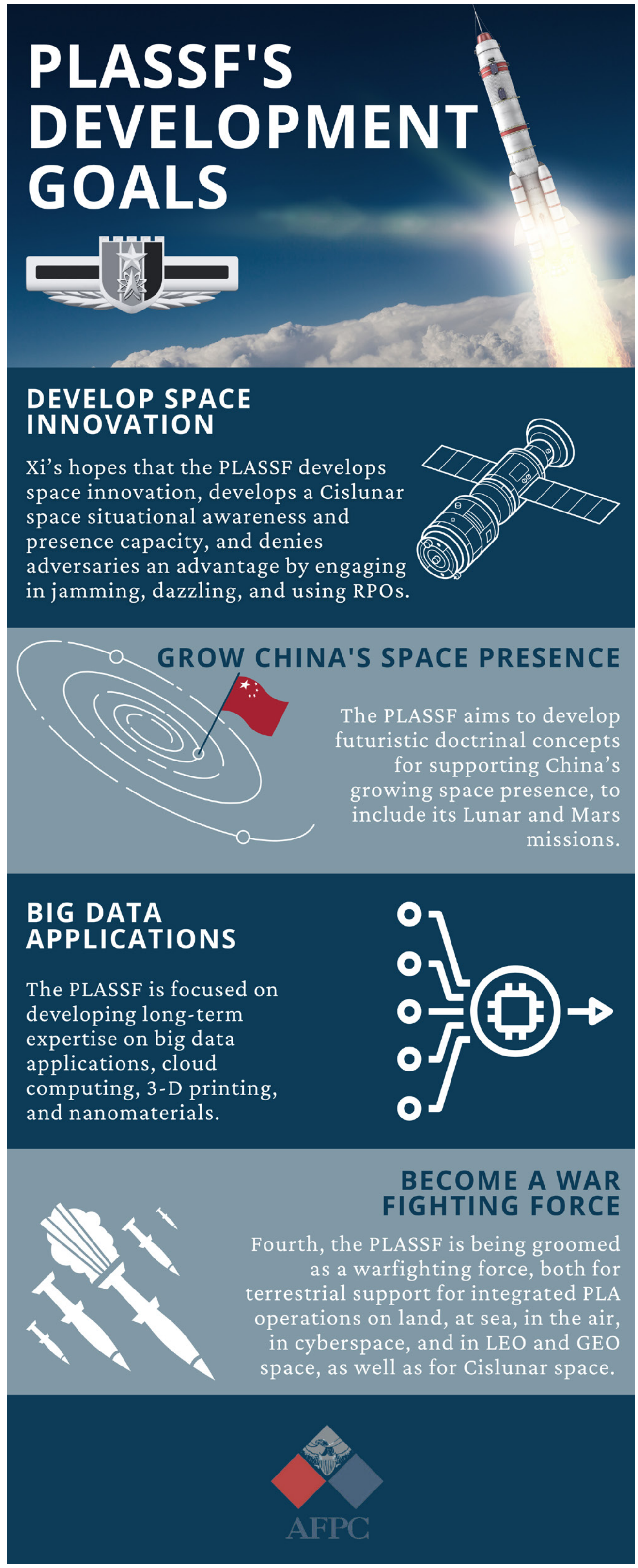
People's Liberation Army Strategic Support Force

In 2015, under the direction of Xi Jinping, China institutionalized a separate space service with the establishment of the PLASSF. In his speech to the new service on August 2016, Xi emphasized that "the strategic support force bears a historic mission, it must strive to be the best in the world and be brave in innovation and exceeding others…. [T]he force should always stay on alert and maintain combat preparedness, map out a development strategy and a capacity building plan, build a new training system, and enhance its deterrence and warfighting capabilities."[110] He stressed the need for innovation and creating new doctrinal concepts to steer the new service as it takes on new roles.

The PLASSF combines China's growing military space assets into a single unit, aimed at dominance across the spectrum of air, space, and cyber. The PLASSF is directed by Xi's civil-military integration strategy. In 2017, the PLASSF signed a cooperation framework agreement with the China University of Science and Technology, Shanghai Jiao Tong University, Xi'an Jiaotong University, Beijing Institute of Technology, Nanjing University, Harbin Institute of Technology, and other six universities, as well as China Aerospace Science and Technology Corporation, China Aerospace Science and Industry Corporation, and China Electronic Technology Group Corporation.[111] This agreement is aimed at civil-military integration to attract talent and innovation, to carry out special training based on technical expertise, and to allow a smooth transition between civilian agencies and the PLASSF.

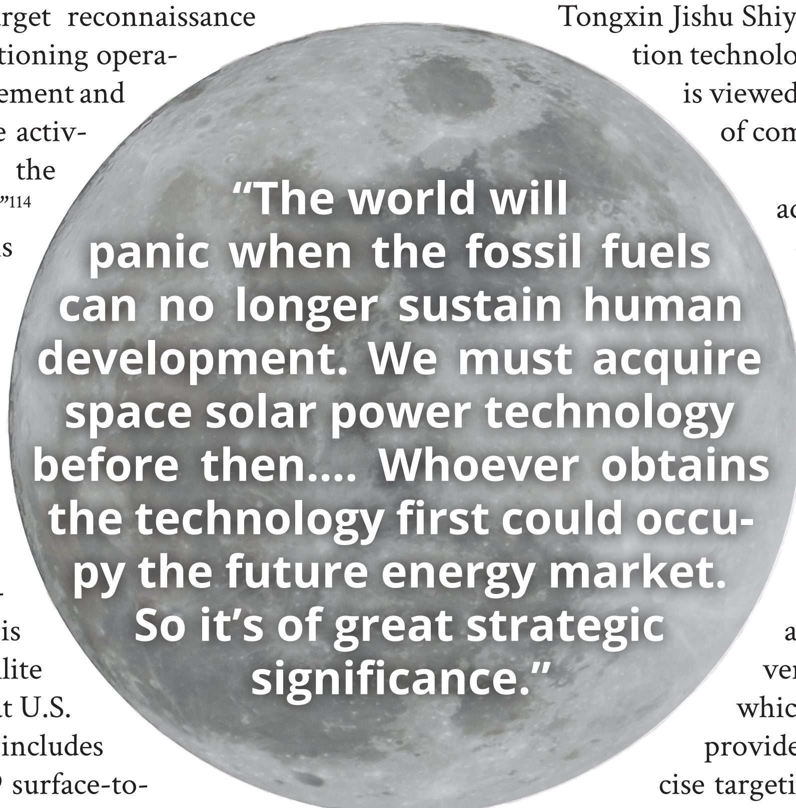
The PLASSF fulfills four key goals for China. First, as per Xi's direction, the service is optimized to develop space innovation, develop a Cislunar space situational awareness and presence capacity, and deny adversaries an advantage via their space system by engaging in jamming, dazzling, and rendezvous and

Figure 9. PLASSF Development Goals



Source: American Foreign Policy Council proximity operations.[112] Second, the PLASSF aims to develop futuristic doctrinal concepts for supporting China's growing space presence, to include its Lunar and Mars missions. Toward this goal, the PLASSF has partnered with China's private space sector since 2014.[113] Third, the PLASSF is focused on developing long-term expertise on "big data applications, cloud computing, 3-D printing and nanomaterials. Always prepared for tomorrow's war." According to Yin Zhuo, director of the PLA Navy's Expert Consultation Committee, "the PLA can maintain superiority in military operations taking place in space and involving the electromagnetic field and the internet…. [T]he force's responsibilities include target reconnaissance and tracking, global positioning operations, space assets management and defending against hostile activities in cyberspace and the electromagnetic field."[114] Fourth, the PLASSF is being groomed as a warfighting force, both for terrestrial support for integrated PLA operations on land, at sea, in the air, in cyberspace, and in LEO and GEO space, as well as for Cislunar space. Reports indicate that the PLASSF is training with anti-satellite missiles (ASATs) aimed at U.S. satellites. These ASATs includes the variant of the HQ-19 surface-to-air missile (utilized in ASAT tests in 2007 and 2010) and the DN-2 (2013) and the DN-3 (2015, 2016, 2017). According to the National Space and Air Intelligence Center report *Competing in Space*,

> China has military units that have begun training with anti-satellite missiles. Russia is probably also developing an anti-satellite missile. These missiles can destroy U.S. and allied space systems in low Earth orbit, making intelligence, surveillance, reconnaissance, and communications satellites vulnerable.[115]

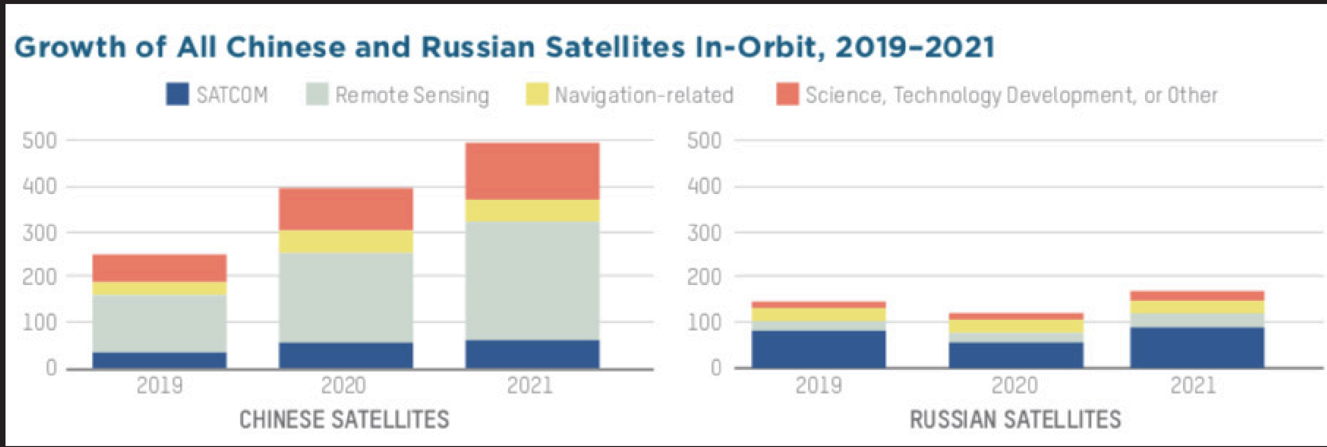


Military Satellites and ASAT Weapons

China possesses nearly 260 satellites for intelligence, surveillance, and reconnaissance, according to a 2022 U.S. Department of Defense report.[116] The functions of these military satellites can be divided into communication, early warning, meteorology, navigation, ocean surveillance, reconnaissance (optical and radar), signals intelligence (SIGINT), electronic intelligence (ELINT), and communication intelligence (COMINT). The Feng Huo (FH) series are data relay satellites that enable China to relay and pass data to ground receiving stations that are out of sight. Built by CASC, this series provides military units with both C-band and ultra-high-frequency (UHF) communications.[117] For early warning and detection, China possesses the Huoyan-1 series, of which the Tongxin Jishu Shiyan Weixing (communication technology test satellite, or TJSW) is viewed as co-linked for purposes of communication from GEO.[118]

An independent BeiDou adds to China's military command, control, and communications (C3) as well. China can now independently guide missiles and bombs onto fixed targets without fear that the United States could turn off GPS navigation services. BeiDou augments China's ability to guide its missiles very close to the target, after which a terminal seeker can provide active guidance for precise targeting. BeiDou augments independent military command and control by providing precise knowledge of the location of one's own forces and the ability to precisely target and provide navigation for military forces and strikes. This capability strengthens China's ability to coerce or compel others within its sphere of interest, such as on issues like the South China Sea, Taiwan, or Hong Kong. An independent BeiDou coupled with 5G means real-time military command and control and devastatingly accurate automated weapons systems.[119] Consequently, China recognizes the vital role that space plays for C3; positioning, navigation, and timing; informationized warfare; space access and presence; space-based communications systems; and developing counter-space capabilities vis-a-vis

Figure 10. Chinese Space Capabilities



Source: Breaking Defense

adversaries. For ocean surveillance and reconnaissance, China possesses the Yaogan, the Gaofen, the Tianhui, the Fanhui Shi Weixing (FSW), the Ludikancha Weixing (land surveying satellites. or LKW), and the Ziyuan (ZY) series of military satellites. Additionally, the Yaogan series is manufactured for Earth observation from LEO. These satellites are built by CAST and the Shanghai Academy of Spaceflight Technology.[120] For SIGINT, COMINT, and ELINT, China has the Yaogan series, the Tongxin Jishu Shiyan (TJS 1, 4, and 9), located in GEO, and the Ji Shu Shiyan Weixing (JSSW), a series of experimental military satellites.[121]

In 2007, China conducted an ASAT test that became infamous for creating a massive amount of debris. ASAT technologies have been further refined in 2010, 2013, and 2014, enhancing their capabilities without generating space debris. According to a 2020 U.S. Department of Defense report, "In 2019, the PRC described space as a 'critical domain in international strategic competition' and stated that the security of space provided strategic assurance to the country's national and social development."[122] Prioritizing the network-centric warfare approach, China is committed to developing its ASAT capacities in LEO and GEO.[123] Key bodies are the Space Systems Department in charge of PLA space operations, including launch, surveillance, missile tracking, and space warfare doctrine and concepts. Space capabilities that China is developing for countering adversaries include kinetic kill, direct ascent, co-orbital, electronic warfare (satellite jammers), ground-based lasers, space robotic capacities with a robotic arm, reconnaissance, and surveillance. These capabilities are intended to create access for China and to deny access to its adversaries in times of conflict.

As stated earlier, the PLASSF is training with ASAT capabilities, and China's missile systems create additive value. The SC-19 modeled on the DF-21C ballistic missiles is China's primary ASAT weapon, with a range of 2,150–2,500 km.[124] China also possesses the DF-26 IRBM and both a land and anti-ship missile, the DF-21A and DF 21E (nuclear tipped), and is predicted to possess 375 MRBM/IRBM missiles by 2025—up from 250 in 2020.[125] Most critically, about 75 of those missiles will be equipped with "hypersonics," especially the DF-17.[126] China has also increased its inventory of nuclear warheads, from 290 (in 2019) to 320 (in 2020).[127]

The *Financial Times* reported on July 27, 2021, that China had tested a nuclear-capable hypersonic glide vehicle that traversed LEO, circling Earth before striking close to its target at a speed of Mach 5.[128] China's Ministry of Foreign Affairs spokesperson, Zhao Lijian, denied the report that it was a nuclear hypersonic glide vehicle, instead stating that it was the test of a reusable spacecraft.[129] U.S. Air Force Secretary Frank Kendall stated that China's test could be similar to the Fractional Orbital Bombardment System developed by the Soviet Union.[130] China is believed to have launched a suborbital space plane in July 2021. CASC put out a press release stating that "on July 16, 2021, the suborbital reusable demonstration project carrier developed by the First Academy of China Aerospace Science and Technology Corporation Group Co. Ltd ignited and took off on time at the Jiuquan Satellite Launch Center. After completing the flight according to the set procedure, it landed smoothly and horizontally in Alxa

Youqi Airport." The press release described the flight as "a complete success."[131] Some observers suggest this development was motivated by the United States's X-37 robotic space plane, or Orbital Test Vehicle.

Commercial Space

Under the direction of Xi Jinping, China has been developing its commercial space capability, which was made a priority in 2014 when Document 60 was released by the State Council of the CCP to encourage China's private space sector.[132] Since then, there have been larger investments in China's private space sector as well as a focus on civil-military integration.[133] Since 2016, China's private space funding has increased to approximately $3 billion annually.[134] Private space companies have achieved orbital launch and are invested in developing critical technologies such as reusable space launch capability. Among the known private space companies are OneSpace, one of the first companies to successfully launch to suborbit,[135] followed by attempts made by Linkspace and Landspace. In August 2019, Linkspace experimented with the first of China's reusable launch vehicles, when its rocket reached an altitude of 300 meters before landing, intact, back on Earth.[136] Beijing Interstellar Glory Space Technology Ltd. (known as ispace) launched its Hyperbola-1 rocket into orbit in July 2019, marking the first such successful orbital launch by a Chinese private company.[137] China's ispace is aspiring to launch China's first reusable rocket into orbit, the Hyperbola-2.[138] In December 2021, Galactic Energy, a private space company, built and launched its four-stage Ceres-1 rocket, which placed five satellites in LEO. Also known as Gushenxing-1, the first Ceres-1 rocket was tested successfully in November 2020, making Galactic Energy the second Chinese space company, after ispace, to launch a rocket to LEO.[139] Galaxy Space, another Chinese space startup, aims to launch 142 5G satellites into orbit. China is planning to establish a commercial spaceport as part of its plan to build a modern space infrastructure.[140]

Scenarios and Conclusions

Based on the assessment of China's space program drivers, goals, and capabilities, it is evident that China aims to become a comprehensive great power in civilian, military, and commercial space arenas. China's space capability is focused on building space infrastructure for Lunar and Mars landings, space-based solar power, asteroid mining, and planetary defense. More important, China aims to build its own national satellite constellation, prioritizing the critical importance of satellite internet. It has also developed policy to encourage its private space sector via funding and subsidized access to its PLA-maintained launch sites. Most important of all, the vision for China's leadership in space comes directly from President Xi Jinping, who time and again has highlighted the need for China to innovate in technologies such as space, artificial intelligence, and quantum, to name a few. Xi's civil-military integration strategy and the National Defense Law of 2021 are strategic moves to ensure that China's space investments tie into China's comprehensive national power, a systems approach led and directed by the Chinese Communist Party.

China's investments in its military space capability are aimed at ensuring that it offers China both compellence (coercing adversaries to behave in ways that are in China's interest) and deterrence (deterring adversaries from assuming dominance in space or deterring them from targeting China's space systems). The development of China's anti-satellite missile capabilities, its rendezvous and proximity operations, its development of blinding and dazzling weapons, its satellites with robotic arms that can both clean debris and grab an adversary satellite in LEO and GEO, its independent navigation and satellite communication systems, and the establishment of the PLASSF are clearly aimed at showcasing China's military space capabilities. China views space as a warfighting domain, and Xi has directed the PLASSF to develop new operational and doctrinal concepts to establish space superiority for purposes of power projection.

Chinese senior space leadership views space from an economic perspective, especially highlighting the potential of the Moon, Mars, and asteroid mining. In accordance with this vision, China is establishing space programs that are geared toward taking advantage of "first presence" concepts on the Moon and Mars, to establish regulatory frameworks with China at the lead. Given China's record of accomplishing its stated space goals, those who dismiss or ignore China's announced road maps for space should consider that achievements in space are directly connected to the CCP's legitimacy and are not taken lightly—especially given the CCP's high levels of political engagement with the space program. China's achievements in the field of science and technology are well documented.[141] While the United States has been quick to dismiss China's achievements as based on allegations of theft of intellectual property, this perspective fails to take into account the fact that China has emerged as second only to the U.S. in research and development (R&D) investments.[142] In 2021, China increased its investments in R&D to 2.79 trillion yuan ($441 billion), an increase of 14 percent over 2020.[143] The case of Huawei emerging as a leader in 5G, despite the naysayers, should give U.S. policymakers pause. Huawei, which has nearly 80,000 people employed on its R&D staff alone, has committed $15–$20 billion to its R&D program.[144] This is augmented by the rapid increase in engineering, science, and tech graduates in China since 1999.[145] To be sure, those with engineering and science degrees are sought after and draw high starting salaries. This is further supported by the Chinese government's Made in China 2025 policy.[146] The Chinese Academy of Sciences, which has about 120 other institutions under it, followed by Chinese Science and Technology universities, and their privately owned industries, are steering the course of space development in China.[147]

As China and Russia establish their research base (a permanent structure on the South Pole of the Moon, expected to be completed by 2036), they could deny other countries the ability to land in that area by building a "safety or noninterference zone." Such behavior can be seen in the East China Sea, where China has created an air defense identification zone, as well as in the South China Sea, where, despite ongoing territorial disputes, China has decided to build artificial permanent structures on the islands there and harden airfields to then install military hardware. Given the dominant position of China's military power in this region, there have been few counter-moves by other countries, including the United States, in response to China's aggressive moves on these islands. Who will stop China from behaving in a similar fashion on the Moon, once it has the capacity to access Lunar resources? International law is weak in this regard, and we have seen nations unilaterally interpret the Outer Space Treaty (OST) of 1967 to suit their national interest.

Finally, China under Xi Jinping is a confident great power and is focused on national rejuvenation and establishing the legitimacy of the CCP with an iron hold, both internally and internationally. This became clear during Xi's speech at the 20th National Congress of the Communist Party of China.[148] Alignments with the Belt and Road Initiative Spatial Information Corridor have built up China's image, among the intended audience, as a capable country with the resources needed to build the space and information infrastructure that these countries require. Consequently, membership in the BRI is high, at nearly 151 nations. With space as part of the BRI, China's ability to influence regional and global events increases. According to Liu Mingfu, author of the book *The China Dream*, to win without fighting is the strategy of a superior civilization. It is evident that China is edging closer to space leadership, by recognizing the impact of space on its national strategy and by prioritizing space as part of its infrastructure.

Endnotes

[1] Jun. J. Nohara, "Sea Power as a Dominant Paradigm: The Rise of China's New Strategic Identity," Journal of Contemporary East Asian Studies, 6, no. 2 (2017): 210–232, https://www.tandfonline.com/action/showCitFormats?doi=10.1080%2F24761028.2017.1391623.

[2] China National Space Administration, "China's Space Program: A 2021 Perspective," January 28, 2022, http://www.cnsa.gov.cn/english/n6465652/n6465653/c6813088/content.html.

[3] Ibid.

[4] Ibid.

[5] Constitution of the Communist Party of China, Revised and Adopted at the 19th National Congress of the Communist Party of China on October 24, 2017, p. 3, http://www.xinhuanet.com/english/download/Constitution_of_the_Communist_Party_of_China.pdf.

[6] "Full Text of Xi Jinping's Report at 19th CPC National Congress," *Xinhua*, November 4, 2017, https://www.chinadaily.com.cn/china/19thcpcnationalcongress/2017-11/04/content_34115212.htm.

[7] "Xi Stresses Innovation as Primary Driving Force for Development," *Xinhua*, October 30, 2020, http://www.xinhuanet.com/english/2020-10/30/c_139478353.htm.

[8] Chethan Kumar, "Space Race: China in Orbit With 7 Times More Funding," *Times of India*, February 1, 2020, https://timesofindia.indiatimes.com/business/india-business/space-race-china-in-orbit-with-7-times-more-funding/articleshow/73824661.cms.

[9] "China's Space Station to Host 6 Astronauts by End of 2022," *Xinhua*, March 4, 2022, http://www.xinhuanet.com/english/20220304/b2d55553be114fa4b7bfc6a5c2f83e03/c.html.

[10] "China Unveils Follow-Up Lunar Exploration Missions," *Xinhua*, January 14, 2019, http://www.xinhuanet.com/english/2019-01/14/c_137743015.htm.

[11] Zhao Lei, "Scientists Envision Solar Power Station in Space," *China Daily*, February 27, 2019, http://www.chinadaily.com.cn/a/201902/27/WS5c75c8b3a3106c65c34eb8e3.html.

[12] Namrata Goswami, "China in Space: Ambitions and Possible Conflict," *Strategic Studies Quarterly*,12, no. 1 (2018): 74–97, https://www.airuniversity.af.edu/Portals/10/SSQ/documents/Volume-12_Issue-1/Goswami.pdf.

[13] Jeff Foust, "Space Investments Hits Record High in 2018," *SpaceNews*, April 10, 2019, https://spacenews.com/space-investment-hits-record-high-in-2018/.

[14] China Public Private Partnership Center, "Guiding Opinions of the State Council on Innovating the Investment and Financing Mechanisms in Key Areas and Encouraging Social Investment," April 14, 2015, https://www.cpppc.org/en/zy/994006.jhtml.

[15] "China to Boost Int'l Cooperation on Space Exploration," Xinhua, June 6, 2021, http://www.xinhuanet.com/english/2021-06/12/c_1310004733.htm. For those interested in an in-depth assessment, see Min Ye, *The Belt Road and Beyond: State-Mobilized Globalization in China, 1998–2018* (Cambridge, UK: Cambridge University Press, 2020).

[16] Law of the People's Republic of China on National Defense Order of the President of the People's Republic of China, December 26, 2020, came into effect January 2021, http://www.npc.gov.cn/englishnpc/c23934/202109/567129ffe3144ccb9ff358fed798b9e3.shtml; for those interested in reading the Chinese version, please see 中华人民共和国国防法（1997年3月14日第八届全国人民代表大会第五次会议通过根据2009年8月27日第十一届全国人民代表大会常务委员会第十次《关于修改部分法律的决定》修正2020年12月26日第十三届全国人民代表大会常务委员会第二十四次会议修订）, http://www.mod.gov.cn/regulatory/2020-12/27/content_4876050.htm.

[17] Stanford Encyclopedia of Philosophy. "Legalism in Chinese Philosophy," n.d. https://plato.stanford.edu/entries/chinese-legalism/.

[18] Sun Tzu, *The Art of War*, http://classics.mit.edu/Tzu/artwar.html.

[19] Mao Tse Tung, *On Guerilla Warfare* (Martino Fine Books, 2017).

[20] "The Chinese Dream," https://www.chinadaily.com.cn/china/Chinese-dream.html.

[21] The State Council, People's Republic of China, "Full Text of Resolution on Amendment to CPC Constitution," October 24, 2017, http://english.www.gov.cn/news/top_news/2017/10/24/content_281475919837140.htm.

[22] Shi Yu, "On Chang'e 5 Mission Day, Looking Back on Xi's Key Quotes on China's Space Dream," CGTN, November 24, 2020, https://news.cgtn.com/news/2020-11-24/No-end-for-space-exploration-Xi-s-key-quotes-eye-China-s-space-dream-VGy11L9qEw/index.html.

[23] See Stacey Solomone, *China's Strategy in Space* (New York: Springer, 2013). Also see Brian Harvey, *China's Space Program—From Conception to Manned Spaceflight* (New York: Springer Praxis Books, 2004). Also see Michael Pillsbury, *The Hundred-Year Marathon: China's Secret Strategy to Replace America as the Global Superpower* (New York: St Martin's Griffin, 2016).

[24] Stephen Chen, "China's Nuclear Spaceships Will Be 'Mining Asteroids and Flying Tourists' as It Aims to Overtake the US in a Space Race," *South China Morning Post*, November 17, 2017, https://www.scmp.com/news/china/policies-politics/article/2120425/chinas-nuclear-spaceships-will-be-mining-asteroids.
[25] David Sacks, "Countries in China's Belt and Road Initiative: Who's In and Who's Out," Council on Foreign Relations, March 24, 2021, https://www.cfr.org/blog/countries-chinas-belt-and-road-initiative-whos-and-whos-out. "China's BRI 'Circle of Friends' Expanding," *Helsinki Times*, January 16, 2023, https://www.helsinkitimes.fi/china-news/22817-china-s-bri-circle-of-friends-expanding.html.
[26] Kerry Brown, "China's Geopolitical Aims: The Curious Case of the 16-plus 1", *The Diplomat*, May 03, 2017, https://thediplomat.com/2017/05/chinas-geopolitical-aims-the-curious-case-of-the-16-plus-1/
[27] "Xi Jinping Thought Added Into Curriculum: Ministry of Education," *Global Times*, August 24, 2021, https://www.globaltimes.cn/page/202108/1232364.shtml.
[28] Ministry of Foreign Affairs, "Full Text of the Report to the 20th National Congress of the Communist Party of China," October 25, 2022, https://www.fmprc.gov.cn/eng/zxxx_662805/202210/t20221025_10791908.html.
[29] State Council, People's Republic of China, "China's Space Activities," November 2000, https://www.fmprc.gov.cn/ce/celt/eng/zt/zfbps/t125258.htm.
[30] Cao Siqi, "China Mulls $10 Trillion Earth-Moon Economic Zone," *Global Times*, November 1, 2019, https://www.globaltimes.cn/page/201911/1168698.shtml.
[31] Mark Andrews, "Navigating the World," CKGSB Knowledge, March 15, 2021, https://english.ckgsb.edu.cn/knowledges/china-global-navigation-system-beidou/.
[32] "China Focus: Capture an Asteroid, Bring It Back to Earth?" *Xinhua*, July 23, 2018, http://www.xinhuanet.com/english/2018-07/23/c_137342866.htm.
[33] Namrata Goswami, "Asia's Space Race: China Leads India on Strategy," *The Interpreter*, March 9, 2022, https://www.lowyinstitute.org/the-interpreter/asia-s-space-race-china-leads-india-strategy. Also see Harlan W. Jencks, "Chinese Evaluations of 'Desert Storm': Implications for PRC Security," *Journal of East Asian Affairs*, 6, no. 2 (1992), 447–477.
[34] Minnie Chan, "Unforgettable Humiliation Led to Development of GPS Equivalent," *South China Morning Post*, November 13, 2009, https://www.scmp.com/article/698161/unforgettable-humiliation-led-development-gps-equivalent.
[35] Zhao Lei, "Civil-Military Integration Will Deepen," *China Daily*, March 3, 2018, http://www.chinadaily.com.cn/a/201803/03/WS5a99d67ca3106e7dcc13f437.html. "Xi Stresses Military-Civilian Integration in a New Era," Speech Delivered by Xi Jinping at the First Session of the 13th People's Congress," *Xinhua*, March 21, 2018, https://www.chinadailyhk.com/articles/184/187/127/1521628772832.html. Backgrounder: "Xi Jinping's Vision for China's Space Development," *Xinhua*, April 24, 2017, http://eng.chinamil.com.cn/view/2019-02/18/content_9429066.htm.
[36] Ibid.
[37] China National Space Administration, "China's Space Program: A 2021 Perspective," January 28, 2022, http://www.cnsa.gov.cn/english/n6465652/n6465653/c6813088/content.html.
[38] "China Launches Space Station Core Module Tianhe," *Xinhua*, April 4, 2021, http://www.xinhuanet.com/english/2021-04/29/c_139914454.htm.
[39] "China Launches First Crewed Mission to for Space Station Construction," *Xinhua*, June 17, 2021, http://www.xinhuanet.com/english/2021-06/17/c_1310012945.htm.
[40] "Core Focus: More Details of China's Space Station Unveiled," *Xinhua*, May 18, 2020, http://www.xinhuanet.com/english/2020-05/18/c_139067133.htm.
[41] Fan Anqi, "China to Study Assembly Mechanics of Kilometer-Level Extra-Large Spacecraft," *Global Times*, August 25, 2021, https://www.globaltimes.cn/page/202108/1232426.shtml.
[42] Stephen Chen, "Chinese Scientists Plan Monkey Reproduction Experiment in Space Station," *South China Morning Post*, November 3, 2022, https://www.scmp.com/news/china/science/article/3198222/chinese-scientists-plan-monkey-reproduction-experiment-space-station.
[43] "China Unveils Follow-Up Lunar Exploration Missions," *Xinhua*, January 14, 2019, http://www.xinhuanet.com/english/2019-01/14/c_137743015.htm.
[44] China National Space Administration, "China and Russia Sign a Memorandum of Understanding Regarding Cooperation for the Construction of the International Lunar Research Station," March 9, 2021, http://www.cnsa.gov.cn/english/n6465652/n6465653/c6811380/content.html.
[45] Deng Xiaoci and Fan Anqi, "Chang'e 5 Completes Lunar Trip, More Space Missions Planned," *Global Times*, December 17, 2020, https://www.globaltimes.cn/page/202012/1210275.shtml.
[46] "China Focus: China Pioneers Ceramic 3D Printing in

Micro-Gravity," *Xinhua*, June 19, 2018, http://www.xinhuanet.com/english/2018-06/19/c_137265536.htm. Richard P. Appelbaum et.al., *Innovation in China: Challenging the Global Science and Technology System* (New York, Polity, 2018). George S. Yip and Bruce McKern, *China's Next Strategic Advantage: From Imitation to Innovation* (Cambridge, MA: MIT Press, 2017).

[47] "China Focus: China Pioneers Ceramic 3D Printing in Microgravity," *China Daily*, June 19, 2018, http://www.chinadaily.com.cn/a/201806/19/WS5b291e1aa3104bcf48c155d9.html.

[48] Ibid.

[49] "What Does China Want to Do in Space," BBC, April 20, 2016, https://www.bbc.com/news/av/36089689/what-does-china-want-to-do-in-space; Marina Koren, "China's Growing Ambitions in Space," *The Atlantic*, January 23, 2017, https://www.theatlantic.com/science/archive/2017/01/china-space/497846/.

[50] Guo Meiping, "China's 'Lunar Palace' Breaks Record After 365+5 days," CGTN, May 15, 2018, https://news.cgtn.com/news/3d3d514e7a67444e77457a6333566d54/share_p.html.

[51] Rafi Letzter, "There Are Plants and Animals on the Moon Now (Because of China)," LiveScience, January 3, 2019, https://www.livescience.com/64413-china-space-moon-plants-animals.html.

[52] Ibid.

[53] Luyuan Xu, "How China's Lunar Relay Satellite Arrived in Its Final Orbit," Planetary Society, June 15, 2018, http://www.planetary.org/blogs/guest-blogs/2018/20180615-queqiao-orbit-explainer.html.

[54] Andrew Jones, "China to Launch Relay Satellite Next Year to Support Moon Landing Missions," *SpaceNews*, January 18, 2023, https://spacenews.com/china-to-launch-relay-satellite-next-year-to-support-moon-landing-missions/.

[55] Zhao Lei, "Scientists Envision Solar Power Station in Space," *China Daily*, February 27, 2019, http://www.chinadaily.com.cn/a/201902/27/WS5c75c8b3a3106c65c34eb8e3.html. For more on SBSP, see Brian O'Leary, "Construction of Satellite Solar Power Stations From Non-Terrestrial Material," *Journal of Energy*, 1, no. 3 (1977): 155–158.

[56] Pan Zhaoyi, "China Starts to Build World's First Space Based Solar Power Plant," CGTN, February 18, 2019, https://news.cgtn.com/news/3d3d514f34597a4e32457a6333566d54/index.html.

[57] Ibid.

[58] Ibid.

[59] Chinese Scientists Mull Power Station in Space," *Space Daily*, March 31, 2015, http://www.spacedaily.com/reports/Chinese_scientists_mull_power_station_in_space_999.html.

[60] Ibid.

[61] Ibid.

[62] For elaboration on sources, please see Namrata Goswami, "Statement of Dr. Namrata Goswami, Independent Senior Analyst and Author, 2016-2017 Minerva Grantee, Before the U.S.-China Economic and Security Review Commission Hearing on "China in Space: A Strategic Competition?" April 25, 2019, https://www.uscc.gov/sites/default/files/Namrata%20Goswami%20USCC%2025%20April.pdf.

[63] Leonard Davis, "Parts of Doomed Russian Mars Probe to Hit Earth in January," *Space.com*, December 27, 2011, https://www.space.com/14056-doomed-mars-probe-phobos-grunt-falling-debris.html.

[64] "China Aims to Launch Mars Probe in 2020," *China Daily*, March 21, 2016, http://usa.chinadaily.com.cn/china/2016-03/21/content_23998140_2.htm.

[65] "China Succeeds in First Mars Landing," *Xinhua*, May 15, 2021, http://www.xinhuanet.com/english/2021-05/15/c_139947277.htm.

[66] Deng Xiaoci, "Chinese Rocket Manufacturers Outlines manned Mars Mission Roadmap, Timetable," *Global Times*, June 23, 2021, https://www.globaltimes.cn/page/202106/1226925.shtml.

[67] "China Plans to Retrieve Samples from Mars by 2030, Study the Edge of the Solar System," *Global Times*, March 7, 2022, https://www.globaltimes.cn/page/202203/1254136.shtml.

[68] Andrew Jones, "China to Launch Tianwen 2 Asteroid Sample Return in 2025," Space.com, May 18, 2022, https://www.space.com/china-tianwen2-asteroid-sampling-mission-2025-launch.

[69] Xiaojing Zhang et al., "Zhenghe—A Mission to a Near-Earth Asteroid and a Main Belt Comet," 50th Lunar and Planetary Science Conference 2019 (LPI Contrib. No. 2132), https://www.hou.usra.edu/meetings/lpsc2019/pdf/1045.pdf.

[70] Andrew Jones, "Russia Joins China's Mission to Sample an Asteroid and Study a Comet," Space.com, April 22, 2021, https://www.space.com/russia-joins-china-asteroid-comet-mission.

[71] Ibid.

[72] "China Pushes Forward Exploration of Small Celestial Bodies," *Xinhua*, April 24, 2021, http://www.xinhuanet.com/english/2021-04/24/c_139903587.htm.

[73] "Capture an Asteroid, Bring It Back to Earth?" Chinese Academy of Sciences, June 24, 2018, http://english.cas.cn/newsroom/news/201807/t20180724_195396.shtml. For more on asteroid mining, see John Lewis, *Mining the Sky: Untold Riches From the Asteroids, Comets, and Planets* (New York: Helix Books, 1997). Robert Zubrin, *Entering Space: Creating a Spacefaring Civilization* (New York: TarcherPerigee, 2007).

[74] Andrew M. Thorpe, *The Commercial Space Age: Conquering Space Through Commerce* (Bloomington, IN: AuthorHouse, 2003), p. 149.

[75] "China Focus: Capture an Asteroid, Bring It Back to Earth?" *Xinhua*, July 23, 2018, http://www.xinhuanet.com/english/2018-07/23/c_137342866.htm.

[76] Andrew Jones, "China Is Developing Plans for a 13,000 Satellite Megaconstellation," *SpaceNews*, April 21, 2021, https://spacenews.com/china-is-developing-plans-for-a-13000-satellite-communications-megaconstellation/.

[77] "Two Sessions | Bao Weimin: The State Will Set Up a 'State Grid' Company to Coordinate the Construction and Operation of Satellite Internet!" March 10, 2021, https://news.cnstock.com/news,bwkx-202103-4667755.htm

[78] "Long March-5B Rocket Enables China to Construct Space Station," *Xinhua*, May 5, 2020, http://www.xinhuanet.com/english/2020-05/05/c_139032959.htm.

[79] Jeff Foust, "China's Powerful Long March 5 Rocket Fails on 2nd Launch," Space.com, July 2, 2017, https://www.space.com/37376-china-long-march-5-rocket-failure.html.

[80] Namrata Goswami, "Why China's Long March 11 Launch Matters," *The Diplomat*, June 10, 2019, https://thediplomat.com/2019/06/why-chinas-long-march-11-launch-matters/.

[81] Andrew Jones, "China Scraps Expendable Long March 9 Rocket Plan in Favor of Reusable Version," *SpaceNews*, November 9, 2022, https://spacenews.com/china-scraps-expendable-long-march-9-rocket-plan-in-favor-of-reusable-version/.

[82] Zhao Lei, "Super-Powerful Long March 9 Said to Begin Missions Around 2030," *China Daily*, March 11, 2019. http://www.chinadaily.com.cn/a/201903/11/WS5c859b62a3106c65c34edcc0.html.

[83] As quoted from *Journal of Rocket Propulsion*, January 2011, in https://www.globalsecurity.org/space/world/china/cz-x.htm.

[84] See China National Space Administration, "China's Space Program: A 2021 Perspective," January 28, 2022, http://www.cnsa.gov.cn/english/n6465652/n6465653/c6813088/content.html.

[85] "What's Special About China's Long March-8 Rocket?," *Xinhua*, December 23, 2020, http://www.xinhuanet.com/english/2020-12/23/c_139613492.htm.

[86] Deng Xiaoci, "China's Potentially Reusable Long March-8 Makes Successful Maiden Flight," *Global Times*, December 22, 2020, https://www.globaltimes.cn/page/202012/1210622.shtml.

[87] "China Begins Construction of Its Fifth Rocket Launch Site," Reuters, April 7, 2021, https://www.reuters.com/article/us-space-exploration-china/china-begins-construction-of-its-fifth-rocket-launch-site-idUSKBN2BV0CF.

[88] Deng Xiaoci, "China to Deliver First Rocket Launching Vessel by 2022," *Global Times*, October 31, 2021, https://www.globaltimes.cn/page/202110/1237756.shtml.

[89] Zhao Lei, "Smart Dragon 3 Rocket Makes Maiden Flight," *China Daily*, December 10, 2022, https://www.chinadaily.com.cn/a/202212/10/WS6393c15ea31057c47eba3b04.html.

[90] Ibid.

[91] Union of Concerned Scientists, "UCS Satellite Database," January 1, 2022, https://www.ucsusa.org/resources/satellite-database.

[92] Lisa Grossman, "Half of All Active Satellites Are Now From SpaceX. Here Is Why That May Be a Problem," *ScienceNews*, March 3, 2023, https://www.sciencenews.org/article/satellites-spacex-problem-space-pollution.

[93] Ibid.

[94] Namrata Goswami, "The Economic and Military Impact of China's BeiDou Navigation System," *The Diplomat*, July 1, 2020, https://thediplomat.com/2020/07/the-economic-and-military-impact-of-chinas-beidou-navigation-system.

[95] Eric Hagt, "China's BeiDou: Implications for the Individual and the State," *SAIS Review*, 34, no. 1 (2014), 129–140, https://www.jstor.org/stable/27000948.

[96] "From Compass to BeiDou: Chinese Wisdom Help Navigate Belt & Road," *China Daily*, November 19, 2018. https://global.chinadaily.com.cn/a/201811/19/WS5bf25cb3a310eff303289946.html.

[97] "Exploiting Earth-Moon Space: Chinese Ambitions After Space Station," *Xinhua*, March 8, 2016, http://m.chinadaily.com.cn/en//2016-03/08/content_23775949.htm.

[98] Ibid.

[99] Deng Xiaoci, "China to Carry Out Phase-4 Lunar Probe Missions Before 2030, Build Permanent Station by 2035: Project Chief Designer and Political Advisor Wu Weiren," *Global Times*, March 8, 2022, https://www.globaltimes.

cn/page/202203/1254281.shtml.
[100] Andrew Jones, "China Reveals Details of Next Gen Crewed Spacecraft's 1st Test Flight," Space.com, June 19, 2020, https://www.space.com/china-crew-spacecraft-test-flight-details.html.
[101] State Council, People's Republic of China, "Ministry of Industry and Information Technology," http://english.gov.cn/state_council/2014/08/23/content_281474983035940.htm.
[102] State Council, People's Republic of China, "State Administration for Science, Technology, and Industry for National Defense," http://english.www.gov.cn/state_council/2014/10/06/content_281474992893468.htm.
[103] "Xi Calls for Deepened Civil Military Integration," *Xinhua*, March 12, 2018 at http://www.xinhuanet.com/english/2018-03/12/c_137034168.htm.
[104] "Full Text of Resolution on Amendment to CPC Constitution," *China Daily*, October 24, 2017, http://www.chinadaily.com.cn/china/19thcpcnationalcongress/2017-10/24/content_33656521.htm (Accessed March 28, 2022). Also see Liu Mingfu, *The China Dream: Great Power Thinking & Strategic Posture in the Post-American Era* (New York: CN Times, 2015).
[105] "Full Text of White Paper on China's Space Activities in 2016," http://www.china.org.cn/government/whitepaper/node_7245058.htm. Also see Col. Qiao Liang and Col. Wang Xiangsui, *Unrestricted Warfare China's Master Plan to Destroy America* (Panama: Pan American Publishing Company, 2002).
[106] "Xi Urges Efforts to Boost Integrated Military and Civilian Development," *Xinhua*, June 21, 2017, http://www.xinhuanet.com//english/2017-06/20/c_136381338.htm.
[107] "Strive to Build a Strong, Modern Strategic Support Force: Xi," *Xinhua*, August 28, 2016, http://www.china.org.cn/china/2016-08/29/content_39190469.htm.
[108] Hu Yuwei and Xu Hailin, "Xi Stresses CPC's Leadership and Achieving Goals Set for PLA Centennial Prior to Army Day," *Global Times*, July 31, 2021, https://www.globaltimes.cn/page/202107/1230155.shtml. Also see "Xi Focus: Xi Calls on Young Officials to Strengthen Loyalty, Competency for Important Tasks," *Xinhua*, September 1, 2021, http://www.news.cn/english/2021-09/01/c_1310162324.htm.
[109] Esteban Pardo, "Chinese 'Space Cleaner' Spotted Grabbing and Throwing Away Old Satellite," DW, February 9, 2022, https://www.dw.com/en/chinese-space-cleaner-spotted-grabbing-and-throwing-away-old-satellite/a-60658574.
[110] "Build a Strong, Modern Strategic Support Force: Xi," *Xinhua*, August 31, 2016, http://en.people.cn/n3/2016/0831/c90786-9108062.html.
[111] "Strategic Support Force Cooperates With 9 Local Units to Train High End Talents of New Combat Forces," *Xinhua*, July 13, 2017, http://military.people.com.cn/n1/2017/0713/c1011-29402123.html.
[112] M. Stoakes, "China's Space and Counterspace Capacities and Activities," U.S.-China Economic and Security Review Commission, March 30, 2020, https://www.uscc.gov/sites/default/files/2020-05/China_Space_and_Counterspace_Activities.pdf.
[113] "PLA Welcomes Launches of Private Rockets," *China Daily*, February 18, 2019, http://eng.chinamil.com.cn/view/2019-02/18/content_9429066.htm.
[114] Zhao Lei, "Xi Calls New PLA Branch a Key Pillar," *People's Daily*, August 30, 2016, http://en.people.cn/n3/2016/0830/c90000-9107205.html.
[115] National Air and Space Intelligence Center, "Competing in Space," December 2018, https://media.defense.gov/2019/Jan/16/2002080386/-1/-1/1/190115-F-NV711-0002.PDF, 21.
[116] U.S. Department of Defense, " Military and Security Developments Involving the People's Republic of China 2022," Annual Report to Congress, https://media.defense.gov/2022/Nov/29/2003122279/-1/-1/1/2022-MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA.PDF.
[117] "Feng Huo 1 (FH-1)," https://www.globalsecurity.org/space/world/china/fh-1.htm.
[118] Leo Bruce, "China Launches Chang Zheng 3B for Seventh TJSW Mission," NASA Spaceflight.com, August 24, 2021, https://www.nasaspaceflight.com/2021/08/tjsw-7-launch/.
[119] Namrata Goswami, "The Economic and Military Impact of China's BeiDou Navigation System," *The Diplomat*, July 1, 2020, https://thediplomat.com/2020/07/the-economic-and-military-impact-of-chinas-beidou-navigation-system/.
[120] Andrew Jones, "China Launches New Set of Yaogan Earth Reconnaissance satellites," Space.com, November 10, 2021, https://www.space.com/china-yaogan-35-reconnaissance-satellites-launch-november-2021.
[121] For details, please see Gunter Space Page, "Military Spacecraft China," https://space.skyrocket.de/directories/sat_mil_china.htm, https://space.skyrocket.de/directories/sat_mil_china.htm.
[122] "Military and Security Developments Involving the People's Republic of China," Annual Report to Congress, 2020, https://media.defense.gov/2020/Sep/01/2002488689/-1/-1/1/2020-DOD-CHINA-MILI-

TARY-POWER-REPORT-FINAL.PDF, viii

[123] Sandra Irwin, "Pentagon Report: China Amassing Arsenal of Anti Satellite Weapons," *SpaceNews*, September 1, 2020, https://spacenews.com/pentagon-report-china-amassing-arsenal-of-anti-satellite-weapons/.

[124] "SC 19 Anti-Ballistic Missile Interceptor," Global security.org, https://www.globalsecurity.org/space/world/china/sc-19-abm.htm.

[125] "DF-26," Missile Threat, CSIS Missile Defense Project, https://missilethreat.csis.org/missile/dong-feng-26-df-26/.

[126] Hans M. Kristensen, "The (Other) Red Storm Risings: INDOPACOM China Military Projection," Federation of American Scientists, September 15, 2020.

[127] "Nuclear Weapon Modernization Continues but the Outlook for Arms Control Is Bleak," SIPRI, June 15, 2020. https://www.sipri.org/media/press-release/2020/nuclear-weapon-modernization-continues-outlook-arms-control-bleak-new-sipri-yearbook-out-now. Also see Namrata Goswami, "Status of Existing and Emerging Asia Pacific Space Powers Capabilities," APLN, August 17, 2021, https://www.apln.network/projects/wmd-project/status-of-existing-and-emerging-asia-pacific-space-powers-capabilities.

[128] Demetri Sevastopulo and Kathrin Hille, "China Tests New Space Capability With Hypersonic Missile," *Financial Times*, October 16, 2021, https://www.ft.com/content/ba0a3cde-719b-4040-93cb-a486e1f843fb.

[129] "China Denies Report of Hypersonic Missile Test, Says Tested Space Vehicle," Reuters, October 18, 2021, https://www.reuters.com/world/china/china-disputes-report-hypersonic-missile-test-says-tested-space-vehicle-2021-10-18/.

[130] Shannon Bugos, "China Tested Hypersonic Missile Capability: U.S. Says," *Arms Control Today*, November 2021, https://www.armscontrol.org/act/2021-11/news/china-tested-hypersonic-capability-us-says.

[131] "我国亚轨道重复使用运载器飞行演示验证项目首飞取得圆满成功 (translated as "The first flight of my country's suborbital reusable vehicle flight demonstration project was a complete success"), Press Release, CASC, July 16, 2021, https://mp.weixin.qq.com/s/ncJePW1znFexqkSbZ-0YRg.

[132] State Council Information Office of the People's Republic of China, "Guiding Opinions of the State Council on Encouraging Social Investment in Investment and Financing Mechanisms in Key Innovation Areas: Document 60," November 16, 2014, http://www.gov.cn/zhengce/content/2014-11/26/content_9260.htm.

[133] Zhao Lei, "Civil-Military Integration Will Deepen," *China Daily*, March 3, 3018, http://www.chinadaily.com.cn/a/201803/03/WS5a99d67ca3106e7dcc13f437.html.

[134] Michael Sheetz, "China Increases Investment in Emerging Private Space Industry," CNBC, October 10, 2018, https://www.cnbc.com/2018/10/10/china-increases-investment-in-emerging-private-space-industry.html

[135] "China Launches First Rocket Designed by a Private Company," Reuters, May 17, 2018, https://www.reuters.com/article/us-space-launch-china-onespace/china-launches-first-rocket-designed-by-a-private-company-idUSKCN1II0FK.

[136] "China Successfully Launches Largest Reusable Rocket," *Global Times*, August 10, 2019, https://www.globaltimes.cn/content/1160951.shtml

[137] "Chinese Rocket Startup Puts Satellites Into Orbit for First Time," Reuters, July 25, 2019, https://www.reuters.com/article/us-china-space/chinese-rocket-startup-puts-satellites-into-orbit-for-first-time-idUSKCN1UK0KY.

[138] "China's Private Reusable Rocket to Be Launched in 2021," *Xinhua*, October 18, 2019, http://www.xinhuanet.com/english/2019-10/18/c_138482839.htm.

[139] Justin Davenport, "China's Galactic Energy Launches Second Ceres-1 Rocket Successfully," NASA Spaceflight.com, December 7, 2021, https://www.nasaspaceflight.com/2021/12/chinas-galactic-energy-launches-second-ceres-1-rocket-successfully/.

[140] See "Outline of the 14th Five-Year Plan (2021–2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China," August 9, 2021, https://en.ndrc.gov.cn/policies/202203/P020220315511326748336.pdf.

[141] "China's Quantum Satellite Clears Major Hurdle on Way to Ultrasecure Communications," *Nature*, June 15, 2017, https://www.nature.com/news/china-s-quantum-satellite-clears-major-hurdle-on-way-to-ultrasecure-communications-1.22142; Louis Columbus, "How China Is Dominating Artificial Intelligence," *Forbes*, December 16, 2018, https://www.forbes.com/sites/louiscolumbus/2018/12/16/how-china-is-dominating-artificial-intelligence/#550950de2b2f.

[142] Matt Hourihan, "New Data Says U.S. R&D Has Topped 3% of GDP for the First Time Ever," American Association for the Advancement of Science, March 25, 2021, https://www.aaas.org/news/new-data-says-us-rd-has-topped-3-gdp-first-time-ever.

[143] National Bureau of Statistics for China, "China's R&D Expenditure Reached 2.79 Trillion Yuan in 2021," January 27, 2022, http://www.stats.gov.cn/english/PressRe-

lease/202201/t20220127_1827065.html.

[144] Sijia Jiang, "China's Huawei to Raise Annual R&D Budget to at Least $15 Billion," Reuters, June 26, 2018, https://www.reuters.com/article/us-huawei-r-d/chinas-huawei-to-raise-annual-rd-budget-to-at-least-15-billion-idUSKBN1KG169.

[145] Katherine Stapleton, "Inside the World's Largest Higher Education Boom," *The Conversation*, April 10, 2017, https://theconversation.com/inside-the-worlds-largest-higher-education-boom-74789.

[146] U.S. Chamber of Commerce, "Made in China 2025: Global Ambitions Built on Local Protections," 2017, https://www.uschamber.com/sites/default/files/final_made_in_china_2025_report_full.pdf; Joachim Jan Thraen, *Mastering Innovation in China: Insights From History on China's Journey Towards Innovation* (Wiesbaden, Germany: Gabler Verlag, 2016).

[147] Ibid.

[148] Ministry of Foreign Affairs of the People's Republic of China, "Full Text of the Report to the 20th National Congress of the Communist Party of China," October 25, 2022, https://www.fmprc.gov.cn/eng/zxxx_662805/202210/t20221025_10791908.html.

Figure Notes

Figure 1: AI-Generated, DeepAi, https://deepai.org/machine-learning-model/text2img

Figure 2: "China space station: What is the Tiangong?," *BBC News*, July 26, 2022, https://www.bbc.com/news/world-asia-china-61511546 (Image credit: Xinhua)

Figure 3: "Microwave power beaming: US Navy successfully tests an orbiting solar panel that could one day beam power from space to anywhere on Earth," Strange Sounds.org, February 2021, https://strangesounds.org/2021/02/us-navy-tests-pram-orbiting-solar-panel-beam-power-from-space-to-earth.html

Figure 4: Andrew Jones, "China's Zhurong rover reveals complex layers beneath the surface of Mars," Space.com, February 28, 2023, https://www.space.com/china-zhurong-rover-mars-subsurface-layers (Image credit: China News Service)

Figure 5: Marlowe Hood, "Perseverance 'SuperCam' begins hunt for past life on Mars", CTV News, March 10, 2021, https://www.ctvnews.ca/sci-tech/perseverance-supercam-begins-hunt-for-past-life-on-ma rs-1.5342091?cache=qhrreidjy; AI-Generated, DeepAi, https://deepai.org/machine-learning-model/text2img; Long March (rocket family), Wikimedia Commons, https://en.wikipedia.org/wiki/Long_March_(rocket_family)#cite_note-23.

Figure 6: Long March (rocket family), Wikimedia Commons, https://en.wikipedia.org/wiki/Long_March_(rocket_family)#cite_note-23; "Long March-5B," Global Security.org, https://www.globalsecurity.org/space/world/china/cz-5b.htm

Figure 7: "Ready for launch," *The Economist*, January 8, 2015, https://www.economist.com/china/2015/01/08/ready-for-launch

Figure 8: "A Brief History of GPS," The Aerospace Corporation, https://aerospace.org/article/brief-history-gps#:~:text=In%20February%201978%2C%20the%20first,space%2Fcontrol%2Fuser%20system; Elizabeth Howell, "China launches final Beidou satellite to complete GPS-like navigation system," Space.com, June 22, 2020, https://www.space.com/china-launches-final-beidou-navigation-satellite.html; David H. Millner, Stephen Maksim, and Marissa Huhmann, "BeiDou: China's GPS Challenger Takes Its Place on the World Stage," Joint Force Quarterly 105, National Defense University Press, April 14, 2022, https://ndupress.ndu.edu/Media/News/News-Article-View/Article/2999161/beidou-chinas-gps-challenger-takes-its-place-on-the-world-stage/; "Space Segment," GPS.gov, https://www.gps.gov/systems/gps/space/; Reuters Staff, "China puts final satellite for Beidou network into orbit -state media," Reuters, June 22, 2020, https://www.reuters.com/article/space-exploration-china-satellite/china-puts-final-satellite-for-beidou-network-into-orbit-state-media-idUKB9N2DN010

Figure 9: Emblem of People's Liberation Army Strategic Support Force.png, Wikimedia Commons, June 9, 2020, https://commons.wikimedia.org/wiki/File:Emblem_of_People%27s_Liberation_Army_Strategic_Support_Force.png

Figure 10: Theresa Hitchens, "DIA sees 'dramatic' change in space competition; China, Russia 'mature' capabilities," *Breaking Defense*, April 12, 2022, https://breakingdefense.com/2022/04/dia-tracking-dramatic-change-in-space-competition-as-china-russia-mature-capabilities/

Special thank you to Christopher Oueis and Riley Wallace for their graphic design support.

AMERICAN FOREIGN POLICY COUNCIL

Space Policy Review

ABOUT THE SPACE POLICY INITIATIVE

For America, space represents the next great strategic frontier. Yet the United States now faces growing competition in that domain from countries like Russia and China, each of which are developing technologies capable of targeting U.S. space assets. As such, defining a strategy for ensuring space security, sustainability, and commerce needs to be a strategic priority for the U.S. AFPC's top-notch array of experts form a robust team that make a major contribution to crafting space policy by providing policymakers with the ideas and tools they need to chart a course in this emerging domain. For regular insights from space thought leaders tune into SPI's Space Strategy podcast (available at https://anchor.fm/afpcspacepod). SPI co-directors: Richard M. Harrison and Peter A. Garretson

ABOUT AFPC

For more than four decades, AFPC has played an essential role in the U.S. foreign policy debate. Founded in 1982, AFPC is a 501(c)(3) non-profit organization dedicated to bringing information to those who make or influence the foreign policy of the United States and to assisting world leaders with building democracies and market economies.

AFPC is widely recognized as a source of timely, insightful analysis on issues of foreign policy, and works closely with members of Congress, the Executive Branch and the policymaking community. It is staffed by noted specialists in foreign and defense policy, and serves as a valuable resource to officials in the highest levels of government.

AFPC MISSION STATEMENT

The American Foreign Policy Council seeks to advance the security and prosperity of the United States by:

1. Providing primary source information, as well as policy options, to persons and organizations who make or influence the national security and foreign policies of the United States;
2. Arranging meetings and facilitating dialogue between American Statesmen and their counterparts in other countries; and
3. Fostering the acceptance and development of representative institutions and free market economies throughout the world in a manner consistent with the Constitution, the national interest, and the values of the United States.

April 2023 | No. 3 Layout and Graphic Design by Rehna Sheth

AMERICAN FOREIGN POLICY COUNCIL
509 C Street NE, Washington, D.C. 20002 | Telephone: 202.543.1006 | Fax: 202.543.1007 | www.afpc.org