



China's space development activities for becoming a "Space Science Superpower"

March 2026

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Executive Summary

This report aims to clarify the current status of space development in the People's Republic of China (hereinafter referred to as China), based on information related to China's space development that the author has continuously collected and accumulated over many years, with a particular focus on the period after 2020 where remarkable progress has been made.

China's space development began in the 1950s under the slogan of "Two Bombs, One satellite" ("Two Bombs" means nuclear bombs and ballistic missiles) to boost national prestige. In April 1970, China became the fifth country in the world to launch an artificial satellite on its own, after the former Soviet Union, the United States, France and Japan. Looking at the trends in satellite launches since then, there has been a dramatic increase, from 151 satellites in the 40 years up to 2010, to 131 satellites in the 12th Five-Year Plan (2011-2015), and 314 satellites in the 13th Five-Year Plan (2016-2020).

During this time, the development of the Zhangcheng (Long March) series of launch vehicles for launching various satellites has progressed, and a wide variety of space transportation means have been developed, including the super-heavy lift Long March 5. The development of such space transportation systems is the foundation that supports China's wide-ranging space activities, including earth observation, communications, satellite positioning, space stations, and lunar and planetary exploration, and in some areas, China has achieved results that surpass those of the United States and Russia, which are ahead of China.

The progress of China's main space activities are as follows: In the field of manned space activities, the China Space Station (CSS) has been in operation since 2021, and three astronauts have continuously crewed it from 2022 onwards. Regarding the much-anticipated boarding of foreign astronauts, it has been announced that Pakistan will be the first country to come aboard in February 2025.

In the field of lunar and planetary exploration, in 2019, Chang'e-4 landed on the far side of the moon, the first ever to do so, with the support of the data relay satellite Queqiao (Magpie Bridge). This was a historic first, a feat that neither the United States nor Russia have achieved. In 2024, Chang'e-6 also succeeded in the first sample return from the far side of the moon. In the future, China plans manned landings on the moon by 2030 and to build the Lunar Science Research Station (ILRS) between 2035 and 2045. In 2021, Tianwen-1 marked China as the third country to land a spacecraft on Mars after Russia and the United States, and the Mars rover Zhurong also successfully operated on it. The fact that China was able to successfully orbit, soft-land and operate the rover all at once on its first Mars exploration shows that China's technological level in the field of exploration is steadily improving.

In the field of space science, many astronomical observation satellites and astrophysics satellites were launched by China for the first time. In 2024, the Chinese Academy of Sciences announced the National Mid and Long-Term Development Program for Space Science (2024-2050) (hereinafter referred to as the Mid-to Long-Term Plan for Space Science), setting out a gradual goal of becoming a "Space Science Superpower". It aims for China to contribute to the expansion of human knowledge and the development of civilization through innovative advances in basic science in space science.

In the field of earth observation, China has launched many types of satellites, including land, ocean, and

atmospheric observation satellites, under the 10-year plan for civilian space infrastructure development that began in 2015. These include the "Yaoguang" (remote sensing) series of dual use earth observation satellites operated by the People's Liberation Army.

In the field of satellite communications, in order to compete with the United States' Starlink, developed by SpaceX, China is launching geostationary satellites, low-orbit satellites, polar-orbit satellites, etc. one after another from 2024, and is developing an Internet relay satellite network.

In the field of navigation and positioning, development has been carried out in three stages since 2000, and in 2019, the construction of a global positioning system using 35 Beidou-3 satellites was completed.

It is expected that China will continue to steadily promote space development in order to achieve its goal of becoming a "Space Science Superpower". During the 15th Five-Year Plan period starting in 2026, China is scheduled to implement notable plans such as providing opportunities for foreign astronauts to board the Chinese Space Station (within the next few years), launching the Tianwen-3 probe to return samples from Mars (around 2028), and even competing with the United States for a manned lunar landing (by 2030). It will be necessary to continue to pay close attention to China's space development trends.

The title of this report says "China's space development activities for becoming a "Space Science Superpower," was a goal set out in the "national mid and long-term development program for space science (2024-2050)" announced by the Chinese Academy of Sciences in 2024. Although it is called space science, it does not only refer to science in the narrow sense such as astronomical observation, but also science in a broad sense that includes the space station and manned lunar exploration. China has built a position that will enable it to pioneer the frontiers of space science through the accumulation of various technological developments in areas such as space transportation, manned spaceflight, Earth observation, communications, and navigation.

As China aims to become a "Space Science Superpower" through its long-term space science program, this report also covers important developments in areas such as Earth observation, satellite communications and navigation.

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1 Introduction

The People's Republic of China (hereinafter referred to as "China") recognizes that space development contributes to practical benefits such as national economic growth and improved living standards for its citizens, and has steadily increased the number of satellite launches each year, aiming to achieve a moderately prosperous society (a society with some degree of affluence) by 2020. Over the past five years, the super heavy-lift rocket "Changzheng 5" (CZ-5) has entered operational service. Of the 258 rocket launches worldwide in 2024, the United States ranked first with 142 launches, followed by China in second place with 68, surpassing Russia's 17. In terms of the number of satellites launched worldwide in 2024, out of a total of 2,841, the United States launched 2,285, China launched 258, and Russia launched 99. These figures indicate that China has already surpassed Russia and become a major space power, now trailing only the United States. This report aims to clarify the current status of space development in China, based on information related to China's space activities that the author has continuously collected and accumulated over many years, with particular focus on the period after 2020, during which remarkable progress has been made.

China's space development began in the 1950s under the slogan of "Two Bombs, One Satellite" ("Two Bombs" referring to nuclear weapons and ballistic missiles), primarily to enhance national prestige. In April 1970, China became the fifth country in the world to independently launch an artificial satellite, following the former Soviet Union, the United States, France, and Japan. In the 30 years up to the end of the 20th century, China launched a cumulative total of 63 satellites. This number rose to 88 by 2010, and further increased to 131 satellites during the 12th Five-Year Plan (2011–2015), far surpassing Japan's 46 launches during the same period. Subsequently, during the 13th Five-Year Plan (2016–2020), China launched 314 satellites, marking significant progress. During this period, the development of the "Changzheng (Long March)" series of launch vehicles advanced steadily, and a wide range of space transportation systems was developed, including the super heavy-lift rocket "Changzheng 5."

The development of these space transportation systems forms the foundation supporting China's wide-ranging space activities, including Earth observation, communications, satellite navigation, space station operations, and lunar and planetary exploration. In some areas, China has achieved results that surpass those of the United States and Russia, which have traditionally been more advanced in space exploration. The progress of China's main space activities is outlined below.

In the field of human spaceflight, the Chinese Space Station (CSS) has been in operation since 2021, with three astronauts continuously crewed aboard from 2022 onward. Regarding the long-anticipated participation of foreign astronauts, it has been announced that Pakistan will become the first country to send astronauts to the CSS, with boarding planned for February 2025.

In the field of lunar and planetary exploration, in 2019, "Chang'e-4" landed on the far side of the Moon for the first time in history, with support from the data relay satellite "Queqiao (Magpie Bridge)." This was a historic achievement that neither the United States nor Russia had previously accomplished. In 2024, "Chang'e-6" also succeeded in the world's first sample return from the far side of the Moon. In Mars exploration, in 2021, "Tianwen-1" made China the third country to successfully land a spacecraft

on Mars, after Russia and the United States, and the Mars rover “Zhurong” also operated successfully on the Martian surface. China’s ability to achieve orbital insertion, soft landing, and rover operation in a single mission during its first Mars exploration demonstrates the steady improvement of its technological capabilities in planetary exploration.

In the field of space science, China has launched numerous astronomical observation and astrophysics satellites for the first time. In 2024, the Chinese Academy of Sciences (CAS) announced the “National Mid- and Long-Term Development Program for Space Science,” which sets out a phased objective of becoming a “Space Science Superpower.” The program aims for China to contribute to the expansion of human knowledge and the advancement of civilization through innovative breakthroughs in fundamental space science.

In the field of Earth observation, China has launched a wide range of satellites, including land, ocean, and atmospheric observation satellites, under the mid- and long-term civilian space infrastructure development plan initiated in 2015 (2015–2025). These include the “Yaogan” (remote sensing) series of dual-use Earth observation satellites operated by the People’s Liberation Army (PLA).

In the field of satellite communications, in order to compete with the United States’ Starlink system developed by SpaceX, China has begun launching geostationary and polar-orbit satellites in succession since 2024 and is developing an Internet relay satellite network.

In the field of navigation and positioning, development has progressed through three stages since 2000, and in 2019, the construction of a global navigation system using 35 “Beidou-3” satellites was completed.

Chapter 2 of this report summarizes recent major policies, projects, and promotional structures. Chapters 3 through 10 provide basic information useful for understanding trends in eight fields—space transportation, manned space activities, lunar and planetary exploration, space science, Earth observation, satellite communications, navigation and positioning, and technical testing—including recent achievements, related organizations, individual projects, and comparisons with other countries. Chapter 11 describes activities related to international cooperation. The information contained in this report is primarily based on publicly available sources from the Chinese government, and information on military use has been collected and presented within this scope. Detailed news covering the activities of the China Aerospace Science and Technology Corporation (CASC), which leads most of China’s space development efforts, from 1999 through three years prior has been compiled in “A Chronology of Twentieth-Century China (大事記),”¹ while information from the subsequent approximately three years up to the present has been published in “Group Highlights (集團要聞).”² For information on launch vehicles developed by private companies other than CASC, as well as global trends, the author referred to the Chronology, Launch Vehicle, and Spacecraft by Nation sections of “Gunter’s Space Page.”³

This report uses aggregated figures for China’s rocket and satellite launch activities up to the end of 2024, which continue to increase rapidly, and the tables reflect the achievements of individual satellite launches thereafter as comprehensively as possible up to March 2025.

¹ “A Chronology of Twentieth-Century China,” CASC, <https://www.spacechina.com/n25/n142/n152/n176/index.html>

² “Group Highlights (集團要聞),” CASC, <https://www.spacechina.com/n25/n2014789/n2014804/index.html>

³ Gunter’s Space Page. <https://space.skyrocket.de/>.

2 Recent major policies, projects, and promotional structures

China's space development, which began under the slogan of "Two Bombs, One Satellite," continues to uphold that spirit while today aiming to meet the needs of economic development, scientific and technological advancement, national security, and social progress, and to enhance the nation's overall comprehensive strength. Its long-term objective is to build a space superpower (see, for example, the "2021 China Space White Paper"). China has set the political goal of completing its transformation into a modern socialist power by the middle of this century, marking the 100th anniversary of the founding of the People's Republic of China in 2049. In pursuit of this objective, China has proposed a range of national strategies, including becoming a "Science and Technology Superpower," a "Manufacturing Superpower," an "Internet Superpower," and a "Talent Superpower." The strategies of becoming a "Space Superpower" and a "Space Science Superpower," which place particular emphasis on space science, should be understood within this broader strategic context.

With regard to the specific objectives of becoming a superpower nation, the long-term plan entitled "National Mid- and Long-Term Development Program for Space Science," which aims to establish China as a "Space Science Superpower," sets out the goal of achieving world-class status by continuously producing groundbreaking and original results with significant international influence, developing high-quality space science, pioneering innovative breakthroughs in space technology, and promoting the transformation of space utilization models. The China Space White Paper, which announced the commencement of the comprehensive construction of a "Space Superpower," states that space technology has made important contributions to building China into a science and technology superpower, a manufacturing superpower, a network superpower, and a transportation superpower. This indicates that efforts to become a space superpower are not confined to the development of the space sector alone, but also serve to advance the country's broader superpower strategies. Space activities can therefore be regarded as a form of common infrastructure or an accelerator that supports the enhancement of comprehensive national power, in conjunction with these other strategies.

It is essential that China's space activities, aimed at achieving the status of a "Space Superpower," be viewed from a broad and long-term perspective that takes these considerations into account.

This chapter outlines the trends, promotional structures, and future plans of China's major space development projects, which are being pursued across a wide range of domains. This reflects China's long-term commitment to steady progress in all aspects of space science, technology, and utilization. It is anticipated that these efforts will generate complex synergistic effects in the future through cross-sectoral linkages with the country's various superpower strategies.

2.1 Recent Major Policies and Projects

Since the 2010s, China has made significant progress, surpassing Japan in the cumulative number of

satellite launches. Over the 15-year period from 2010 to 2024, China launched a total of 432 "Changzheng" rockets, steadily advancing its technological capabilities in space exploration and utilization across a wide range of fields, including manned spaceflight, lunar exploration, space science, Earth observation, communications and broadcasting, navigation and positioning, and technical testing.

First, during the 12th Five-Year Plan period, China launched the lunar lander "Chang'e-3" in December 2013 and successfully achieved a soft landing on the Moon, making China the third country to do so after Russia and the United States. China also successfully deployed the lunar rover "Yutu," which operated through several lunar nights, each lasting approximately 14 days. In July 2015, the State Council of China enacted the "National Security Law,"⁴ which states that the effective utilization of space contributes to national security and stipulates that space assets constitute national infrastructure that must be protected. Subsequently, in October 2015, the National Development and Reform Commission, the Ministry of Finance, and the State Administration for Science, Technology and Industry for National Defense (SASTIND) announced the National Medium- and Long-Term Development Plan for Civil Space Infrastructure covering the period from 2015 to 2025. Furthermore, in "Made in China 2025," announced in May 2015, space was identified as one of the ten key sectors, alongside aviation. In the fourth edition of its Space White Paper, "China's Space Activities in 2016,"⁵ China stated that it would further develop space science, space technology, and space applications, actively promote international space exchanges and cooperation, and encourage participation by the private sector in space activities.

During the 13th Five-Year Plan period, new rocket series such as the "Changzheng 6" (CZ-6), "Changzheng 7" (CZ-7), and "Changzheng 5" were launched from the Taiyuan and Hainan Island launch sites. Numerous projects progressed in parallel and largely according to plan, including preparations for the construction of the CSS "Tiangong," development of the initial phase of a lunar probe aimed at lunar sample return, establishment of civilian space infrastructure (Earth observation, communications and broadcasting, and navigation and positioning satellites), and the launch of astronomical observation satellites.

During this period, in May 2018, the data relay satellite "Queqiao," positioned between the far side of the Moon and Earth, was launched toward Earth-Moon Lagrange Point 2 (EML-2), where the gravitational forces of the Earth and Moon balance to create a stable environment. With the support of this satellite, China achieved the world's first successful landing of the lunar lander "Chang'e-4," launched in December of the same year, on the far side of the Moon. This achievement demonstrated that China had acquired leading-edge space technologies, rather than merely following the technological paths of Russia and the United States. In the field of space science, launches of astronomical observation and astrophysics satellites, which had not previously been undertaken, began in 2015, and many research institutions, including the CAS and universities, carried out launches at a high frequency. Regarding navigation and positioning infrastructure originally scheduled for completion by 2025, the construction of a global

⁴ National Security Law of the People's Republic of China, China Government Network, July 1, 2015, https://www.gov.cn/xinwen/2015-07/01/content_2888316.htm.

⁵ "China's Space Activities in 2016," China Government Network, December 27, 2016, https://www.gov.cn/xinwen/2016-12/27/content_5153378.htm.

positioning system using 35 Beidou-3 satellites was completed ahead of schedule in 2019.

In the five years since 2020, the super heavy-lift rocket "Changzheng 5" has entered operational service in the field of space transportation. In manned space activities, the launch and docking of the three modules—Tianhe, Wentian, and Mengtian—that constitute the initial configuration of the CSS "Tiangong" have been completed. In lunar and planetary exploration, the lunar sample return missions "Chang'e-5" and "Chang'e-6" (the latter achieving the world's first successful sample return from the far side of the Moon, together with the launch of Queqiao-2), as well as the successful landing of China's first Mars probe, "Tianwen-1," have marked major milestones. In the field of satellite communications, a series of large spacecraft that can only be launched by the "Changzheng 5" have been successfully deployed, including the world's largest geostationary satellite, "Shijian 18."

The CSS entered the phase of permanent crewed operations starting with the "Shenzhou 14" mission in June 2022, establishing a routine of two crewed launches per year. In 2021, the "Long March 5B" successfully launched "Tianhe," the core module of the CSS "Tiangong." As of the end of November 2024, the number of people worldwide with spaceflight experience (excluding space tourists) had reached 602 from 39 countries, including 362 from the United States, 131 from Russia, 24 from China, 12 from Japan, 11 from Germany, and 10 each from France and Canada, placing China in third position. Considering the recent frequency of rocket launches and crewed space activities broadcast via the internet, China appears to have reached a technological level that significantly surpasses that of Russia.

The number of Earth observation satellites has also exceeded 500. Among these, the largest constellation comprises 165 "Yaogan" satellites operated by the PLA, followed by the 141-satellite "Jilin" constellation commercially operated by Changguang Satellite Technology Co., Ltd. In the field of satellite communications, while fixed-line communications remain relatively sluggish, China has established a new state-owned space company, "Guowang," whose primary business is internet relay services, in order to compete with "Starlink," which is being rapidly expanded by the US company SpaceX as its satellite internet relay system. Since 2024, this company has been launching geostationary, polar-orbit, and low-Earth-orbit satellites at an accelerated pace. In the same year, the CAS announced its mid- and long-term space science plan extending to 2050, outlining a phased objective of becoming a "Space Science Superpower."

The Chinese government does not publicly disclose its space development budget, making it difficult to determine the exact amount. However, according to Novaspace, government expenditure for 2024 is estimated at USD 19.886 billion (United States: USD 79.678 billion; Japan: USD 6.796 billion).⁶

2.2 Promotional Structures

China's space development organizations include various departments of the central government (equivalent to Japanese ministries), the PLA, state-owned enterprises (CASC and CASIC), the CAS, universities, and private companies. In addition, cross-organizational structures are formed on a project-by-

⁶ "Government Space Programs" . December 2024 24th Edition (Free Extract) p.9. Novaspace.

https://digital-platform.euroconsult-ec.com/wp-content/uploads/2025/01/Extract_Gov-Space-Progs-2024.pdf?t=678689c4c10ca.

project basis for manned spaceflight, lunar exploration, and navigation and positioning (Figure 2-1).

The central administrative body for space development is the Ministry of Industry and Information Technology (MIIT), which oversees the State Administration of Science, Technology and Industry for National Defense (SASTIND) and the China National Space Administration (CNSA). These two organizations play central roles in formulating and promoting China's space development policies. In terms of personnel structure, a Vice Minister of MIIT, equivalent to a Deputy Minister in Japan, concurrently serves as Director of SASTIND and Director of CNSA, thereby exercising comprehensive authority over China's space development.

Under this administrative framework are two state-owned enterprise groups: the CASC⁷ and the China Aerospace Science and Industry Corporation (CASIC)⁸. CASC oversees the three most important large-scale research and production institutes: the China Academy of Launch Vehicle Technology (CALT), the China Academy of Space Technology (CAST), and the Shanghai Academy of Spaceflight Technology (SAST). As group corporations, CASC and CASIC control a large number of subsidiary organizations, including research institutes, commercial business divisions, and other entities such as associations comparable to Japanese incorporated associations.

Within the military structure, the Equipment Development Department of the PLA includes the Beijing Aerospace Flight Control Center (BACC), which manages rocket launch operations and oversees four launch sites: Jiuquan, Xichang, Taiyuan, and Wenchang.

In recent years, local governments have also become active in space development, with Jilin Province being particularly prominent. Changguang Satellite Technology Co., Ltd. has been launching satellites under the "Jilin" designation at an exceptionally rapid pace.

Universities are also actively engaged in satellite development and launch activities. In addition to many universities under the Ministry of Education, institutions under the Ministry of Industry and Information Technology, including Beihang University (Beijing University of Aeronautics and Astronautics) and Nanjing University of Aeronautics and Astronautics, participate in space development. Furthermore, the National University of Defense Technology under the Central Military Commission and the University of Science and Technology of China under the CAS are also involved. As a result, the number of universities with a track record of satellite launches has increased significantly, and the Beijing Institute of Technology has also successfully installed experimental equipment on the International Space Station (ISS).

⁷ CASC. <https://www.spacechina.com/n25/index.html>.

⁸ CASIC. <http://www.casic.com.cn>

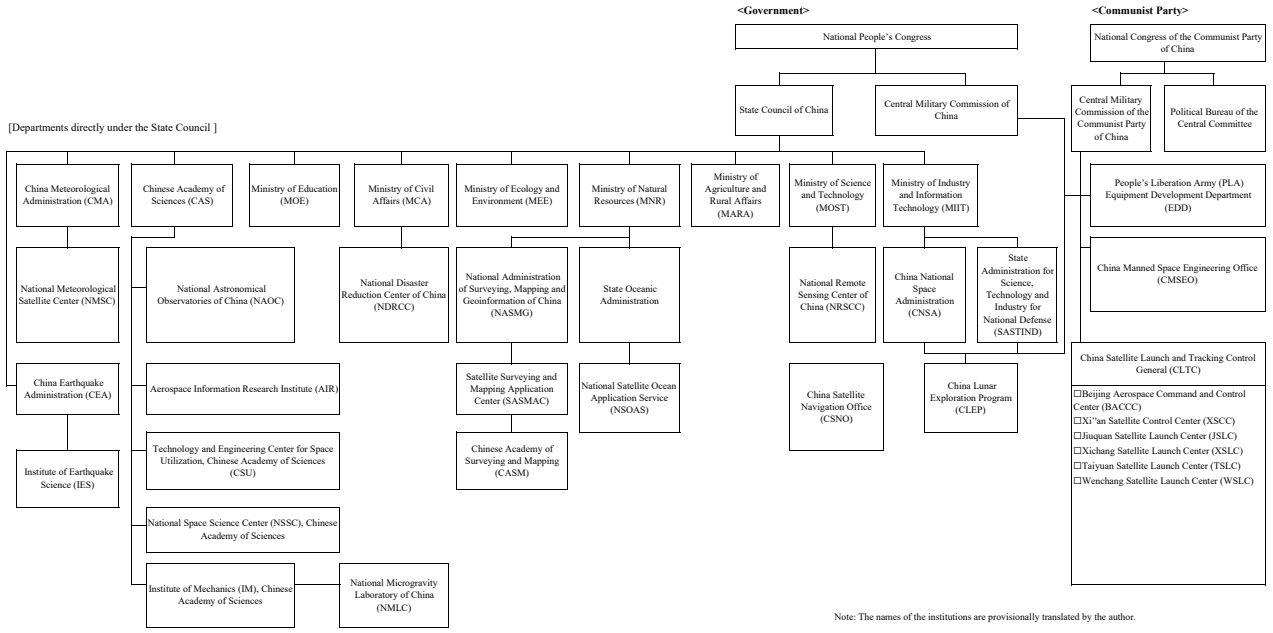


Figure 2-1 China's space development organizations (as of December 31, 2024)

3 Space Transportation Systems Field

China launched its first satellite, Dongfanghong-1, in 1970 using the Long March 1 (CZ-1) launch vehicle. Since then, China has steadily developed larger rockets and improved its launch capabilities. In 1984, the CZ-3 successfully placed the geostationary (GEO) Experimental Communications Satellite into orbit. In 1988, the CZ-4 launched the polar-orbiting meteorological satellite Fengyun-1A, and in 1999, the CZ-2F achieved the unmanned launch of the crewed spacecraft Shenzhou, marking the completion of the primary goals of the earlier Long March series and allowing China to catch up with advanced nations. In 2016, China successfully launched the technology-demonstration satellite Shijian-17 aboard the CZ-5, one of the world's largest rockets. This enabled a series of major missions—including the launches of the three modules of the Chinese Space Station, a lunar sample-return mission, and a Mars probe—which were all successfully completed by 2022. Upgrades such as low-pollution propulsion and modular designs were also implemented. Alongside the new-series Long March rockets (CZ-5, CZ-6, CZ-7), additional models such as CZ-8, CZ-11, and CZ-12 have been developed. The early development of reusable rockets has emerged as a key challenge. During this period, numerous commercial rockets—including Jielong, Kuaizhou, Hyperbola, and Ceres-1—also entered service. In 2024, out of a total of 68 launches, 19 were performed by non-Long March rockets, meaning that nearly one-third of China's launches were carried out by other commercial or non-traditional vehicles.

Currently, China is developing the super-heavy rocket CZ-9⁹ for lunar exploration and the CZ-10¹⁰ for crewed lunar missions, aiming to create launch vehicles capable of competing with the U.S.-led Artemis program.

During this period, China conducted the world's highest number of launches almost every year from 2016 to 2021, entering a new era of U.S.–China dual dominance in space, partly in response to the rapid rise of SpaceX.

3.1 Global Rocket Launch Status

The global rocket launch status from 2020 to 2024 (as of the end of December) is shown in Table 3-1. This period coincided with the COVID-19 pandemic, during which Europe was unable to carry out most launches as planned because of infections among launch personnel and other disruptions. In contrast, SpaceX in the U.S. and China significantly increased their annual number of launches during these years. Recently, SpaceX has also taken on the launch of most small satellites from European countries, as well as key satellites for major projects of the European Space Agency (ESA).

⁹ “长征九号”. 百度百科, <https://baike.baidu.com/item/长征九号/8926764>.

¹⁰ “长征九号”. 百度百科, <https://baike.baidu.com/item/长征九号/8926764>.

Table 3-1 Recent Annual Launch Numbers by Rocket-Launching Countries

Country\Year	2020	2021	2022	2023	2024	Total
U.S.	37 (● 3) [25]	45 (● 2) [31]	78 (● 2) [61]	107 (● 5) [98 ● 2]	142 [135]	409 (●12) [350 ● 2]
China	39 (● 4)	55 (● 3)	64 (●1)	67 (●1)	68 (● 2)	293 (●11)
Russia	15	24	21	19	17	96
Newzealand	7 (●1)	6 (●1)	9	9 (●1)	14	45 (● 2)
India	2	2 (●1)	5 (●1)	7	5	21(● 2)
EU	7 (●1)	7	6 (●1)	3	3	26 (● 2)
Japan	4	3	1(●1)	3 (●1)	7 (● 2)	18 (● 4)
Iran	2 (●1)	3 (● 3)	1	2 (●1)	4	12 (● 5)
South Korea	0	1(●1)	1	2	0	4 (●1)
North Korea	0	0	0	3 (● 2)	1(●1)	4 (● 3)
Israel	1	0	0	1	0	2
Total	114 (●10)	146 (●11)	186 (● 6)	223 (●11)	261(● 5)	930 (● 43)

Note: ● Black circles indicate failures, with the number in parentheses showing the count. The numbers in square brackets [] in the U.S. column indicate the number of SpaceX launches.

3.2 Overview of the Older-Series “Long March” Rocket

This series began with the CZ-1 in 1970, followed by the CZ-2,¹¹ CZ-3¹² (first launched in 1984), and CZ-4¹³ (first launched in 1988), which became China’s main launch vehicles from 1975 onward (Table 3-2). These rockets were developed at the China Academy of Launch Vehicle Technology (CALT) under the China Aerospace Science and Technology Corporation (CASC), based on the DF-5 intercontinental ballistic missile. Among them, the CZ-3B was, at the time, China’s highest-performance rocket, capable of launching a five-ton-class GEO satellite into geostationary transfer orbit (GTO).

In its first launch in 1996, China secured a commercial launch contract from Intelsat—an international communications organization (later privatized)—to place Intelsat 708 (launch mass: 4,180 kg) into orbit. Success would have given China launch competitiveness on par with the U.S. and Russia. However, immediately after liftoff, the rocket began to tilt, eventually crashing to the ground and causing numerous fatalities among nearby residents and launch personnel. Witnesses at the Xichang launch site reported being shocked as the rocket sped past at high speed. The vehicle struck a building in a market area outside the launch complex and came to a stop. The cause of this accident remained unknown for many

¹¹ "CZ-2 (Chang Zheng-2)", Gunter's Space page, https://space.skyrocket.de/doc_lau/cz-2.htm.

¹² "CZ-3 (Chang Zheng-3)", Gunter's Space page, https://space.skyrocket.de/doc_lau/cz-3.htm.

¹³ "CZ-4 (Chang Zheng-4)", Gunter's Space page, https://space.skyrocket.de/doc_lau/cz-4.htm.

years. In July 2013, a Russian Proton rocket crashed at its launch site after exhibiting nearly identical abnormal flight behavior, erupting into a massive fireball. This led to the inference that the Chinese accident 17 years earlier had likely resulted from the same mistake. The Proton failure was determined to have been caused by angular-velocity sensors—used to control the vehicle's orientation—being installed upside down. As a result, immediately after liftoff, the rocket attempted to rotate into an inverted attitude. Because the circumstances closely resembled the Chinese failure, it became highly probable that the Chinese accident had also been caused by incorrectly installed angular-velocity sensors.

Despite this accident, the following year saw the second launch of the CZ-3B, which successfully placed a Philippine GEO satellite into orbit. The rocket then achieved seven consecutive successful launches. However, in 2009, during a launch of Indonesia's PALAPA-D satellite using the same rocket type, it failed to reach the intended orbit, and the satellite had to use its own propulsion system to climb to GEO orbit. As a result, a significant amount of onboard fuel was consumed, shortening its planned 15-year service life by about four years and leading to its retirement in 2020. The replacement satellite, PALAPA-N1, launched in April 2020, was also lost because of another CZ-3B launch failure.

Overcoming these failures, China steadily increased the number of launches, sending three types of rockets from three different launch sites. By around 2016, when the new-series Long March rockets began flying, China's annual launch count had surpassed that of the U.S. and Russia. Launch duties were divided by orbit: Jiuquan for low Earth orbit (LEO) satellites, Xichang for GEO satellites and lunar probes, and Taiyuan for sun-synchronous orbit (SSO) missions. As launches from the newly developed Wenchang site—beginning with the CZ-7—gradually increased, GEO launches from Xichang declined, while LEO and SSO satellite launches grew in number. By the end of 2024, the total number of launches of the older-series Long March rockets had reached 489, with a success rate of 98.2%.

Table 3-2 Overview of the Older-Series "Long March" Rocket (Uses and Configuration)

Rocket Series	CZ-2		CZ-3		CZ-4		
Model Name	CZ-2C	CZ-2D	CZ-2F	CZ-3B	CZ-3C	CZ-4A	CZ-4B
Primary Uses	LEO Satellite		Manned Spacecraft	GEO Satellite	Medium Earth Orbit Satellite	Polar Orbit Satellite	
Strap-on Booster	None		4 x LB-40 /YF-20B	4 x LB-41 /YF-20B	2 x LB-41 /YF-20B	None	
First-Stage Engine	L-172 /YF-21	L-182 /YF-21B	L-180 /YF-20B	L-186/YF-21C		L-182/YF-21B	
Second-Stage Engine	L-55 /YF-24	L-35 /YF-24B	L-90 /YF-24B	L-45/YF-24E		L-35/YF-24B	
Third-Stage Engine	None or SMA	None or YZ-3	None	H-18/2 x YF-75		L-14 /2 x YF40	L-14/(mod.) 2 x YF40
Launch Capability	LEO 2.5t SSO 2t	LEO 3.3t	LEO 7.8t	GTO 5.1~5.5t	GTO 3.8t SSO 6.5t	SSO 2.8t	SSO ? 6t
First Launch	1982	1992	1999	1996	2008	1999	2006
Launch Number	217 (● 4)			159 (● 2)		109 (● 3)	

Note: YF indicates engine type, SMA refers to the upper-stage engine, YZ refers to Yuan Zheng (the upper-stage engine), and ● indicates failure (included in the count).

3.3 Development of the New-Series "Long March" Rockets

China has developed a new series of launch vehicles, with CALT under CASC responsible for the CZ-5¹⁴ and CZ-7,¹⁵ and the Shanghai Academy of Spaceflight Technology (SAST) developing the CZ-6¹⁶ (see Table 3-3). The CZ-5, which has a diameter of 5 meters and can carry large satellites, is manufactured at a newly constructed space industry base in the Binhai New Area of Tianjin. From this coastal industrial zone, located about 50 km from central Tianjin, the vehicles are transported by ships such as the Yuanwang-21 to the Wenchang Space Launch Site in Hainan Province.

In the development sequence for the new rocket series, China first launched the smallest and lightest model, the CZ-6. Next, it launched the CZ-7, which uses four CZ-6 bodies as strap-on boosters. Subsequently, for the launch of the ultra-large CZ-5, the CZ-7's first stage was used as its strap-on booster. In the initial plan, a configuration using the CZ-6 as auxiliary boosters for the CZ-5 was considered. However, because the main engine of the CZ-5—designed as a non-toxic, environmentally friendly engine—failed to achieve its targeted performance, it was replaced with a lower-emission kerosene engine of the same type used by the CZ-7. Even if four upper-stage units from the CZ-6 were attached as strap-on boosters, the larger core-stage diameter of the CZ-5 would still result in reduced launch capability. Consequently, variants such as the CZ-5A and CZ-5C performed below the capabilities of the CZ-7, leading to their removal from the product lineup.

As a result, the CZ-5 was designated primarily for missions involving GEO satellites and lunar or planetary probes, while the CZ-5B, which uses four first-stage units from the CZ-7, became the vehicle for transporting modules to China's space station. Subsequently, to counter SpaceX's Starlink program, the CZ-6A—an upgraded version of the CZ-6 with performance comparable to the CZ-7—and the intermediate-performance CZ-6C were developed by SAST under CASC. These rockets enabled China to conduct high-frequency launches of large numbers of small satellites. In addition, the mission portfolio of the CZ-5 expanded to include Earth observation, and its launch rate gradually increased.

¹⁴ "CZ-5 (Chang Zheng-5)", Gunter's Space page, https://space.skyrocket.de/doc_lau/cz-5.htm.

¹⁵ "CZ-7(Chang Zheng-7)", Gunter's Space page, https://space.skyrocket.de/doc_lau/cz-7.htm.

¹⁶ "CZ-6 (Chang Zheng-6)", Gunter's Space page, https://space.skyrocket.de/doc_lau/cz-6.htm.

Table 3-3 Overview of the New-Series "Long March" Rocket (Uses and Configuration)

Rocket Series	CZ-5		CZ-6			CZ-7	
Model Name	CZ-5	CZ-5B	CZ-6	CZ-6A	CZ-6B	CZ-7	CZ--7A
Primary uses	GEO Satellite Deep Space Probe	Space Station Module	Polar Orbit Satellite LEO Satellite	Polar Orbit Satellite	Polar Orbit Satellite	Cargo Ship	GEO Satellite
Strap-on Booster	CZ-5-300 (2 x YF-100) 4 Unites		4 Unites FG-112	4 Unites Solid type	None	K-2-1 2.25m x4	
First-Stage Engine	CZ-5-500 (2 x YF-77)		K-3-0 YF-100	K-3-0 YF-100	K-3-0 YF-100	YF-100 x 2	
Second-Stage Engine	H-5-2/2 x YF-75D	None	K-2-2/ YF-115	Unknown	2.9m φ / YF-115	K-3-2 (short size)/ 4 x YF115	
Third-Stage Engine	None	None	4 x YF-85	Unknown	None	None	H-18/2 x YF75
Launch Capability	GTO 13t SSO 15t	LEO 25t	SSO 1.1t LEO 1.5t	SSO 4.5t	SSO 2.5t	LEO 10t	GTO 6t
First Launch	2016	2020	2015	2022	2024	2016	2020
Launch Number	8 (●1)	5	13	9	1	9	8 (●1)

Note: ● Black circles indicate failures, with the number in parentheses showing the count.

The first launch of the CZ-5 took place under such tense conditions that the launch window was extended by more than three minutes to ensure safety. Nevertheless, the mission succeeded, symbolizing China's rapidly advancing space program.

At that time, several major missions were approaching—such as the Tianwen-1 Mars probe, the Chang'e-5 lunar sample-return mission, and the launch of the core module of the Chinese Space Station—all scheduled for 2017, contributing to a strong sense of anticipation. However, the failure of CZ-5 Test Vehicle No. 2 during the launch of Shijian-18 on July 2, 2017, caused delays in the missions scheduled afterward, effectively causing China to stumble at the very first major step of its program. Just prior to this, China had also failed to place the GEO communications satellite Zhongxing-9B into its intended orbit; while not a launch failure, the mishap significantly shortened the satellite's operational lifespan. Additionally, in 2020, the first launch of the CZ-7A also ended in failure.

The CZ-7, with a diameter of 3.35 meters and used to launch the Tianzhou cargo spacecraft, is also launched from Hainan Island. This rocket's first stage is identical to the 3.35-meter strap-on boosters used on the CZ-5. The Jiuquan launch site in Gansu Province (the actual location lies within Inner Mongolia), which had previously been used by the CZ-2F to launch the Shenzhou crewed spacecraft, is situated in a high-altitude, cold, and dry environment. In contrast, Hainan Island is hot and humid, requiring special measures to address these environmental conditions.

The CZ-6, whose upper-stage rocket body has a diameter of 2.25 meters, successfully conducted its maiden flight in 2015. The first-stage body of this rocket has the same 3.35-meter diameter as that of the CZ-7. The strap-on boosters of the CZ-7 use rockets based on the CZ-6's second stage, which has a narrower diameter. Since 2020, the CZ-6 has been upgraded from its original design, with the CZ-6A and CZ-6C now in operation and their body diameters increased to the 3-meter class.

3.4 New “Long March” Rocket Models Outside the Main Series

Among the new “Long March” rockets outside the major series (Table 3-4), the CZ-11¹⁷ is a four-stage, all-solid rocket. The CZ-11H is launched from a sea-based platform, with specifications and launch capability identical to those of the CZ-11.

The CZ-8¹⁸ was originally designed as a combination of the CZ-7's first stage and the CZ-3B's third stage. The CZ-8 (1) variant is equipped with four strap-on boosters and is capable of launching GEO satellites, while the CZ-8 (2) variant has no strap-on boosters. In February 2025, the CZ-8A successfully conducted its maiden launch. Its second stage replaces the CZ-3B's third stage with a new configuration: two YF-75H engines mounted on a WB18 stage. It is expected to be further upgraded into the CZ-8R, aiming to evolve into a reusable launch vehicle. The CZ-12¹⁹ features an improved second-stage main engine compared with that of the CZ-8 and has a payload capacity of 6 tons to SSO. Follow-on variants, such as the CZ-12A, may also appear.

CALT is currently developing the CZ-9, a super-heavy launch vehicle intended for crewed lunar exploration. It is comparable to the Saturn V used in the U.S. Apollo program. As meeting the originally targeted 2028 timeline has become difficult, CALT is also developing the CZ-10 in parallel as another large rocket for crewed lunar missions. The CZ-10 is expected to be the first to achieve a crewed lunar landing in China, with a projected launch capability roughly half that of the CZ-9.

Table 3-4 Overview of the New “Long March” Rocket Models Outside the Main Series (Uses and Configuration)

Rocket Series	CZ-11		CZ-8		CZ-12	CZ-9	CZ-10
Model Name	CZ-11	CZ-11H	CZ-8	CZ-8A	CZ-12	CZ-9	CZ-10
Primary uses	LEO Satellite	LEO Satellite	GEO Satellite	Reusable satellite	LEO Satellite	Lunar Transfer Vehicle	Manned Lunar Exploration Vehicle
Strap-on Booster	None		2 XK-2/YF-100		None	TBD	TBD
First-Stage Engine	P35		K-3-1/2 X YF-100		Z-12-1 /4 X YF-100	Diameter 10m	TBD
Second-Stage Engine	Solid type		H-18/2 X YF75	WB2/2 X YF75	CZ-12-2 / 2 X YF-115	TBD	Solid type
Third- and Fourth- Stages Engine	Solid type		None		None	TBD	TBD
Launch Capability	LEO 700kg SSO 350kg		SSO 4.5t LEO 7.6t	Unknown	SSO 6t LEO 10t	LEO 140t	LEO 70t
Hight	20.8m		50.3m	50.3m	60m	114m	92.5m
First Launch	2015	2019	2020	2025	2024	Target 2028	Around 2030
Launch Number	12	5	2	1	1	Under Development	Under Development

¹⁷ "CZ-11 (Chang Zheng-11)", Gunter's Space page, https://space.skyrocket.de/doc_lau_det/cz-11.htm

¹⁸ "CZ-8 (Chang Zheng-8)", Gunter's Space page, https://space.skyrocket.de/doc_lau/cz-8.htm.

¹⁹ "CZ-12 (Chang Zheng-8)", Gunter's Space page, https://space.skyrocket.de/doc_lau/cz-12.htm.

3.5 Rockets Other Than the Long March Series

China has been launching a variety of rockets in addition to the Long March series. Each of these is described below.

① Kuaizhou

The series of rockets developed by the China Aerospace Science and Industry Corporation (CASIC)—including Kuaizhou-1, Kuaizhou-1A,²⁰ and Kuaizhou-11—has been launched 33 times to date (including three launch failures) and has placed 66 satellites into orbit, five of which failed to reach their intended orbit. See Tables 3-5 and 3-6 for details.

Table 3-5 Kuaizhou Rocket Launch Record (–2020)

Launch Year	2013	2014	2017	2018	2019	2020	Total
Kuaizhou-1	1	1				3 (●1)	5 (●1)
Satellite Number	1	1				1,2[1]	5[1]
Kuaizhou-1A			1	1	5		7
Satellite Number	1	1	3	1	2,1,2,1,6		18

Note: ● Black circle and the square brackets [] indicate a failure (included in count), the same applies below.

Table 3-6 Kuaizhou Rocket Launch - Record (2020–March 2025)

Launch Year	2021	2022	2023	2024	2025	Total
Kuaizhou-1	4 (●1)	4	6	3		17 (●1)
Satellite Number	1,1,1[2]	1,2,2,2	4,1,4,5,4,4	4,1,4		40[2]
Kuaizhou-1A-Pro				1		1
Satellite Number				1		1
Kuaizhou-11	1 (●1)		1	1		3 (●1)
Satellite Number	2 (●1)		1	4		7[2]

Note: For fiscal year 2025, the situation up to the end of March is shown.

② Jielong

CASC's CALT-developed Jielong²¹ has successfully placed 44 satellites into orbit across six launches (Table 3-7).

²⁰ "Kuaizhou-1 (KZ-1) / Fei Tian 1", Gunter's Space page, https://space.skyrocket.de/doc_lau/kuaizhou-1.htm.

²¹ "Jielong-1 (Smart Dragon-1, SD-1)", Gunter's Space page, https://space.skyrocket.de/doc_lau/jielong-1.htm.

Table 3-7 Jielong Rocket Launch Record

Launch Year	2019	2022	2023	2024	2025	Total
Jielong-1	1					1
Jielong-3		1	1	2	1	5
Satellite Number	3	14	1	8, 8	10	44

③ Zhongke-1

The Zhongke-1 (also known as Lijian-1)²², a launch vehicle developed under the supervision of the Institute of Mechanics of the Chinese Academy of Sciences (CAS) and jointly undertaken by Beijing Zhongke Aerospace Exploration Technology Co., achieved five consecutive successful launches in its initial missions. During this period, the launch on June 7, 2023, which placed 26 satellites into orbit simultaneously, set a new record for China. However, this record was surpassed just eight days later, when the CZ-2D successfully launched 41 satellites on June 15. Notably, 21 of the 26 satellites from the June 7 mission remain unnamed or unidentified (see Table 3-8).

Table 3-8 Zhongke-1 Rocket Launch Record

Launch Year	2022	2023	2024	Total
Zhongke-1	1	1	4 (●1)	6 (●1)
Satellite Number	6	26	5, 5, 15[11]	68[11]

④ Gushenxing-1

The small launch vehicle Gushenxing-1 (Ceres-1)²³, developed by Galactic Energy (Beijing Xinghe Dongli Space Technology Co., Ltd.), is a four-stage rocket using solid propellant for stages 1–3 and liquid propellant for stage 4. It is capable of placing 350–400 kg into LEO and 270 kg into a 700-km SSO. To date, it has successfully placed 46 satellites into orbit over 14 launches, with one launch failure (see Table 3-9). Galactic Energy is also developing the medium-to-large launch vehicle PALLAS-1 (Zhishenxing-1), originally planned for its maiden flight in the second half of 2024 and now scheduled for June 2025. While SpaceX's Falcon 9 has achieved up to 25 successful reuses of a single booster, Galactic Energy aims for 50 reuses per vehicle.

Table 3-9 Gushenxing-1 Rocket Launch Record

Launch Year	2020	2021	2022	2023	2024	2025	Total
Gushenxing-1	1	1	2	7 (●1)	3	1	15 (●1)
Satellite Number	1	5	3, 5	5, 2, 7, 1, 4, [1], 2	4, 1, 1	5	47[1]

²² "Lijian-1 (Kinetica-1, Zhongke-1, ZK-1)", Gunter's Space page, https://space.skyrocket.de/doc_lau/lijian-1.htm.

²³ "Ceres-1 (Gushenxing-1, GX-1)", Gunter's Space page, https://space.skyrocket.de/doc_lau/ceres-1.htm.

⑤ Shuangquxian-1

The small launch vehicle “Shuangquxian-1 (Hyperbola-1),”²⁴ developed by Beijing Interstellar Glory Space Technology Co., Ltd., is capable of placing a 300-kg payload into LEO. To date, it has been launched seven times, achieving three successful missions that placed a total of four satellites into orbit. The launch success rate is 42.9% (Table 3-10).

Table 3-10 Shuangquxian-1 Rocket Launch Record

Launch Year	2019	2021	2022	2023	2024	Total
Shuangquxian-1	1	1(●1)	1(●1)	2	1(●1)	7(●4)
Satellite Number	2	7[6, 1]	1[1]	1, 1	3[3]	15[11]

⑥ Zhuque-1

The Zhuque launch vehicle, developed by LandSpace (Blue Arrow Space Technology Co., Ltd.), experienced consecutive failures in 2018 and 2022 but achieved its first successful satellite insertion in 2023. On July 6, 2023, a Zhuque-2²⁵ rocket was erected at the Jiuquan launch site, and reports suggested that the launch was imminent. However, the vehicle that launched on July 12 carried only a dummy payload—essentially the upper stage itself, without functional satellite capabilities. In the 2024 launch, the rocket’s designation was changed to Zhuque-2E (see Table 3-11).

Table 3-11 Zhuque-1 Rocket Launch Record

Launch Year	2018	2022	2023	2024	Total
Zhuque-1	1 (●1)	-	-	-	1(●1)
Zhuque-2	-	1 (●1)	2	-	3(●1)
Zhuque-2E	-	-	-	1	1
Satellite Number	1[1]	1[1]	1, 2	2	7(●2)

⑦ Yinli

The small launch vehicle Yinli,²⁶ developed by Orienspace, successfully completed its maiden flight in January 2024, placing a single satellite into orbit. No second launch has been conducted since then (Table 3-12).

²⁴ “Shuang Quxian-1 (SQX-1, Hyperbola-1)”, Gunter’s Space page, https://space.skyrocket.de/doc_lau/shuang-quxian-1.htm.

²⁵ “Zhuque-2 (ZQ-2, LandSpace-2, LS-2)”, Gunter’s Space page, https://space.skyrocket.de/doc_lau/zhuque-2.htm.

²⁶ “Yinli-1 (Gravity-1, YL-1)”, Gunter’s Space page, https://space.skyrocket.de/doc_lau/yinli-1.htm.

Table 3-12 Yinli Rocket Launch Record

Launch Year	2024
Yinli	1
Satellite Number	1

Note: ● Black circle and the square brackets [] indicate a failure (included in count).

⑧ Tianlong-2

The small launch vehicle Tianlong-2, developed by Beijing Tianbing Technology Co., Ltd. (Space Pioneer), successfully completed its maiden flight in April 2023, placing a single satellite into orbit. No second launch has been conducted since then (Table 3-13).

Table 3-13 Tianlong-2 Rocket Launch Record

Launch Year	2023
Tianlong-2	1
Satellite Number	1

⑨ OS-M1

OneSpace (Zero One Space) is developing the OS-M series of rockets, and its first launch ended in failure (Table 3-14).

Table 3-14 OS-M1 Rocket Launch Record

Launch Year	2019
OS-M1	1 (●1)
Satellite Number	1[1]

⑩ Beijing Lingke Aerospace Technology Co. (Link Space)

The RLV-T5 suborbital rocket, launched in 2019 by Beijing Lingke Aerospace Technology Co. (Link Space), ascended to an altitude of 300 meters and returned safely to the ground, successfully demonstrating vehicle recovery. Since then, the company has been developing various types of rockets, but none have yet reached the stage of launching satellites.

3.6 Commercial Launches of Foreign Satellites

From the perspective of international cooperation and foreign competition, China has steadily accumulated numerous achievements in launching foreign satellites using its launch vehicles. These commercial launch services are provided by China Great Wall Industry Corporation (CGWIC). In the 1990s, China launched many U.S.-made satellites; however, due to U.S. export controls under the International Traffic in Arms Regulations (ITAR), exporting U.S.-manufactured satellites to China is now prohibited. European satellites that do not fall under ITAR restrictions can still be launched on Chinese rockets, offering users the advantage of lower costs compared with Europe's Ariane launch vehicles. For emerging

and developing countries, China also provides turnkey packages that include Chinese-manufactured satellites launched on Chinese rockets, construction of ground facilities, training of control personnel, and even financing for satellite development and launch insurance. Recently launched foreign satellites by CGWIC are shown in Table 3-15.

With satellite lifespans extending beyond 15 years and the expansion of submarine cables and commercial internet-satellite services, the traditional satellite communications and broadcasting sector is experiencing limited growth. Because the remaining small-launch demand is now almost entirely dominated by SpaceX, China's commercial opportunities in this area appear to have declined significantly.

Table 3-15 Launched Foreign Satellites by CGWIC

Satellite Name	Country	Rocket Name	Launch Date	Notes
Simon Bolivar 1	Venezuela	CZ-3B/E	October 30, 2008	
PALAPA-D	Indonesia	CZ-3B	August 31, 2009	Basic success *
Paksat-1R	Pakistan	CZ-3B/E	August 12, 2011	
Eutelsat W3C	Eutelsat	CZ-3B/E	October 7, 2011	
NIGCOMSAT-1R	Nigeria	CZ-3B/G2	December 19, 2011	
Tupac Katari 1	Bolivia	CZ-3B/G2	December 2, 2013	
LaoSat-1	Laos	CZ-3B/G2	November 21, 2015	
Belintersat-1	Belarus	CZ-3B/G32	January 15, 2016	
Paksat-MM 1	Pakistan	CZ-3B/G3	May 30, 2024	

* : "Basic success" is synonymous with "partial failure." Although the satellite managed to reach its designated GEO position using its own propulsion, the increased fuel consumption raised concerns that its remaining lifespan would be shortened. PALAPA-N1, which had been manufactured as the replacement for PALAPA-D, failed during its launch in February 2020 and therefore could not serve as a substitute. On August 31 of the same year, it was officially announced that PALAPA-D was no longer suitable for operation because its fuel was nearly depleted. As a result, all television broadcasting transponders and data-service transponder functions were transferred to the Telkom-4 satellite (launched in August 2018) and the BRIsat satellite (launched in June 2016).

3.7 Technology Test Satellites (Related to Space Transportation Systems)

An example of technology test satellites related to space transportation is shown in Table 3-16. During the inaugural launch of the CZ-7, six payloads of five different types were carried, all of which were successfully inserted into orbit. Among them, the primary mission—the scaled-down unmanned reentry capsule Duoyongtu Feichuan Fanhui Cang (DFFC)²⁷ (mass: 2,600 kg)—was successfully returned to Earth the day after launch. In addition, the ZaiGui Jiazhu Shiyang Zhuangzhi (ZGZ)²⁸, also known as Tianyuan-1 (TY-1), is a device designed to test on-orbit propellant replenishment. The experiment was conducted with the device mounted on the upper-stage Yuanzheng-1A (YZ-1A) of the CZ-7 rocket.

CAST's reusable spaceplane, the "Reusable Test Spacecraft,"²⁹ has been launched three times using the

²⁷ "DFFC", Gunter's Space page, https://space.skyrocket.de/doc_sdat/dfc.htm.

²⁸ "ZGZ Shiyang Zhuangzhi", Gunter's Space page, https://space.skyrocket.de/doc_sdat/zgz_shiyang_zhuangzhi.htm.

²⁹ "Chongfu Shiyang Shiyang Hangtian Qi (CSSHQ)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/csshq.htm.

same vehicle, with all missions successfully recovered.

Table 3-16 Technology Test Satellites Related to Space Transportation

Satellite Name	International Designator	Launch Date	Rocket Name	Launch Site
Multi-Purpose Spacecraft Return Capsule	2016-042D	25-Jun-16	CZ-7/YZ-1A	Wenchang
On-Orbit Refueling Test Device	2016-042D	25-Jun-16	CZ-7/YZ-1A	Wenchang
Reusable Test Spacecraft 1	2020-063A	4-Sep-20	CZ-2F/T	Jiuquan
Reusable Test Spacecraft 2	2022-093A	4-Aug-22	CZ-2F/T	Jiuquan

3.8 Launch Count by Vehicle Type and Launch Site

As shown in Table 3-17, with the establishment of the Wenchang Launch Site, the division of roles among the original three launch sites has shifted. In addition, sea-based launch opportunities have increased.

Table 3-17 Launch Count by Vehicle Type and Launch Site

Company	Rocket Name	Jiuquan	Xichang	Taiyuan	Wenchang	Sea-based Launch	Failure Count
CASC	CZ-1	2	-	-	-	-	-
	CZ-2A	4	-	-	-	-	1
	CZ-2C	40	20	31	-	-	1 (Jiuquan)
	CZ-2D	51	17	20	-	-	-
	CZ-2E	-	7	-	-	-	2
	CZ-2F	24	-	-	-	-	-
	CZ-3	-	13	-	-	-	-
	CZ-3A	-	28	-	-	-	-
	CZ-3B	-	98	-	-	-	2
	CZ-3C	-	24	-	-	-	-
	CZ-4	-	-	2	-	-	-
	CZ-4B	7	2	42	-	-	1 (Taiyuan)
	CZ-4C	27	2	26	-	-	2 (Taiyuan)
	CZ-5	-	-	-	8	-	1
	CZ-5B	-	-	-	5	-	-
	CZ-6	-	-	12	-	-	-

	CZ-6A	-	-	9	-	-	-
	CZ-6C	-	-	1	-	-	-
	CZ-7	-	-	-	8	-	-
	CZ-7A	-	-	-	9	-	1
	CZ-8	-	-	-	3	-	-
	CZ-11	11	3	-	-	-	-
	CZ-11H	-	-	-	-	5	-
	CZ-12	1	-	-	-	-	-
	Fēngbào	6	-	-	-	-	2
	Kāità	1	-	-	-	-	-
	Jielong	2	-	-	-	3	-
	Kuaizhou-1	2	-	-	-	-	-
CASIC	Kuaizhou-A	21	3	4	-	-	3 (Jiuquan)
	Kuaizhou-11	3	-	-	-	-	1
CAS	Zhongke	5	-	-	-	-	1
Galactic Energy	Gushenxing	12	-	-	-	3	1 (Jiuquan)
Beijing Interstellar Glory Space Technology	Shuangquxian	7	-	-	-	-	4
LandSpace	Zhuque	4	-	-	-	-	1
Space Pioneer	Tianlong	1	-	-	-	-	-
OrienSpace	Yinli	-	-	-	-	1	-
	Total	231	217	147	33	12	24

4 Manned Space Activities

China entered the field of space development in 1970; the following year, the United States successfully completed a manned Moon landing with Apollo 11. China had an ambition to catch up with the advanced nations in space development—the United States and the former Soviet Union—in the near future, to construct its own space station where microgravity experiments, extravehicular activities, etc., are carried out continuously by routinely accommodated astronauts using manned spacecraft and/or space cargo ships. Beyond such ambition was a mission of manned Moon landing. Many projects, including the construction of a large-scale space experimental module, development of super-large launch rockets, operation of multiple data relay satellites for communication between the space station and ground bases, training of many astronauts, and preparation of a landing site for the safe landing of astronauts, needed to be implemented step by step to realize such a mission.

In this chapter, details of these projects to realize manned space activities are described.

4.1 Manned Space Flight

The program of manned space activities of China has three major stages. The first stage was to establish the technology for the original manned spacecraft and its operation, the second stage was the acquisition of in-orbit rendezvous and docking technologies, and the third stage was the construction and operation of a permanent space station. In 2003, China successfully carried out its first manned space flight with the spacecraft Shenzhou 5.³⁰ Twenty years after the completion of the first stage of the program, it completed the third stage with the completion of the Chinese Space Station (CSS), consisting of three modules (called Tiangong^{32, 32} as a whole). Currently, three astronauts stay in the space station regularly, and manned transportation to the space station using Tianzhou,³³ a space cargo ship, is carried out three times a year on a regular basis. This has made China the third country comparable to Russia and the USA in space development with regard to manned spaceflight technologies. The development history of spacecraft after Shenzhou 1 is shown in Table 4-1.

³⁰ "Shenzhou 5 (SZ 5)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/sz-1.htm

³¹ "Tiangong 1 (TG 1)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/tg-1.htm.

³² "Tiangong 2, 3 (TG 2, 3)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/tg-2.htm.

³³ "Tianzhou 1, 2, 3, 4, 5 (TZ 1, 2, 3, 4, 5)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/tianzhou-1.htm.

Table 4-1 Development history of spacecraft after Shenzhou 1

Name of the satellite	International Designator	Launch date	Rocket	Notes
Shenzhou (1)	1999-061A	19-Nov-99	Long March 2F	Unmanned, successfully recovered (Same below)
Shenzhou 2	2001-001A	9-Jan-01	Long March 2F	Unmanned
Shenzhou 3	2002-014A	25-Mar-02	Long March 2F	Unmanned, Equipped with a doll simulating an astronaut
Shenzhou 4	2002-061A	29-Dec-02	Long March 2F	Unmanned
Shenzhou 5	2003-045A	15-Oct-03	Long March 2F	Manned (1 astronaut)
Shenzhou 6	2005-040A	12-Oct-05	Long March 2F	Manned (2 astronauts)
Shenzhou 7	2008-047A	25-Sep-08	Long March 2F	Manned (3 astronauts), Carried out extra-vehicular activities
Tiangong 1	2011-053A	29-Sep-11	Long March 2F/T	Unmanned when launched; docking target of Shenzhou 8 to 10; completed data service on March 16, 2016; disappeared upon re-entering the atmosphere on April 2, 2018
Shenzhou 8	2011-063A	1-Nov-11	Long March 2F/T	Unmanned, first docking to Tiangong 1
Shenzhou 9	2012-032A	16-Jun-12	Long March 2F/G	Manned (3 astronauts, including a first female astronaut), manual docking with Tiangong 1
Shenzhou 10	2013-029A	11-Jun-13	Long March 2F/G	Manned (3 astronauts), docking with Tiangong 1.
Tiangong 2	2016-057A	15-Sep-16	Long March 2F/T	Unmanned when launched; docking with Shenzhou 11 and Tenshu 1; separated and orbited the Earth independently before disappearing upon re-entering the atmosphere on July 19, 2019
Shenzhou 11	2016-061A	16-Oct-16	Long March 2F/G	Manned (3 astronauts), Manual docking with Tiangong 2
Tianhe	2021-035A	29-Apr-21	Long March 5B	The rocket body fell into the Indian Ocean at 72 degrees east longitude on May 9, 2021 without control.
Shenzhou 12	2021-053A	17-Jun-21	Long March 2F/G	Manned (3 astronauts), docking with Tianhe
Shenzhou 13	2021-092A	15-Oct-21	Long March 2F/G	Manned (3 astronaut)
Shenzhou 14	2022-060A	5-Jun-22	Long March 2F/G	Manned (3 astronauts), started an eternal manned mission
Wentian	2022-085A	24-Jul-22	Long March 5B	Experimental module of the Chinese space station, the rocket body fell on the Earth on July 30, 2022 without control.
Mengtian	2022-143A	31-Oct-22	Long March 5B	Experimental module of the Chinese space station, the rocket body fell on the Earth on November 4, 2022 without control.
Shenzhou 15	2022-162A	19-Nov-22	Long March 2F/G	Manned (3 astronauts); transferred the mission inside the CSS; six astronauts were on board simultaneously (for fifteen days)
Shenzhou 16	2023-077A	30-May-23	Long March 2F/G	Manned (3 astronaut)
Shenzhou 17	2023-164A	26-Oct-23	Long March 2F/G	Manned (3 astronauts); its orbital module disappeared on December 19, 2024 (reportedly observed in the west regions of Japan)
Shenzhou 18	2024-078A	25-Apr-24	Long March 2F/G	Manned (3 astronaut)
Shenzhou 19	2024-194A	29-Oct-24	Long March 2F/G	Manned (3 astronauts); currently in flight; carried out extra-vehicular activities

4.2 Astronauts

Twenty-four astronauts had been trained by 2024, and the total number of space missions multiplied by the number of astronauts for each mission is 38 (see Table 4-2). All launches of manned spacecraft Shenzhou are carried out at Jiuquan Satellite Launch Center using Long March 2F (the only rocket equipped with an emergency escape device in China).

Table 4-2 List of Chinese astronauts (as of the end of March 2025)

Number	Name	Period of spaceflight	Boarding spacecraft
1-1	Yang Liwei	15-Oct-03	Shenzhou 5
2-1	Fei Junlong	October 12 to October 16, 2005	Shenzhou 6
2-2		November 19, 2022 to June 4, 2023	Shenzhou 15
3-1	Nie Haisheng	October 12 to October 16, 2005	Shenzhou 6
3-2		June 11 to June 26, 2023	Shenzhou 10
3-3		June 17 to September 17, 2021	Shenzhou 12
4-1	Zhai Zhigang	September 25 to September 28, 2008	Shenzhou 7
4-2		October 15, 2021 to April 16, 2022	Shenzhou 13
5-1	Liu Boming	September 25 to September 28, 2008	Shenzhou 7
5-2		June 17 to September 17, 2021	Shenzhou 12
6-1	Jing haipeng	September 25 to September 28, 2008	Shenzhou 7
6-2		June 16 to 29, 2012	Shenzhou 9
6-3		October 16 to November 17, 2016	Shenzhou 11
6-4		May 30 to November 16, 2023	Shenzhou 16
7-1	Liu Wang	June 16 to June 29, 2012	Shenzhou 9
7-1	<i>Liu Yang</i>	June 16 to June 29, 2012	Shenzhou 9
8-2		June 5 to December 4, 2022	Shenzhou 14
9-1	Zhang Xiaoguang	June 11 to 26, 2023	Shenzhou 10
10-1	<i>Wang Yaping</i>	June 11 to 26, 2023	Shenzhou 10
10-2		October 15, 2021 to April 16, 2022	Shenzhou 13
11-1	Chen Deng	October 16 to November 17, 2016	Shenzhou 11
11-2		June 5 to December 4, 2022	Shenzhou 14
12-1	Tang Hongbo	June 17 to September 17, 2021	Shenzhou 12
12-2		October 26, 2023 to April 30, 2024	Shenzhou 17
13-1	Ye Guangfu	October 15, 2021 to April 16, 2022	Shenzhou 13
13-2		April 25 to November 4, 2024	Shenzhou 18
14-1	Cai Xuzhe	June 5 to December 4, 2022	Shenzhou 14
14-2		October 29, 2024 (ongoing)	Shenzhou 19
15-1	Deng Qingming	November 19, 2022 to June 4, 2023	Shenzhou 15
16-1	Zhang Lu	November 19, 2022 to June 4, 2023	Shenzhou 15
17-1	Zhu Yangzhu	May 30 to November 16, 2023	Shenzhou 16
18-1	Gui Haichao	May 30 to November 16, 2023	Shenzhou 16
19-1	Tang Shengjie	October 26, 2023 to April 30, 2024	Shenzhou 17
20-1	Jiang Xinlin	October 26, 2023 to April 30, 2024	Shenzhou 17
21-1	Li Cong	April 25 to November 4, 2024	Shenzhou 18
22-1	Li Guangsu	April 25 to November 4, 2024	Shenzhou 18
23-1	Zong LngLingdong	October 29, 2024 (ongoing)	Shenzhou 19
24-1	<i>Wang Haohui</i>	October 29, 2024 (ongoing)	Shenzhou 19

Note: Names written in italics indicate female individuals.

The first Chinese female astronaut is Liu Yang. She boarded the spacecraft Shenzhou 9 with the male astronauts Jing Haipeng, on his second mission, and Liu Wang. Liu Yang was selected as an astronaut candidate when she was a People's Liberation Army aviation pilot and started her training to become an astronaut in 2010. She was one of the two astronauts, with one backup, selected from seven candidates for a space mission when a female astronaut was to board Shenzhou 9. According to information obtained in advance, the first female astronaut was originally planned to board Shenzhou 10, since a training period of at least four years was considered necessary, which was judged to be too long for the launch of Shenzhou 9. However, in the case of Liu Yang and the fellow candidate, they already had more than two years of experience as aircraft pilots, which reduced the training period to two years. The fact that the launch of Shenzhou 9 had been delayed also contributed to the decision to include a female astronaut on Shenzhou 9. Not only did Liu Yang have all the physical and mental abilities necessary for an astronaut, but she also achieved excellent results in training across several tens of subjects.

When a Chinese rocket returns to Earth, the manned capsule separated from the service module lands at the Siziwang Banner Landing Field in Inner Mongolia. Until around 2010, the track record of manned space missions was led overwhelmingly by the United States and Russia, while China was regarded as only a beginner in this field. China was 11th in the cumulative number of days spent in space after the United States, Russia, Japan, Germany, France, Canada, Kazakhstan, Italy, the Netherlands, and Belgium (see Table 4-3), with the numbers for all these countries being 200 days or more. While the cumulative number of days spent in space for Japan increased by about 1,300 days as of the end of December 2024, that for China increased to about 3,800 days after the start of full-scale operation of the space station, which makes the annual number of days spent in space by China close to that of the United States and Russia.

**Table 4-3 Number of astronauts and number of days spent in space for each country
(as of the end of December 2012 and December 2024)**

As of the end of December 2012	The United States	Russia	Japan	Germany	China (11th)	World total
Number of astronauts	334	113	9	10	8	529
Number of days staying in the Space	approximately 15,800	approximately 22,100	740	494	59	approximately 41,000
As of the end of December 2024	The United States	Russia	China (3rd)	Japan	Germany	World total
Number of astronauts	362	132	24	12	11	604
Number of days staying in the Space	26,750	33,324	3,783	2,037	1,021	70,697

4.3 Experimental modules Tiangong 1 and Tiangong 2

The target of the second stage following the successful launch of manned spaceships was an experimental rendezvous and docking of a manned spaceship and the space station. The experimental module of the space station, the docking target module Tiangong 1, was launched in September 2011; the unmanned spaceship, the docking tracking module Shenzhou 8, was launched in November of the same year; and the two modules successfully rendezvoused and automatically docked, which was the first such event for China. The fourth manned spaceship, Shenzhou 9, was further launched in June 2012 and successfully docked with Tiangong 1 manually during its 13-day flight.

The second experimental module of the space station, Tiangong 2, conducted a manual rendezvous and docking experiment with Shenzhou 11. As a result of these successful missions, the next step of space exploration became the launch of the CSS. However, the launch of Long March 5 in 2017 failed, and the whole program stagnated. After that, the third experimental module succeeded in 2019, and newly designed experimental spacecraft, the Mars rover Tianwen, Chang'e-5 for returning samples from the Moon, etc., were launched by Long March 5 from 2020, before the awaited launch of the core module of the space station, Tianhe, became ready.

4.4 Cargo spacecraft Tianzhou

Operation of the cargo spacecraft Tianzhou started in 2017, eight of which were launched by the end of 2024 at the Wenchang Space Launch Site by Long March 7 (Table 4-4). After operation at the CSS, it is separated and disappears in the atmosphere.

Table 4-4 Launch of cargo spacecraft Tianzhou

Name of the satellite	International Designator	Launch date	Notes
Tianzhou 1	2017-021A	20-Apr-17	Docking with Tiangong 2, Disappeared on September 22, 2017
Tianzhou 2	2021-046A	29-May-21	Docking with Tianhe (same below), Disappeared on March 31, 2022
Tianzhou 3	2021-085A	20-Sep-21	Disappeared on July 27, 2022
Tianzhou 4	2022-050A	9-May-22	Disappeared on November 14, 2022
Tianzhou 5	2022-152A	12-Nov-22	Disappeared on April 12, 2023
Tianzhou 6	2023-063A	10-May-23	Released Dalian 1, disappeared on January 19, 2024
Tianzhou 7	2024-013A	17-Jan-24	Disappeared on November 17, 2024
Tianzhou 8	2024-211A	15-Nov-24	Currently connected to Tianhe

4.5 Chinese Space Station (CSS) Tiangong

Launch and operation of a permanent space station, the final target of the third stage, started at full scale when Long March 5 became available. In April 2021, the basic module was launched using Long

March 5B at the Wenchang Space Launch Site on Hainan Island, was successfully placed into orbit, and was named Tianhe. In June 2021, three crew members of Shenzhou 12 entered Tianhe, which was in orbit, for the first time. In October of the same year, three crew members were sent to Tianhe by Shenzhou 13. In June of the next year, 2022, Shenzhou 14 was launched, and the CSS became a permanent manned space station with astronauts staying regularly. The first experimental module of the CSS, Wentian, was launched in July 2022, and in October of the same year, the second experimental module, Mengtian, was launched. When Shenzhou 15 was launched in November of the same year, transfer of mission was carried out inside the CSS, within six astronauts staying there for 15 days for the first time. Six modules were connected to Tiangong during this period, with Wentian and Mengtian connected to docking ports on both sides (left and right) of Tianhe, and two Shenzhou modules (launched at the Jiuquan Satellite Launch Center) and a cargo spacecraft Tianzhou (launched at the Wenchang Space Launch Site) connected to three docking ports at both ends (front and rear) and the lower center. The CSS is a complex of these spacecraft and is called Tiangong as a whole. Such a construction process of a space station is similar to that used by the former USSR, which started the space station Mir program in 1986.

While the United States leads the International Space Station (ISS), it gave up developing a core spacecraft like Mir by itself and ordered Russia to prepare a core module, Destiny. The first launch of any kind of ISS component was in 1998, 12 years after the launch of Mir. Even transportation of cargo depended mainly on Progress, a Russian cargo spacecraft, and the Russian spacecraft Soyuz became the only manned transportation method after the accident of the Space Shuttle Columbia, which exploded immediately after launch in 2003. The United States restored its crew transportation capability when Crew Dragon, a manned spacecraft constructed based on the cargo spacecraft Dragon, was launched by SpaceX and successfully returned to Earth in 2020.

While operation of the ISS has been determined to continue to 2030, with the situation thereafter being unclear, China has started full-scale operation of its original space station. As of the end of 2024, Shenzhou 19 is connected to the station, where astronauts stay for about half a year before transferring their mission to fellow members. Like the Intercosmos Project and international joint flight projects, in which the former Soviet Union let astronauts from communist countries and friendly nations stay on its space station, the CSS is also expected to accept astronauts or travelers from various countries in the future.

4.6 Data Relay Satellite Tianlian

Tianlian is China's first data relay satellite developed by the China Academy of Space Technology (CAST), and Tianlian 1-01 (TL-1A) was launched by Long March 3C in April 2008 (Table 4-5). The satellite bus necessary for the basic functions of this satellite is Dongfanghong-3. The launch weight of the four modules launched by Long March 3B was 5,000 kg, and that of the five modules launched by Long March 3C was 2,100 kg. Tianlian 2A-01 (TL-2A), launched in 2019, uses the Dongfanghong-4 bus. Its main mission was communication between the manned spacecraft Shenzhou and ground stations, with a significantly longer linking duration than before.

Table 4-5 Launch of satellite Tianlian

Name of the satellite	International Designator	Launch date	Launch vehicle	Geostationary position
Tianlian 1-01	2008-019A	25-Apr-08	Long March 3C	East Longitude 80.4 degree
Tianlian 1-02	2011-032A	11-Jul-11	Long March 3C	East Longitude 171.1 degree
Tianlian 1-03	2012-040A	25-Jul-12	Long March 3C	East Longitude 20.3 degree
Tianlian 1-04	2016-072A	22-Nov-16	Long March 3C/G2	East Longitude 76.9 degree
Tianlian 2-01	2019-017A	31-Mar-19	Long March 3B/G2	East Longitude 79.8 degree
Tianlian 1-05	2021-063A	6-Jul-21	Long March 3C/G2	East Longitude 16.7 degree
Tianlian 2-02	2021-124A	13-Dec-11	Long March 3B/G3	East Longitude 171 degree
Tianlian 2-03	2022-078A	12-Jul-22	Long March 3B/G3	East Longitude 10.5 degree
Tianlian 2-04	2025-062A	26-Mar-25	Long March 3B/G3	In the process of becoming geostationary

4.7 Organizations Leading the Manned Space Activities

The manned space program of China is promoted through the participation of related organizations and companies, including astronauts, under leadership headed by the Minister of Equipment Development of the Central Military Commission. The China Manned Space Agency (CMSA) implements the actual operations.³⁴ Research organizations, including the Technology and Engineering Center for Space Utilization, the China Aerospace Science and Technology Corporation (CASC), the Changchun Institute of Optics, Fine Mechanics and Physics (CIOMP), the Shanghai Institute of Technical Physics (SITP), the Center for Space Science and Applied Research (CSSAR), the Institute of Physics (IOP), the Shanghai Institute of Ceramics (SIC), and the Institute of Optics and Electronics (IOE) under the Chinese Academy of Sciences (CAS), participate in the manned space program to carry out research related to manned space activities, such as the utilization of the microgravity environment. As state-owned enterprises, the China Aerospace Science and Industry Corporation (CASIC) and the China Electronics Technology Group Corporation (CETC) joined the original member, the CASC, in 2011. The chairman of both enterprises, Chen Mingbo, was appointed as one of the Deputy General Commanders of the manned space program.

Most Chinese astronauts have been soldiers of the People's Liberation Army, while scientists and other non-military personnel are also selected as astronauts following the operation of the CSS. The People's Liberation Army carries out the selection and training of astronauts, as well as the operation of launch site and control equipment.

³⁴ 中国载人航天. <https://www.cmse.gov.cn/>.

5 Lunar and Planetary Exploration

The lunar exploration program launched in 2007 has been pursued under a three-stage strategy ("Three-Step Approach") comprising "unmanned lunar exploration," "manned lunar landing," and "construction of a lunar base." Within the "unmanned lunar exploration" phase, the mission has been implemented in three stages—绕 (ráo) (lunar orbit), 落 (là) (lunar landing), and 回 (huí) (bringing back lunar samples)—under the "three-step approach" to achieve its objectives by 2024. Lunar orbit missions have been conducted twice: in 2007 ("Chang'e-1") and 2010 ("Chang'e-2"). Lunar landings took place in 2013 ("Chang'e-3," landing on the near side of the Moon in 2014) and 2018 ("Chang'e-4," landing on the far side of the Moon in 2019). Lunar sample return missions were also implemented in 2020 ("Chang'e-5") and 2024 ("Chang'e-6," targeting the Moon's far side). Over the course of 17 years, all satellite missions have been successful. In the upcoming fourth step of unmanned exploration, missions such as Chang'e-7 and Chang'e-8 are expected to primarily conduct scientific investigations and resource surveys for water and other elements on the far side of the Moon. Concurrently, efforts will be directed toward the future construction of crewed lunar bases.

5.1 Organizations Leading Lunar and Planetary Exploration

China's lunar exploration program is promoted by the "Chinese Lunar Exploration Program" (CLEP), which operates under the direct authority of the State Administration of Science, Technology, and Industry for National Defense (SASTIND), an agency of the Ministry of Industry and Information Technology (MIIT).³⁵

Similar to manned space activities, the members of the CLEP include personnel from the People's Liberation Army responsible for rocket launches, researchers and engineers from the China Aerospace Science and Technology Corporation (CASC) developing spacecraft, and scientists from the Chinese Academy of Sciences (CAS) engaged in scientific research. In particular, Ouyang Ziyuan, an academican of the Chinese Academy of Sciences (the highest honor in the field of science and technology), has led the scientific mission of the lunar exploration project, including the publication of a global map of the Moon based on data from the "Chang'e-1" mission.

5.2 Lunar Exploration Achievements by Country

The United States has an overwhelming advantage in lunar exploration. Russia has also achieved substantial exploration accomplishments despite failing to land astronauts on the Moon, including photography of the far side of the Moon, soft landings, and sample returns. Table 5-1 shows a comparison of global lunar exploration achievements, including those of Europe, Japan, and India. China's lunar exploration program is still in its early phases, but given its proven track record of reliably executing and

³⁵ Chinese Lunar Exploration Program, <http://www.clep.org.cn/>.

successfully completing large-scale projects, achieving the first phase—catching up with the United States and Russia—is considered highly feasible.

Table 5-1 Flagship Lunar Exploration Achievements of Leading Nations and Regions

Category	US	Europe	Russia	Japan	China	India
Lunar Orbiter (unmanned)	Clementine	Smart-1	Luna 10	Kaguya	Chang'e 1,2	Chandrayaan 1
Lunar Lander (unmanned)	Surveyor 1	-	Luna 9	Hakuto	Chang'e 3,4	Chandrayaan 2
Lunar sample return	-	-	Luna 16	-	Chang'e 5,6	-
Lunar Lander (manned)	Apollo 11	-	-	-	-	-

Note) The breakdown of Apollo program launches to lunar orbit is as follows: 2 crewed lunar orbits (Apollo 8, Apollo 10), 6 successful lunar landings (Apollo 11–12, Apollo 14–17), and 1 aborted landing attempt (Apollo 13).

5.3 Unmanned Lunar Exploration

China's lunar exploration program divides its first phase into multiple stages: the first stage involves lunar orbiting; the second stage includes lunar landing and lunar exploration using a rover; the third stage focuses on sample return; and the fourth stage plans for landing at the Moon's South Pole. The second phase plans for short-term manned landings and returns, whereas the third phase envisions a long-term manned lunar base. Based on a phased plan, China has advanced the development of its unmanned lunar probe "Chang'e" and communication satellites "Queqiao" and "Tiandu" (Table 5-1). This section outlines a chronology of these developments.

Table 5-2 Launch Status of Unmanned Probes and Communication Satellites

Satellite	International Designator	Date of Launch	Launch Vehicle	Launch Site	Note
Chang'e-1	2007-051A	Oct. 24, 2007	Long March 3A	Xichang	Lunar Orbit
Chang'e-2	2010-050A	Oct. 1, 2010	Long March 3C	Xichang	Lunar Orbit
Chang'e-3	2013-070A	Dec. 1, 2013	Long March 3B/G3Z	Xichang	Lunar Landing
Queqiao	2018-045A	20-May-18	Long March 4C	Xichang	Deta Relay
Chang'e-4	2018-103A	Dec. 7, 2018	Long March 3B/G3Z	Xichang	Landing on the far side of the moon
Chang'e-5	2020-087A	Nov. 23, 2020	Long March 5	Wenchang	Sampling
Queqiao 2	2024-051A	Mar. 20, 2024	Long March 8(1)		Deta Relay
Tiandu 1	2024-051D	Mar. 20, 2024	Long March 8(1)	Wenchang	Telecommunication with the moon
Tiandu 2	2024-051C	Mar. 20, 2024	Long March 8(1)		Telecommunication with the moon
Chang'e-6	2024-083A	3-May-24	Long March 5	Wenchang	Lunar Sampling on the far

Unmanned lunar exploration in China began with the launch of Chang'e-1³⁶ on October 24, 2007.

³⁶ "Chang'e 1 (CE 1)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/change-1.htm

This marked China's first extraterrestrial orbital flight, representing a groundbreaking advancement in its space technology capabilities by securing a rocket powerful enough to break free from Earth's gravitational pull and venture into deep space beyond our planet. China became the fifth country to achieve lunar orbiting after Russia, the United States, Europe, and Japan. Chang'e-1 orbited at an altitude of approximately 200 km above the lunar surface and performed investigations such as acquiring three-dimensional images of the lunar surface, determining the content of useful elements on the surface, characterizing the distribution of material types, measuring the thickness of the regolith, and collecting data on cislunar space. These vast amounts of valuable data were transmitted back to Earth, providing crucial information that can serve as a reference for future lunar missions in China.

China manufactured a ground-backup spacecraft in parallel with the development of Chang'e-1. It was produced to enable the prompt launch of a replacement vehicle in the event of a launch failure. Following the great success of Chang'e-1, this backup spacecraft was designated as Chang'e-2 and launched in October 2010 with additional complex missions. Chang'e-2 orbited the Moon at an altitude of approximately 100 km, similar to Japan's Kaguya. During its roughly one-year operational period, it conducted higher-precision observations than Chang'e-1 and acquired detailed observational data of the planned landing site required for the next lunar landing mission phase. The first phase of China's lunar exploration program was completed during this mission.

Chang'e-2 minimized its fuel consumption during lunar orbit insertion, leaving a significant amount of fuel remaining and thereby allowing for the addition of a new mission extending beyond the Moon. It conducted astronomical observations at the second Sun-Earth Lagrange point (SEL-2), located 1.5 million kilometers away from Earth's orbital path, a location where the satellite's position is stabilized by the gravitational balance of the Sun and Earth. Furthermore, it aimed to rendezvous with the near-Earth asteroid "Toutatis" (asteroid number 4179). Chang'e-2 successfully completed all these missions.

China developed Chang'e-3³⁷ as part of the second phase of its first lunar exploration program. The satellite was launched toward the Moon on December 1, 2013 (UTC; early morning of the 2nd in China), and entered lunar orbit on December 6. As there is no atmosphere on the Moon, parachutes cannot be used for lunar landings. Instead, engines dedicated to reverse thrust must be employed to adjust the descent speed and gradually lower the altitude. This engine has the highest thrust among all satellite-mounted engines in China. When the perigee reached 15 km, the spacecraft entered the powered descent phase by firing its engines with reverse thrust. After initiating the powered descent, the laser altimeter accurately measured the distance to the lunar surface. When the altitude reached a few meters above the surface, the engine was shut down, and the spacecraft entered free fall under the gravity of the Moon, reaching the lunar surface. The timing of the engine shutdown command is a critical factor that determines the success of a soft landing. The spacecraft safely landed at Sinus Iridium (Bay of Rainbows), its planned landing site, on December 14.

This made China the third country in the world to land on the Moon, joining Russia and the United States. The last lunar soft landing had been achieved by the Soviet Union's Luna 24 in 1976, marking the

³⁷ "Chang'e 3, 4 (CE 3, 4)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/change-3.htm.

first lunar landing in 37 years. After landing, the lunar rover "Yutu" was deployed. The rover and lander took photographs of each other and commenced their respective scientific missions.

Chang'e-3 was designed to perform its mission almost entirely autonomously from descent to landing, featuring Chinese-developed technological innovations. Although the Moon's gravitational pull is only one-sixth that of Earth, the landing cushioning mechanism was meticulously designed to protect the Chang'e-3 equipment as much as possible. The landing gear had to be sufficiently strong to withstand the impacts sustained during landing. Weight restrictions were extremely strict and required all components to be as light as possible. To develop a lightweight yet strong structure, all unnecessary parts were eliminated, resulting in a minimal yet robust landing gear design. Sensors were equipped on the landing gear and designed to send a signal upon touchdown on the Moon to confirm a successful landing.

The four-legged lander carries a telescope body and a rotating platform for the mirror, enabling astronomical observations from the lunar surface. After unloading the lunar rover "Yutu," the lander itself became a "lunar observatory," conducting astronomical observations during the long lunar day (the period when the Sun is visible from the Moon), equivalent to 14 Earth days. It is generally believed that optical astronomical observations during the day are impossible on Earth because the atmosphere scatters sunlight, causing the sky to glow brightly. The Moon has no atmosphere, so the sky does not glow brightly; both the Sun and Earth can be seen as stars floating in pitch-black darkness. The observation data were transmitted to Earth via a communication system installed on the lander. At night on the Moon, temperatures can drop to -150°C , and equipment would freeze solid without protection. The lander utilizes radioisotope heater units (RHUs) to keep it warm and spends long lunar nights in a state akin to hibernation. When the Sun rises, it can be revived as if spring had arrived.

Additionally, the lander is equipped with an extreme ultraviolet (EUV) camera to measure the structure of fine-particle dust clouds surrounding the Earth. It is not possible to observe the plasma layer surrounding the Earth from the Earth's surface, and satellite observational data are also fragmentary. From the lunar surface, which is 380,000 km away, it is possible to capture the entire plasma layer of the Earth as a three-dimensional image.

The primary scientific mission of the six-wheeled lunar rover "Yutu" is to traverse the lunar surface using a subsurface radar mounted on its underside (the bottom surface facing the Moon) to measure subsurface structures up to 30 m deep and the structure of a second subsurface layer at a depth of 100 m. Such underground radar measurements are commonly employed on Earth, and measurements on the lunar surface are expected to yield unprecedented observational data. It also carried a panoramic camera and an infrared spectrometer, enabling elemental analysis of the surface.

The power source for "Yutu" is RHUs. One day on the Moon is equivalent to one month on Earth. That is, once the Sun begins to rise, daylight continues for half a month; once the Sun sets, the night continues for half a month, and one month later, the Sun begins to rise again. Relying on solar panels for power during the half-month period of extreme cold is difficult during nighttime operations and heating. China overcame one of the greatest technical challenges in this lunar exploration mission by using nuclear batteries.

Chang'e-3 and "Yutu" protect their internal equipment with multilayer thermal insulation materials to minimize the loss of heat gained from the Sun during the daytime, but this alone cannot maintain the

components within their operational temperature range, necessitating a separate heat source, in which radioactive isotope heat sources play a crucial role.

During the "daytime" under the Sun, temperatures can exceed 150 ° C, while during the "nighttime" after the Sun sets, temperatures can reach as low as -150 ° C. U.S. probes spent only one lunar night, but the Chang'e-3 mission, designed for a three-month operation, employed a radioisotope heat source (RHU). Scientists and engineers conducted research on radiation protection technology, ground testing and verification technology, nuclear energy conversion technology, and other areas with technical bottlenecks. This was the first time China had used nuclear energy in a space project. With the success of this mission, China acquired key technologies that will be crucial for future space projects, such as lunar and deep-space exploration.

Chang'e-4, developed in parallel as a backup for Chang'e-3, successfully performed the world's first autonomous landing in the Aitken Basin on the far side of the Moon on January 3, 2019, in coordination with the Queqiao data relay satellite. The world's first successful landing on the far side of the Moon was achieved, and the lunar rover "Yutu-2" was deployed to conduct on-site geological surveys. It also conducted unprecedented lunar exploration missions, including observations of cosmic microwave background radiation in a magnetically quiet environment and experiments on the growth of plants and animals. To land on the far side of the Moon—a feat no country had previously achieved—communication had to be established at a location beyond the direct reach of Earth's radio waves. To solve this challenge, China launched the "Queqiao," data relay satellite in May 2018. This satellite circles in an orbit at a point approximately 60,000 km from the Moon. China's successful landing on the far side of the Moon—the first of its kind and not merely following the footsteps of developed nations—demonstrates the momentum of China's progress in space technology. Photographs of Chang'e-4 taken by "Yutu-2" were transmitted to Earth via "Queqiao." As of September 29, 2021, "Yutu-2" had achieved its 1,000th day of operation, with a total distance traveled of 839.37 m.

The third phase of the lunar mission, following orbiting and landing, involves the challenge of performing a relaunch from the lunar surface and returning samples of lunar rocks and soil collected there to Earth—the so-called "sample return." The development of Chang'e-5 was completed in 2017, and it was launched from the Wenchang Satellite Launch Site in November 2020 aboard the Long March 5 rocket. Thereafter, it returned to Earth with approximately 2 kg of soil and rock samples collected from the lunar surface.

The most difficult challenge in the sample return mission is release from the Moon. Fortunately, the Moon's gravity is only approximately one-sixth that of Earth, is extremely weak, and there is no air resistance. Therefore, even low-thrust propulsion engines that cannot be applied for practical use on Earth can be used for relaunching from the lunar surface. However, safely landing the entire launch system, including the relay vehicle, on the lunar surface and remotely operating it from Earth to load recovered samples and prepare for a relaunch pose significant technical challenges. The remote operation of rovers for sample collection was pioneered by Russia in the 1960s with the Lunokhod rover. Successfully combining remote operation from Earth with the rover's own autonomous control on the lunar surface requires considerable development effort, even with today's advanced communication technology (in the United States, NASA's Jet Propulsion Laboratory (JPL) conducted unmanned exploration of Mars, and it is possible that China referenced proven unmanned exploration technology from Mars rovers following the

Apollo program).

To overcome these technical challenges, the Chang'e-5 mission successfully retrieved samples in December 2020. The Chang'e-5 orbital module, after jettisoning the sample return capsule that had returned to Earth, subsequently flew toward the second Lagrange point in the Sun–Earth system (SEL-2, located on the opposite side of the Sun as seen from Earth and approximately 1.5 million kilometers away from Earth).

As described above, China advanced the second and third phases of the first stage of its lunar exploration program simultaneously, thereby shortening the overall development period of the first stage. The sheer number of people capable of making this happen is another strength of China.

On May 3, 2024, China launched the Chang'e-6 mission using the Long March 5 rocket. Supported by the Queqiao-2 relay satellite launched earlier, it landed in the Aitken Basin on the far side of the Moon on June 2. In addition to Queqiao-2, two Tiandu satellites were launched to conduct tests on navigation, positioning, and communication on the Moon. On June 4, it collected lunar samples and launched a return vehicle from the far side of the Moon for the first time worldwide. On June 25, the return vehicle landed in the Inner Mongolia Autonomous Region, successfully completing the sample return. The Pakistani lunar orbiter "ICUBE-Q," launched simultaneously, also successfully entered orbit and established communication with Chang'e-6.

On January 15, 2024, the CASC announced that the launch of Chang'e-7, the first mission of Phase 4 of the first-stage lunar exploration program, was scheduled for 2026. The mission aims to obtain evidence of water and ice at the Moon's south pole. The payloads aboard Chang'e-7 include missions solicited internationally. Along with the development of Chang'e-7, demonstration activities are also advancing for follow-on missions, such as Chang'e-8 and the International Lunar Research Station (ILRS). The ILRS is a joint initiative between China and Russia, with Nicaragua as a participating country, and two international organizations—the Asia-Pacific Space Cooperation Organization (APSCO) and the Arab Union for Astronomy and Space Sciences—have expressed their participation.

5.4 Manned Lunar Exploration

China aims to conduct short-term manned lunar stays during the second phase (2025–2030) of its lunar exploration program and to construct a manned lunar base capable of long-term stays during the third phase (from 2030 onwards). If the first-stage technological achievements for lunar exploration, as well as for manned space activities such as the space station, continue to be steadily acquired, the time when full-scale manned lunar exploration begins by combining these technologies may not be too far off. By 2025, the primary equipment for the manned lunar exploration mission is currently in the prototype development phase, and its naming has been finalized: the manned spacecraft is "Mengzhou," the lunar lander is "Lanyue," the lunar spacesuit is "Wangyu," and the manned lunar rover is "Tansuo."

China's objectives for pursuing a manned lunar landing remain unclear, but various motivations have been speculated, including water extraction, obtaining helium-3 for fusion power generation, securing lunar resources, utilizing the Moon as a staging base for Martian missions, and transferring technology to industry. The lunar surface, like the Antarctic continent, is considered unclaimed by any nation; however,

activities such as building construction for scientific observation purposes are possible.

5.5 Planetary Exploration

Regarding China's planetary exploration efforts concerning Mars, there is the Chinese Mars orbiter "Yinghuo-1," which was piggybacked aboard Russia's Mars probe "Phobos-Grunt," launched in November 2011. However, both failed to separate from the upper stages of the rocket when they attempted to enter the Martian transfer orbit from Earth orbit, resulting in failed orbital insertion and re-entry into the atmosphere. Thereafter, the Tianwen-1³⁸ Mars probe was injected into Martian orbit on February 10, 2021 (Table 5-3). China became the sixth country in the world to achieve Mars orbit insertion, following Russia, the United States, Europe, India, and the UAE, as the UAE's Mars probe, Al-Amal, successfully entered Mars orbit one day earlier on February 9.

The Tianwen-1 spacecraft successfully landed on Mars on May 15 of the same year, making China the third country in the world to achieve a Martian landing, following Russia and the United States. The dispatch of the Mars rover "Zhurong" was also successful. After the United States, China became the second country to conduct surface activities on Mars, such as rover operations. Zhurong also successfully established communication with "Mars Express," the European Space Agency's (ESA) Mars orbiter. Around October 20 of the same year, when the Earth and Mars were nearly aligned in a straight line with the Sun in between, Tianwen-1 encountered a phenomenon—in which its communications were disrupted by the Sun's powerful electromagnetic waves—similar to a solar eclipse (a solar eclipse occurs when the Sun passes behind the Earth, even for satellites near Earth). It successfully weathered this period (in Chinese, "度过"). The headline in the CASC news featured the four-character compound "度過日凌."

Table 5-3 Launch Status of Tianwen-1

Satellite Name	International Designator	Date of Launch	Launch Vehicle	Launch Site	Note
Tianwen-1	2020-049A	23-Jul-20	Long March/YZ2	Wenchang	Mars Explorer

Regarding other planetary exploration, following the successful completion of its lunar orbit mission as an extension of the Chang'e-2 mission, a rendezvous was made on December 13, 2012, with the near-Earth asteroid "Toutatis" (asteroid number 4179), and images from angles previously unseen from Earth revealed that it is not a nearly spherical object like a potato, but rather an elongated asteroid. In future Tianwen series missions, a sample return from the moons of Mars is planned. From 2025 to 2028, the asteroid exploration spacecraft Tianwen-2 and Tianwen-3 may be launched in succession. Furthermore, it is possible that the Tianwen-4 mission to explore Jupiter will be launched by 2030. Regarding the deep-space antenna system used for planetary exploration and communication with Earth, the Xi'an Satellite Tracking and Control Center (XSCC) completed its installation in Kashgar, Xinjiang Uygur Autonomous Region, in November 2020. Deep-space communication with Chang'e-4, Chang'e-5, and Tianwen-1 commenced using four 35-meter-diameter antennas: three newly installed antennas and one existing antenna.

³⁸ "Tianwen 1 / Zhurong (Huoxing 1, HX 1)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/tianwen-1.htm

6 Space Science Field

6.1 Mid-to-Long-Term Development Plan for Space Science

In 2009, the Chinese Academy of Sciences (CAS) created roadmaps for all science and technology fields through 2050. In the space sector, it set a strategic goal of achieving a crewed Mars landing by 2050. For the next 15 years, CAS did not release updated versions. In October 2024, CAS announced the "National Mid-to-Long-Term Development Plan for Space Science," which aims to make China a major space science power by 2050. The plan specifies targets, including the selection and number of missions to be developed in three phases: up to 2027, 2028–2035, and 2036–2050.³⁹

The objectives and candidate missions for each of the three phases are described below.

(1) Phase I: Up to 2027

<Objectives>

- The overall level of scientific research will advance significantly, with continued world-class achievements in fields with strong foundations and advantages, such as high-energy time-domain astronomy, the Sun–Earth system, the formation and evolution of the Moon and Mars, microgravity physics, and space life science.
- The ability to conduct numerous space science missions will be demonstrated. Five to eight missions will be selected in scientific frontier areas, such as dark matter, the extreme universe, gravitational waves, primordial nebulae, exoplanets, solar activity, the solar system, and the Earth system. In addition, two to three large-scale missions with potential for breakthrough results will be identified.
- Significant progress will occur in developing new models for space activities. "Leader" and "pioneer" groups will be established in space science, talent development will advance, and international standing will increase.

<Candidate Missions>

- Operate the Chinese Space Station and conduct crewed lunar exploration, the Phase IV lunar exploration program, and planetary exploration programs, producing many original achievements with significant international influence.
- Select two or three large-scale missions from areas such as coordinated multi-band signal observations (including space-based X-rays), X-ray hot baryon detection, cosmic gravitational wave detection, and solar polar orbit exploration. Additionally, select three to five medium-, small-scale, or opportunity missions from fields such as dark matter particle detection, space-based very long baseline interferometry (VLBI), space infrared observations, detection of hidden natural objects, transparent-ocean constellations, all-weather three-dimensional wind observations, Earth's radiative energy balance,

³⁹ Chinese Academy of Sciences. "National Mid-to-Long-Term Development Plan for Space Science (2024–2050). <https://www.cas.cn/zt/kjzt/kjxqgh/>.

cross-scale magnetospheric constellation observations, solar observations from the Sun–Earth L5 point, space-based solar radio array observations, high-precision observation of traces of human activity, spatiotemporal patterns of global vegetation biomass, observations of the Jovian system, and exoplanet exploration.

(2) Phase II: 2028–2035

<Objective>

- In internationally leading-edge fields, such as medium- and low-frequency gravitational waves, the cosmic dark ages, the discovery of habitable Earth-like planets, solar activity, Earth system responses, in-situ use of lunar resources, and signs of life on Mars, as well as studies of black holes, neutron stars, dark matter, and dark energy, original and innovative results will be produced continuously. These achievements will show that China has reached the forefront of innovation-oriented nations worldwide.
- In scientific frontiers such as the early universe, new physics of extreme astrophysical objects, nearby habitable exoplanets, early solar system archaeology, the search for extraterrestrial life, solar eruptions and coronal heating mechanisms, and detection of the edge of the solar system, about 15 space science missions will be justified and implemented, including four or five large-scale missions.
- China will achieve integrated development in space science, space technology, and space applications, establish a comparative advantage in the global competition for talent in space science, and ensure that its national strategic talent capacity and teams of leading scientists remain at the forefront globally.

<Candidate Missions>

- Through Phase 1 (missions up to 2027), China aims to achieve world-leading, original scientific results. This phase includes operating the China Space Station and conducting scientific missions such as crewed lunar exploration, establishing a lunar scientific research station, detecting the edge of the solar system, studying giant planetary systems, and carrying out a Venus atmospheric sample-return mission.
- Missions include high-precision infrared observations in space, comprehensive monitoring of earthquakes caused by tidal forces of celestial bodies, solar-orbit probing, space-based high-energy and X-ray detection, and gravitational wave detection in space. From large-scale missions not yet approved at the planning stage in 2027, four or five major missions will be selected. These will cover ultraviolet astronomical observations, satellite constellations for measuring ocean energy levels, observations of cross-boundary coupling processes in critical regions, and studies of thermodynamic structures and chemical compositions in boundary layers. Additionally, depending on opportunity, 10 or 11 medium- and small-scale missions will be chosen from directions and candidates not approved by 2027. These include global high-precision geomagnetic satellite constellations, Earth stress observations, exploration of Earth's radiation belts, investigation of space weather sources, detection of solar high-energy phenomena in stratified regions, quadrupolar collaborative scientific observations (polar–macro, polar–micro, extreme conditions, and highly integrated and cross-disciplinary), monitoring dynamic changes of the Earth, asteroid detection, and detection of satellites of exoplanets.

(3) Phase III: 2036–2050

<Objective>

- China will become an international leader in key fields and a major global power in space science. By making significant advances in basic research on the origin and evolution of the universe, the nature of space and time, the solar system, the origin of life, and crewed deep-space exploration, China will expand the boundaries of human knowledge and support the progress of human civilization.
- China will lead global space science development by planning and carrying out more than 30 space science missions, demonstrating core competitive strengths and strong leadership in the new scientific and technological revolution.
- China will assemble world-class scientific teams, establish leading global space science centers and innovation hubs, and serve as a key indicator of a strong, modern socialist nation.

<Candidate Missions>

- China's main areas of space science will achieve a world-leading level. The country will carry out five to six large-scale missions, about 25 medium- and small-scale missions, and additional missions based on available opportunities.

6.2 Astronomical Observation and Astrophysical Science

Astronomical observation has traditionally relied on the human eye and optical telescopes. In China, the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST), also known as the Guo Shoujing Telescope, was developed as a national project in the mountainous region of Liaoning Province and completed in 2009. LAMOST has an effective optical aperture of about 4 meters and offers the world's largest field of view for all-sky surveys at 5 degrees. It can acquire spectra for 4,000 stars simultaneously in a single observation. According to a March 2023 announcement by the National Astronomical Observatories of the CAS (NAOC) titled "China's LAMOST Spectral Data Surpasses 20 Million: A World First, Enabling a New Upgrade in Understanding the Universe," the total number of spectra obtained has surpassed 20 million.

Spaceborne telescopes on artificial satellites include instruments for X-ray, gamma-ray, and infrared observations. In recent years, many countries have conducted coordinated observations across multiple frequency bands, combining optical astronomy with radio-wave and energetic particle measurements. In China, independent astronomical observations using satellites began around 2015, following a period of slower development in space science. Compared with ground-based telescopes, orbital observations avoid atmospheric and cloud interference. Additionally, orbital parameters can be selected to meet specific observational objectives.

The National Astronomical Observatories' long-established observational facilities include the Changchun Satellite Observatory, Nanjing Institute of Astronomical Optics and Technology, Purple Mountain Observatory, Shanghai Astronomical Observatory, Yunnan Observatories, and Urumqi Astronomical Observatory. Research in astronomical observation covers topics such as X-ray hot baryons, cosmic gravitational waves, dark matter particles, VLBI, radio array observations, and solar polar orbit

exploration. While some topics have been studied for many years, high-priority research themes can also emerge unexpectedly. Table 6-1 lists the various astronomical observation satellites launched by China since 2015.

Table 6-1 Launch Status of Space Science Satellites (Excluding GRID Programs)

Satellite Name	International Designator	Launch Date	Rocket Name	Launch Site	Mission
Wukong	2015-078A	17-Dec-15	CZ-D2	Jiuquan	Dark Matter
Huiyan	2017-034A	15-Jun-17	CZ-4B	Jiuquan	X-ray
Tianqin-1	2019-093C	20-Dec-19	CZ-4B	Taiyuan	Gravitational wave
Longjiang-1	2018-045B	20-May-18	CZ-4C	Xichang	Radio-waves
Longjiang-2	2018-045C				
Longxia yan	2020-051B	25-Jul-20	CZ-4B	Taiyuan	X-ray
Gravitational Wave High-energy Electromagnetic Counterpart All-sky Monitor Satellites	2020-094A	10-Dec-20	CZ-11	Xichang	Gravitational wave
	2020-094B				
Yangwang	2021-050B?	11-Jun-21	CZ-2D (2)	Taiyuan	Optical Telescope
Solar Explorer for Scientific and Technological Demonstration, Xihe	2021-091A ?	14-Oct-21	CZ-2D (2)	Taiyuan	Solar
Kuafu	2022-129A	8-Oct-22	CZ-2D (2)	Jiuquan	Solar
Einstein Probe	2024-007A	9-Jan-24	CZ-2C (3)	Xichang	X-ray
SVOM	2024-116B	21-Jun-24	CZ-2C (3)	Xichang	Gamma-ray
CATCH 1	2024-116A	21-Jun-24	CZ-2C (3)	Xichang	X-ray
eXTP	Under Development	In 2025	Undetermined		Black Holes
SPORT	Under Development	Undetermined	Undetermined		Solar

The dark matter explorer “Wukong,”⁴⁰ launched in December 2015, is operated by the Purple Mountain Observatory in Jiangsu Province. It carries five types of observation instruments, including a neutron detector. During 683 days of flight, it observed 3.13 billion high-energy cosmic-ray particles. The satellite flies in a Sun-synchronous polar orbit at an altitude of 500 km, has a mass of 1,900 kg, and a design lifetime of three years; however, it remains in orbit around the Earth.

In June 2017, the CAS launched the Hard X-ray Modulation Telescope “Huiyan” (HXMT).⁴¹ This was China’s first X-ray astronomical observation satellite. Its primary missions are to discover high-energy celestial objects and observe black holes. The Ministry of Science and Technology (MOST), Tsinghua University, and other organizations contributed to its development. The satellite currently operates in a low Earth orbit (LEO) at an altitude of 500 km with an orbital inclination of 43 degrees.

In May 2018, Harbin Institute of Technology launched two lunar-orbit radio astronomy satellites, “Longjiang-1” and “Longjiang-2.”⁴² These satellites orbit the Moon and were launched with the Chang’e-4 data relay satellite “Queqiao” aboard a Long March-4C (CZ-4C) launch vehicle. They entered lunar orbits with a perilune of 200 km and an apolune of 900 km. Their mission is to observe using ultra-long-wavelength radio waves.

⁴⁰ “DAMPE (Wukong)”, Gunter’s Space page, https://space.skyrocket.de/doc_sdat/dampe.htm.

⁴¹ “HXMT (Huiyan)”, Gunter’s Space page, https://space.skyrocket.de/doc_sdat/hxmt.htm.

⁴² “DSLWP A1, A2 (Longjiang 1, 2 / LO 93, 94 / Lunar-OSCAR 93, 94)”, Gunter’s Space page, https://space.skyrocket.de/doc_sdat/dslwp-a.htm.

In December 2019, Sun Yat-sen University's Zhuhai campus launched the gravitational wave observation satellite "Tianqin-1."⁴³ The program aims to carry out space-based gravitational wave observations and precision space metrology with three satellites flying in formation. The launch of "Tianqin-2" is planned for approximately 2025.

The X-ray astronomical observation satellite "Lobster Eye" (official name: "Lobster Eye X-ray Exploration Satellite"),⁴⁴ developed by Nanjing University, the University of Hong Kong, and others, has a mass of 50 kg and is equipped with an X-ray detector for astronomical observations despite its small size. It is claimed to be the world's first satellite to use technology that detects soft X-rays based on an imaging principle inspired by lobster eyes.

In December 2020, two "Gravitational wave High-energy Electromagnetic Counterpart All-sky Monitor" satellites (GECAM), also known as "Huairou,"⁴⁵ were launched. Each satellite has 25 gamma-ray detectors (GRDs) and eight charged-particle detectors (CPDs). Each satellite weighs 140 kg and operates in low Earth orbit at an altitude of 550–600 km with an orbital inclination of 29 degrees. The National Space Science Center (NSSC) of the CAS led the development of these satellites. The Innovation Academy for Microsatellites of CAS (IAMCAS) developed and manufactured the satellite systems. The Institute of High Energy Physics (IHEP) defined the scientific missions and developed the onboard payloads and scientific use systems. The Aerospace Information Research Institute (AIR) built the ground-based scientific data reception system.

In June 2021, Shenzhen Dongfanghong Satellite Company launched "Yangwang," which is equipped with an optical telescope. Shenzhen Origin Space Technology Company planned to launch additional satellites; however, the launch of its second satellite failed in December 2024.

In October 2021, the CAS launched the space science satellite "Xihe" (Chinese H-alpha Solar Explorer, CHASE)⁴⁶ for scientific and technological demonstration of solar exploration, using a CZ-2 launch vehicle.

The Advanced Space-based Solar Observatory (ASO-S) "Kuafu,"⁴⁷ launched in October 2022 by the CAS, is a satellite designed to observe and study the formation mechanisms, interrelationships, and dynamic characteristics of the solar magnetic field, solar flares, and coronal mass ejections (CMEs). The satellite has a mass of 859 kg and a mission lifetime of four years. It carries instruments such as a Full-Disc Vector Magnetograph (FMG), a Lyman-alpha Solar Telescope (LST), and a Hard X-ray Imager (HXI). Solar observations take place from a Sun-synchronous orbit (SSO) at an altitude of 720 km and an orbital inclination of 98.2 degrees.

On January 9, 2024, the CAS launched the X-ray astronomical observation satellite "Einstein Probe" (Aiyinsitan Tanzhen).⁴⁸ It operates in low Earth orbit at an altitude of approximately 600 km and an orbital inclination of 29 degrees.

On June 22, 2024, the CAS launched the gamma-ray astronomical observation satellite "Space Variable

⁴³ "Tianqin 1/CAS 6 (TQ-OSCAR 108)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/tianqin-1-cas-6.htm.

⁴⁴ "Longxia Yan 1 (Lobster Eye 1)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/longxia-yan-1.htm.

⁴⁵ "GECAM A, B (KX 08A, 08B / Xiaoji, Xiaomu)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/gecam.htm.

⁴⁶ "CHASE (Xihe)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/chase.htm.

⁴⁷ "ASO-S (Kuafu)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/aso-s.htm.

⁴⁸ "Einstein Probe (EP, Aiyinsitan Tanzhen)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/einstein-probe.htm.

Objects Monitor" (SVOM),⁴⁹ also known as the China–France astronomical satellite, which was jointly developed by China and France. The mission focuses on observing gamma-ray bursts. The China National Space Administration (CNSA) coordinated international cooperation, and the Xi'an Branch of the China Academy of Space Technology (CAST) under CASC developed the Chinese payload instruments. The satellite operates in low Earth orbit at an altitude of approximately 600 km with an orbital inclination of 30 degrees.

The IHEP of the CAS launched the X-ray and gamma-ray astronomical observation satellite "Quanbianyuan Zhuizong Lieren Xingzuo" (Chasing All Transient Constellation Hunter 1; CATCH 1) at the same time as SVOM. Its mission is to conduct multi-frequency astronomical observation using a narrow-field X-ray telescope and wide-field X-ray and gamma-ray telescopes. This satellite also carries Payload No. 10B of the TianGe (GRID) program. Like SVOM, it operates in low Earth orbit at an altitude of approximately 625 km with an orbital inclination of 30 degrees. GRID is a program that deploys a constellation of 24 small satellites in a lattice configuration at an altitude of about 600 km to observe gamma rays from gravitational wave source objects.⁵⁰ Between 2018 and 2023, GRID payloads were mounted on satellites, and observational coverage gradually increased (Table 6-2). Although the mission of the third "Yuan-Guang" satellite failed, by December 2024, a total of 12 payloads had been deployed on 10 satellites.

Table 6-2 Satellites Carrying GRID Payloads and Associated Research Infrastructure

Satellite Name	International Designator	Launch Date	Satellite-owning organization	Notes
Zhaojin-1 (Tongchuan-1)	2018-083B?	29-Oct-18	Tongchuan City	GRID Program-01; Tsinghua University; experimental satellit
Beihang Aerospace	2020-079M	6-Nov-20	Beihang University (Beijing University of Aeronautics and Astronautics)	GRID Program-02; Tsinghua University
Yuanguang	2020-102A	22-Dec-20	Changsha Tianyi Research Institute	GRID Program-03; Tsinghua University; mission failure
Chuangxing Leishen	2022-019*	27-Feb-22	Beijing University of Posts and Telecommunications	GRID Program-03B; Tsinghua University
Jilin-1 Mofang-02A-07	2023-007*	15-Jan-23	Chang Guang Satellite Technology Co., Ltd	GRID Program-04; Tsinghua University
Jilin-1 Mofang-02A-04	2023-007*	15-Jan-23	Chang Guang Satellite Technology Co., Ltd	GRID Program-05B; Tsinghua University
BUPT-1	2023-007*	15-Jan-23	Beijing University of Posts and Telecommunications	GRID Program-06B; Nanjing University; Sichuan University
Chasing All Transient Constellation Hunter (CATCH 1)	2024-116*	21-Jun-24	Institute of High Energy Physics, CAS	GRID Program-07; Beijing Normal University / TianGe Program-08B; Tsinghua University
Jilin-1 Platform-02A-03	2024-205*	11-Nov-24	Chang Guang Satellite Technology Co., Ltd	GRID Program-08B; Tsinghua University
Guangchuan-01	2024-222*	27-Nov-24		GRID Program-10B; Nanjing University; Sichuan University
Guangchuan-02	2024-222*	27-Nov-24		GRID Program-11; Tsinghua University; Sichuan University
				GRID Program-12; Tsinghua University
				GRID Program-13; Tsinghua University

⁴⁹ "SVOM", Gunter's Space page. https://space.skyrocket.de/doc_sdat/svom.htm.

⁵⁰ "TianGe Program," Huiji Wiki. <https://sat.huijiwiki.com/wiki/天格计划>.

In addition, the NSSC is developing the enhanced X-ray Timing and Polarization observatory (eXTP: extended X-ray Timing and Polarization) for launch in 2025. This mission focuses on observing black holes and neutron stars and is considered a successor to "Huiyan" (HXMT). The International Space Science Institute–Beijing Branch is also developing the Solar Polar Orbit Telescope (SPORT), which aims to observe CMEs, high-latitude solar magnetic fields, and the fast solar wind.

6.3 Geospace Science

Geospace science aims to understand how space activities interact with life and human society by observing the Earth's surrounding environments, including the atmosphere, ionosphere, thermosphere, magnetosphere, and space weather. The following section describes geospace science–related satellites (Table 6-3).

Table 6-3 Launch Status of Geospace Science–Related Satellites

Satellite Name	International Designator	Launch Date	Rocket Name	Launch Site
Double Star-1	2003-061A	29-Dec-03	CZ-2C/SM	Xichang
Double Star-2	2004-029A	25-Jul-04	CZ-2C/SM	Taiyuan
SJ-1	1971-018A	3-Mar-71	CZ-1	Jiuquan
SJ-2A	1981-093D	19-Sep-81	Fengbao-1	Jiuquan
SJ-4	1994-010A	8-Feb-94	CZ-3A	Xichang
SJ-5	1999-025B	10-May-99	CZ-4B	Taiyuan
SJ-6 (01A)	2004-035A	8-Sep-04	CZ-4B	Taiyuan
SJ-6 (01B)	2004-035B	8-Sep-04	CZ-4B	Taiyuan
SJ-6 (02A)	2006-046A	24-Oct-06	CZ-4B	Taiyuan
SJ-6 (02B)	2006-046B	24-Oct-06	CZ-4B	Taiyuan
SJ-6 (03A)	2008-053A	25-Oct-08	CZ-4B	Taiyuan
SJ-6 (03B)	2008-053B	25-Oct-08	CZ-4B	Taiyuan
SJ-6 (04A)	2010-051A	6-Oct-10	CZ-4B	Taiyuan
SJ-6 (04B)	2010-051B	6-Oct-10	CZ-4B	Taiyuan
Zhangheng-1 (01)	2018-015C	2-Feb-18	CZ-2D (2)	In operation
TanSat	2016-081A	21-Dec-16	CZ-2D (2)	Jiuquan
Lixing-1	2016-051B	15-Aug-16	CZ-4C	Xichang
MIT	Under Development	Undetermined	Undetermined	Undetermined

"Double Star"⁵¹ is a magnetospheric exploration program conducted jointly by the CNSA and the European Space Agency (ESA). Its objective was to investigate the Earth's magnetosphere in three dimensions together with ESA's four space science satellites (Cluster FM5–FM8). Under this program, one satellite was launched from each of two Chinese launch sites: Jiuquan and Taiyuan. The first satellite entered a highly elliptical orbit closer to the Sun-facing side of the Earth (altitude 555 km × 78,000 km, orbital inclination 28.5°). The second satellite was placed in a highly elliptical polar orbit (altitude 770 km × 39,000 km, orbital inclination 90°).

⁵¹ "TC 1, 2 / Double Star 1, 2", Gunter's Space page, https://space.skyrocket.de/doc_sdat/tc-1.htm.

China manufactured the satellite bus, certain onboard instruments, and the launch vehicles, while ESA supplied eight types of scientific instruments, including some identical to those on the Cluster satellites. Some ESA-provided instruments were installed on both Double Star satellites, while others were used only on Double Star-1 or Double Star-2, as detailed below.

<Instruments Carried on Both Double Star Satellites>

- Fluxgate Magnetometer (FGM)
- Plasma Electron and Current Experiment (PEACE)
- High Energy Electron Detector (HEED)
- High Energy Proton Detector (HEPD)
- Heavy Ion Detector (HID)

<Instruments Carried on only Double Star-1>

- Active Spacecraft Potential Control (ASPOC)
- Hot Ion Analyzer (HIA)
- Components of the Spatio-Temporal Analysis of Field Fluctuations (STAFF) and Digital Wave Processor (DWP)

<Instruments Carried on only Double Star-2>

- Neutral Atom Detection Unit (NUADU)
- Low Energy Ion Detector (LEID)
- Low Frequency Electromagnetic Wave Detector (LFEW)

The CAST launched several satellites named "Shijian" (SJ) as technology demonstration satellites, including some designed to observe the near-Earth environment.

"Shijian-1" (SJ-1),⁵² China's second satellite, was a technology demonstration satellite designed to verify solar cell technology, thermal control technology, and long-duration operational performance. Its polyhedral configuration was similar to that of China's first satellite, "Dongfanghong-1." The data transmitted by SJ-1's onboard instruments provided experience that later supported the development of operational satellites. Besides demonstrating satellite technology, SJ-1 carried instruments to measure space environment data, such as magnetic fields, X-rays, cosmic radiation, and external heat flux. Two instruments focused on space environment measurements: a Geiger-Müller (G-M) counter, which measured the flux of protons with energies above 16.4 MeV and electrons with energies above 0.88 MeV in cosmic rays, and an X-ray dosimeter, an ionization chamber with a beryllium window designed to measure solar X-rays with wavelengths of 1.8×10^{-24} m. Although SJ-1 was designed for a one-year mission, it operated for eight years, from 1971 to 1979. The G-M counter recorded particle counts at an average rate of less than one particle per second within altitude ranges of 1,300–1,826 km and 260–700 km over Chinese territory.

In addition to near-Earth environment observation, the missions of the "Shijian" satellites include

⁵² "SJ 1", Gunter's Space page, https://space.skyrocket.de/doc_sdat/sj-1.htm.

astronomical observation technology demonstrations (SJ-7), space breeding (i.e., cultivar improvement using the space environment; SJ-8, SJ-10, and SJ-19), Earth observation technology demonstrations (SJ-9), early warning technology demonstrations (SJ-11), and rendezvous and docking technology demonstrations (SJ-12).

In February 2018, "Zhangheng-1" (CSES1)⁵³ was launched as a land observation satellite operating independently, carrying out a specific mission rather than being part of a constellation.

The Global Carbon Dioxide Observation Scientific Experimental Satellite "TanSat" (the character "Tan" denotes the carbon element in Chinese)⁵⁴ is a small satellite designed for CO₂ observation and is China's first satellite dedicated to this purpose. It is the world's third satellite focused on greenhouse-gas observation with an emphasis on CO₂, following Japan's GOSAT ("Ibuki") and the U.S. OCO-2.

The atmospheric observation satellite "Lixing"⁵⁵ operated at a minimum altitude of 109 km, collecting data on atmospheric temperature and density. At this altitude, strong atmospheric drag leads to rapid orbital decay, preventing long-term operation. Lixing was launched on August 15, 2016, and ceased operation on August 19, four days later.

In addition, the NSSC is developing a mission for Magnetosphere-Ionosphere-Thermosphere (MIT) coupling observations. The launch schedule for this mission remains undetermined.

6.4 Space Quantum Communication

Satellites involved in space-based quantum communication include the quantum science experiment satellite "Mozi" (QUESS)⁵⁶ which was developed for long-distance quantum cryptographic key distribution experiments, and the LEO Quantum Key Distribution (QKD) Experiment Satellite (Diguidao Liangzi Miyaofenfa Shiyan)⁵⁷ (Table 6-4).

Efforts to implement quantum communication faced significant challenges, as long-distance QKD experiments were limited by signal attenuation after about 100 km in terrestrial optical fiber or free-space links, which made experimental verification difficult. In contrast, the Mozi satellite showed that quantum communication is possible by transmitting signals through outer space. Launched by the CAS in August 2016, Mozi enabled collaborative experiments between Chinese and Austrian universities. These experiments achieved satellite-to-ground QKD between China and two sites in Austria, as well as ground-based quantum entanglement teleportation. These results fulfilled the mission's main scientific objectives.

The "LEO QKD Demonstration" satellite, similar to the Mozi, is designed to test quantum cryptographic key transmission between a small satellite in low Earth orbit and small ground stations. It was one of six satellites launched in July 2022 aboard the Zhongke-1 rocket, with a mass of 94 kg. The satellite was developed jointly by the Hefei National Laboratory, the University of Science and Technology of China, the Shanghai Institute of Technical Physics of the CAS, the Shanghai Engineering Center for Microsatellites Innovation of the CAS, the Jinan Institute of Quantum Technology, and other institutions.

⁵³ "Zhangheng 1 (CSES 1)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/zhangheng-1.htm.

⁵⁴ "TanSat (CarbonSat)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/tansat.htm.

⁵⁵ "Lixing 1", Gunter's Space page, https://space.skyrocket.de/doc_sdat/lixing-1.htm.

⁵⁶ "QSS (QUESS, Mozi, Micius)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/qss.htm.

⁵⁷ ", Gunter's Space page, https://space.skyrocket.de/doc_sdat/jinan-1.htm.

Table 6-4 Launch Status of Space-Based Quantum Communication-Related Satellites

Satellite Name	International Designator	Launch Date	Rocket Name	Launch Site	Mission
Mozi-1	2016-051A	15-Aug-16	CZ-2D (2)	Jiuquan	Long-Distance Transmission Demonstration of Quantum Cryptographic Key Communication
LEO QKD Experiment	2022-087B	27-Jul-22	Zhongke-1	Jiuquan	Communication Test Between Ground Station and Small Satellite Using Quantum Cryptographic Keys

6.5 Microgravity Science

In China, the first "recoverable satellite" (Fanhui Shi Weixing; FSW) was launched in 1974 for purposes related to Earth observation, which are discussed later. After the initial failure, China successfully recovered satellites in 14 consecutive launches starting in 1975. Until around 1990, these satellites, similar to Russian reconnaissance missions, were used to retrieve photographic film for Earth observation. From 1992, the mission focus shifted to microgravity experiments in space science, which is the subject of this section.

Over 30 years, China launched 23 FSW recoverable satellites. One launch failed, one satellite was not recovered, and 21 were successfully recovered. Microgravity experiments took place on nine satellites. Later, four satellites dedicated to space breeding—the Shijian series (SJ-8, SJ-10, and SJ-19) and Dini—were launched (Table 6-5). CAST developed and manufactured all recoverable and space-breeding satellites. All launches occurred at the Jiuquan launch site. The landing site was chosen in the mountainous areas of Suining City, Sichuan Province, but in several cases, satellites landed far from the planned locations. Only the 15th recoverable satellite, FSW15, launched in 1993, was not recovered and fell into the eastern Pacific Ocean off the coast of Peru.

Table 6-5 Launch Status of the Recoverable Satellites for Microgravity and Space Breeding Experiments

Satellite Name	Launch Date	Recovery Date	Recovery Duration	Mission	Rocket Name	Landing Site	Notes
FSW13	9-Aug-92	25-Aug	16 days	Microgravity Experiment (Earth Observation)	CZ-2D		
FSW14	6-Oct-92	13-Oct	7 days	Microgravity Experiment (Earth Observation)	CZ-2C		
FSW16	3-Jul-94	18-Jul	15 days	Microgravity Experiment (Earth Observation)	CZ-2D		
FSW17	20-Oct-96	3-Nov	14 days	Microgravity Experiment (Earth Observation)	CZ-2D		
FSW18	3-Nov-03	21-Nov	18 days	Microgravity Experiment (Earth Observation)	CZ-2D	Suining City, Sichuan Province	Successful Recovery
FSW19	29-Aug-04	15-Sept.	27 days	Microgravity Experiment (Earth Observation)	CZ-2C		
FSW20	27-Sep-04	15-Oct	18 days	Microgravity Experiment (Earth Observation)	CZ-2C		
FSW21	2-Aug-05	29-Aug	27 days	Microgravity Experiment (Earth Observation)	CZ-2C		
FSW22	29-Aug-05	17-Oct	49 days	Microgravity Experiment (Earth Observation)	CZ-2D		
SJ-8	9-Sep-06	24-Sep	15 days	Space Breeding Experiment	CZ-2C		
SJ-10	5-Apr-16	18-Apr	13 days	Space Breeding Experiment	CZ-2D	Siziwang Banner, in Inner Mongolia	
Dini	17-Dec-23	Unknown	Unknown	Space Breeding Experiment	Hyperbola -1 (2)	Unknown	Unknown
SJ-19	27-Sep-24	11-Oct	14 days	Space Breeding Experiment	CZ-2D	Ejin Banner, in Alxa League, Inner Mongolia Autonomous Region	Successful Recovery

In 2006, the CAST launched SJ-8, a recoverable satellite dedicated to microgravity experiments, with space breeding as its primary mission. It was the first recoverable satellite designed solely for microgravity experiments, without any reconnaissance mission. Space breeding is a type of life-science experiment; however, China also conducted space-breeding activities for business applications that could offer economic benefits. Later, SJ-10 and SJ-19 were launched as recoverable satellites to conduct additional space-breeding experiments. As the population of Suining City in Sichuan Province grew, landing and recovery in the city became impractical, so SJ-10 landed in Siziwang Banner, which had been developed as a recovery site in Inner Mongolia. With the launch of SJ-19 in 2024, the recoverable satellite became reusable and landed successfully at the Dongfeng Landing Site in Ejin Banner, Alxa League, Inner Mongolia Autonomous Region.

Section 7.3.1, "Land Observation Satellites ((6) Recoverable Satellites)," describes the status of recoverable satellites that conducted Earth observation missions.

7 Earth Observation Field

In China, with its vast territory, Earth observation satellite imagery is required in numerous contexts, including land use surveys, disaster relief and recovery, crop growth monitoring, traffic surveillance, and environmental conservation.

Under the National Civil Space Infrastructure Medium-to-Long-Term Development Plan (2015–2025), launched in 2015 to enhance the observation accuracy of Earth observation satellites and increase the frequency of repeated observations over the same locations, the following satellites are scheduled for deployment by 2024: 36 high-resolution Earth observation satellites "Gaofen," 21 meteorological observation satellites "Fengyun (FY)," 14 resource exploration satellites "CBERS/Ziyuan (ZY)," 15 stereoscopic mapping satellites "Tianyu (TY)," 9 ocean observation satellites "Haiyang (HY)," and 7 environmental observation satellites "Huanjing (HJ)."

The observation instruments are primarily optical, covering not only visible light but also infrared and other wavelengths. They are designed with different observation swaths and orbital revisit frequencies tailored to specific objectives. Radar instruments, which acquire data by detecting reflected radio waves, can operate under all weather conditions, including at night. This capability allows them to be used for applications such as determining optimal crop harvest times and automating maintenance inspections of infrastructure such as roads and bridges.

7.1 Organizations Conducting Earth Observation Research

China's Earth observation activities involve numerous institutions, including the Ministry of Science and Technology (MOST), the Chinese Academy of Sciences (CAS), research institutes under various ministries and provinces, and universities. The main organizations are listed below.

- **The National Remote Sensing Centre of China (NRSCC):** A research institution under the Ministry of Science and Technology (MOST) that specializes in Earth observation. It collaborates with 46 organizations, including various ministries and local governments. The NRSCC also hosts the Chinese Secretariat of the Group on Earth Observations (GEO), an intergovernmental organization specializing in Earth observation. In addition, the NRSCC is a member institution of the Committee on Earth Observation Satellites (CEOS), which is overseen by UNESCO. It conducts ground station operations for acquiring satellite observation data in collaboration with the Aerospace Information Research Institute (AIR) of the Chinese Academy of Sciences (CAS) and the National Satellite Meteorological Center (NSMC).
- **The Chinese Academy of Sciences (CAS):** One of the institutions directly under the State Council, CAS oversees numerous research institutes as affiliated units. In the field of Earth observation, its Beijing-based institutes include the Center for Space Science and Applied Research (CSSAR), the Aerospace Information Research Institute (AIR), the Institute of Tibetan Plateau Research, the Institute of Optics and Electronics, and the Institute of Atmospheric Physics. Outside Beijing, these institutes include the Yantai Institute of Coastal Zone Research in Shandong Province, the Nanjing Institute of Geography and

Limnology in Jiangsu Province, the Cold and Arid Regions Environmental and Engineering Research Institute in Lanzhou, Gansu Province, and the South China Sea Institute of Oceanology in Guangzhou, Guangdong Province. AIR operates satellite remote sensing ground stations in Miyun (suburban Beijing), Sanya (Hainan Island), Kashgar (Xinjiang), and Lijiang (Yunnan Province). These stations acquire image data from Earth observation satellites of various countries, including both Chinese and foreign satellites.

- **The Center for Space Science and Applied Research (CSSAR):** Conducts research and development on observation instruments (sensors) for Earth observation satellites.
- **The National Satellite Meteorological Center (NSMC):** A research institution under the China Meteorological Administration (CMA). It conducts analysis and research using meteorological observation data, with applications extending beyond weather forecasting to oceanography, agriculture, forestry, water resources, aviation, navigation, environmental protection, and military use. The NSMC also provides space weather forecasts, including assessments of the effects of solar activity on satellites and ground systems. It operates antennas for receiving meteorological satellite data. However, it is believed that the Xi'an Satellite Tracking, Telemetry and Control Center of the PLA Equipment Development Department (formerly the General Armament Department) is responsible for tracking and controlling the meteorological satellites themselves, using ground tracking stations in several locations nationwide, including Qingdao and Changchun.
- **The Institute of Geology, China Earthquake Administration (IGCEA):** An institute affiliated with the China Earthquake Administration (CEA).
- **National Satellite Ocean Application Service (NSOAS):** An institute under the State Oceanic Administration (SOA), which is part of the Ministry of Land and Resources. In addition, the SOA includes the First Oceanographic Research Institute through the Third Oceanographic Research Institute.
- **Chinese Academy of Forestry (CAF):** An institution under the State Forestry Administration, which is one of the agencies directly under the State Council.
- **Chinese Academy of Surveying and Mapping (CASM):** An institution under the National Administration of Surveying, Mapping and Geoinformation.

Additionally, universities participating in the joint European Dragon Project include Peking University, Beijing Normal University, Tsinghua University, Nanjing University, Nanjing Normal University, Wuhan University, East China Normal University, Ocean University of China, Shanghai Ocean University, Shanghai Jiao Tong University, China Agricultural University, Northeastern University, Capital Normal University, Yunnan University, Beijing University of Chemical Technology, Macau University of Science and Technology, China University of Geosciences, Jiangxi Normal University, and Chang'an University. All are under the Ministry of Education.

Enterprises also play a role by providing common support for research across various fields based on Earth observation data. The China Academy of Space Technology (CAST) and the Shanghai Academy of Spaceflight Technology (SAST), both subsidiaries of the China Aerospace Science and Technology Corporation (CASC), are responsible for developing Earth observation satellites. CAST has developed a bus for small satellites weighing around 300 kg and has produced various Earth observation satellites

equipped with sensors tailored to the research needs of different institutions. The China Center for Resources Satellite Data Applications (CRESDA), which has been responsible for processing observation data and providing it to users, has become a specialized enterprise under CASC. It serves as a knowledge hub in which doctoral and master's degree holders account for about half of its employees. CRESDA uses observation data from the "Earth Resources Satellites" (CBERS, a collective term for the ZY resource satellites and HJ environmental satellites) to provide analysis, mapping, and solution proposals for researchers in specialized fields such as agriculture, forestry, surveying, land use, ecosystems, resources, and natural disasters.

7.2 China's Activities in the Field of Earth Observation

The Chinese central government, the military, local governments, and enterprises have successively launched a wide range of Earth observation satellites. The People's Liberation Army has launched 165 "Yaogan" (YG) reconnaissance satellites; Chang Guang Satellite Technology Co., Ltd. in Jilin Province has launched 127 "Jilin" (JL) satellites in collaboration with the provincial government; and private companies and universities have launched an additional 84 Earth observation satellites. Including these, the total number reaches 477.

International cooperation is also ongoing. In 2004, China and Europe jointly launched Phase 1 of the "Dragon Plan," which is scheduled to enter Phase 6 in 2024. This reflects steady progress in the development of Earth observation technologies and the advancement of applied research. Furthermore, the Japan Aerospace Exploration Agency (JAXA) and the China National Space Administration (CNSA) are members of the "International Charter Space and Major Disasters," alongside organizations from Europe, the United States, and Russia. Japan and China frequently take turns on a weekly basis.

A crucial aspect of Earth observation activities is the establishment of operational frameworks for satellite-derived data, including defining who analyzes the data, for what purposes, and how, as well as determining data distribution methods. These frameworks support the development of new observation instruments and the maintenance or expansion of satellite fleets. Specifically, the National Network of Ground Receiving Stations for Land Observation Satellite Data was completed in 2017. In 2024, the "Southwest Lijiang Station," an Earth observation data receiving station, was established in Lijiang, Yunnan Province.

7.3 Earth Observation Satellites

China's Earth observation satellites are classified into three categories according to their observation targets: land, ocean, and atmosphere. The performance of the observation equipment and the operational methods vary depending on the specific objectives of the observations. In addition to satellites operated by the central government and the military, there is a growing diversity and number of small Earth observation satellites independently developed by local governments, industry, and universities.

7.3.1 Land Observation Satellites

(1) High-Resolution Earth Observation Satellite "Gaofen"

The high-resolution Earth observation satellite "Gaofen" (GF) is primarily intended for peaceful purposes and is jointly operated by the central government's Ministry of Land and Resources (MLR), Ministry of Agriculture and Rural Affairs (MOA), and Ministry of Ecology and Environment (MEE). The Gaofen series comprises satellites numbered 1 to 14. These include high-resolution optical observation satellites in sun-synchronous polar orbit, medium-resolution geostationary optical observation satellites, radar observation satellites, and satellites in highly elliptical orbits. To date, 36 launches have been conducted. Most recently, Gaofen-12 05 was launched from Jiuquan on 15 October 2024 by a Changzheng 4C rocket (see Table 7-1).

Some satellites in the Gaofen series have been launched multiple times. For example, Gaofen-11 in a highly elliptical orbit and the standard high-resolution Gaofen-12 are each in their fifth launch of the respective models. The radar satellite Gaofen-3 is in its third launch, and the geostationary satellite Gaofen-13 is in its second launch. Future launches of larger satellites, such as Gaofen-14, are also possible.

The Changzheng 4C rocket carrying Gaofen-10, launched on its seventh mission, failed to place the satellite into orbit due to a malfunction. This was the only failure, resulting in a success rate of 97.2%. Furthermore, the rocket that launched "Gaofen-14" in 2020 was the Changzheng 3B/G5, which has a fairing one size larger than standard and was launched from the Xichang Satellite Launch Center in Sichuan Province. It is extremely rare for a polar-orbiting satellite to be launched southward from this launch site. The Gaofen satellites are expected to be central to China's land observation satellite program, forming a key part of its Earth observation infrastructure⁵⁸ development plan extending through 2025.

Table 7-1 "Gaofen" Launch Status

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Gaofen-1	2013-018A	April 26, 2013	Changzheng 2D (2)	Jiuquan	SSO
Gaofen-2	2014-049A	August 19, 2014	Changzheng 4B	Taiyuan	SSO
Gaofen-8	2015-030A	June 26, 2015	Changzheng 4B	Taiyuan	SSO
Gaofen-9 01	2015-047A	September 14, 2015	Changzheng 2D (2)	Jiuquan	SSO
Gaofen-4	2015-083A	December 28, 2015	Changzheng 3B/G2	Xichang	105.7°E
Gaofen-3	2016-049A	August 9, 2016	Changzheng 4C	Taiyuan	Radar
Gaofen-10	2016-F01	August 31, 2016	Changzheng 4C	Taiyuan	Launch Failure
Gaofen-1 02	2018-031A				
Gaofen-1 03	2018-031B	March 31, 2018	Changzheng 4C	Taiyuan	SSO
Gaofen-1 04	2018-031C				
Gaofen-5	2018-043A	May 8, 2018	Changzheng 4C	Taiyuan	SSO
Gaofen-6	2018-048A	June 2, 2018	Changzheng 2D (2)	Jiuquan	SSO
Gaofen-11	2018-063A	July 31, 2018	Changzheng 4B	Taiyuan	Highly elliptical SSO
Gaofen-10R	2019-066A	October 4, 2019	Changzheng 4C	Taiyuan	SSO
Gaofen-7	2019-072A	November 3, 2019	Changzheng 4B	Taiyuan	SSO
Gaofen-12	2019-082A	November 27, 2019	Changzheng 4C	Taiyuan	SSO
Gaofen-9 02	2020-034B	May 31, 2020	Changzheng 4C	Jiuquan	SSO
Gaofen-9 03	2020-039A	June 17, 2020	Changzheng 4C	Jiuquan	SSO
Gaofen duomo	2020-042A	July 3, 2020	Changzheng 4B	Taiyuan	SSO
Gaofen-9 04	2020-054A	August 6, 2020	Changzheng 2D (2)	Jiuquan	SSO
Gaofen-9 05	2020-058A	August 23, 2020	Changzheng 2D (2)	Jiuquan	SSO
Gaofen-11 02	2020-064A	September 7, 2020	Changzheng 4B	Taiyuan	Highly elliptical SSO
Gaofen-13	2020-071A	October 11, 2020	Changzheng 3B/G3	Xichang	118.2°E
Gaofen-14	2020-092A	December 6, 2020	Changzheng 3B/G5	Xichang	SSO
Gaofen-12 02	2021-026A	March 30, 2021	Changzheng 4C	Jiuquan	SSO
Gaofen-5 02	2021-079A	September 7, 2021	Changzheng 4C	Taiyuan	SSO
Gaofen-11 03	2021-107A	November 20, 2021	Changzheng 4B	Taiyuan	Highly elliptical SSO

Gaofen-3 02	2021-109A	November 22, 2021	Changzheng 4C	Taiyuan	Radar
Gaofen-3 03	2022-035A	April 6, 2022	Changzheng 4C	Jiuquan	Radar
Gaofen-12 03	2022-069A	June 7, 2022	Changzheng 4C	Jiuquan	SSO
Gaofen-5 01A	2022-165A	December 8, 2022	Changzheng 2D (2)	Jiuquan	SSO
Gaofen-11 04	2022-176A	December 27, 2022	Changzheng 4B	Taiyuan	Highly elliptical SSO
Gaofen-12 04	2023-123A	August 20, 2023	Changzheng 4C	Xichang	SSO
Gaofen-13 02	2023-036A	March 17, 2023	Changzheng 3B/G3	Jiuquan	148.3°E
Gaofen-11 05	2024-130A	July 19, 2024	Changzheng 4B	Taiyuan	Highly elliptical SSO
Gaofen-12 05	2024-186A	October 15, 2024	Changzheng 4C	Jiuquan	SSO

(2) China–Brazil Earth Resources Satellite “CBERS” and Resource Survey Satellite “Ziyuan”

China’s resource exploration satellites consist of two series: “CBERS (China–Brazil Earth Resources Satellite)” and “Ziyuan (ZY).” A total of eight satellites from both series are currently operational (Table 7-2).

“CBERS” was jointly developed by the China Academy of Space Technology (CAST) and the Brazilian National Institute for Space Research (INPE). Of the six launches conducted to date, only the fourth launch failed, resulting in a launch success rate of 83.3%. Among the onboard instruments, the Multispectral Camera (MUX), Wide Field Imager (WFI), and the data acquisition system were provided by Brazil, while the High Resolution Camera (HRC) and the Aerosol Polarization Detector (APD) were provided by China.

“Ziyuan” is a satellite series developed independently by China. To date, nine satellites have been launched. Most recently, “Ziyuan-1 02E” was launched from Taiyuan on December 26, 2021, using a Changzheng 4C rocket. The launch success rate is 100%.

Table 7-2 Launch Status of “CBERS” and “Ziyuan”

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
CBERS-1	1999-057A	October 14, 1999	Changzheng 4B	Taiyuan	Operation Ended
Ziyuan-2 01	2000-050A	September 1, 2000	Changzheng 4B	Taiyuan	Operation Ended
Ziyuan-2 02	2002-049A	October 27, 2002	Changzheng 4B	Taiyuan	Operation Ended
CBERS-2	2003-049A	October 21, 2003	Changzheng 4B	Taiyuan	Mission Complete
Ziyuan-2 03	2004-044A	November 6, 2004	Changzheng 4B	Taiyuan	Operation Ended
CBERS-2B	2007-042A	September 19, 2007	Changzheng 4B	Taiyuan	Operation Ended
Ziyuan-1 02C	2011-079A	December 22, 2011	Changzheng 4B	Taiyuan	In operation
Ziyuan-3 01	2012-001A	January 9, 2012	Changzheng 4B	Taiyuan	In operation
CBERS-3	2013-F03	December 9, 2013	Changzheng 4B	Taiyuan	Launch Failure
CBERS-4	2014-079A	December 7, 2014	Changzheng 4B	Taiyuan	In operation
Ziyuan-3 02	2016-033A	May 30, 2016	Changzheng 4B	Taiyuan	In operation
Ziyuan-1 02D	2019-059A	September 12, 2019	Changzheng 4B	Taiyuan	In operation
CBERS-4A	2019-093E	December 20, 2019	Changzheng 4B	Taiyuan	In operation
Ziyuan-3 03	2020-051A	July 25, 2020	Changzheng 4B	Taiyuan	In operation
Ziyuan-1 02E	2021-131A	December 26, 2021	Changzheng 4C	Taiyuan	In operation

⁵⁸ “National Civil Space Infrastructure Medium- and Long-Term Development Plan (2015-2025),” Baidu Encyclopedia, [https://baike.baidu.com/item/National Civil Space Infrastructure Medium- and Long-Term Development Plan \(2015-2025\)/20288549](https://baike.baidu.com/item/National%20Civil%20Space%20Infrastructure%20Medium-%20and%20Long-Term%20Development%20Plan%20(2015-2025)/20288549).

(3) Environmental Observation Satellite "Huanjing"

In August 2023, the China Center for Resources Satellite Data and Application (CRESDA) launched the seventh environmental observation satellite, "Huanjing Jianzhai 2F" (Table 7-3). Previously, CRESDA announcements frequently highlighted the use of "Gaofen" and "Ziyuan" satellite imagery, while "Huanjing" (HJ) imagery received less attention. The name change from "Huanjing 2F" to "Huanjing Jianzhai 2F" likely emphasizes its utility for disaster mitigation in addition to environmental surveys.

All seven satellites were launched from the Taiyuan Satellite Launch Center into sun-synchronous orbit (SSO) at an altitude of approximately 600 kilometers to conduct resource surveys and disaster monitoring. In 2008, the "Huanjing 1A" and "Huanjing 1B" satellites, equipped with optical sensors, were launched simultaneously. In November 2012, "Huanjing 1C," equipped with an S-band synthetic aperture radar for environmental observation, was launched. In September 2020, the optical observation satellites "Huanjing 2A" and "Huanjing 2B" were launched simultaneously by a Changzheng 4B rocket. The communication experiment equipment of "Huanjing 1A" was developed by Thailand as part of Asia-Pacific Space Cooperation Organization (APSCO) activities.

Table 7-3 Launch Status of "Huanjing" and "Huanjing Jianzhai" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Huanjing-1 A	2008-041A	September 6, 2008	Changzheng 2C (3)	Taiyuan	Optical and Communication Experiment
Huanjing-1 B	2008-041B				Optics
Huanjing-1 C	2012-064A	November 18, 2012	Changzheng 2C (3)	Taiyuan	Radar
Huanjing-2 A	2020-067A	September 27, 2020	Changzheng 4B	Taiyuan	Optical
Huanjing-2 B	2020-067B				
Huanjing-2 E	2022-132A	October 13, 2022	Changzheng 2C (3)	Taiyuan	Optical
Huanjing Jianzhai-2 F	2023-116A	August 8, 2023	Changzheng 2C (3)	Taiyuan	Optical

(4) Three-Dimensional Survey Satellite "Tianhui"

"Tianhui (TH)" is a satellite series supporting the surveying operations of the National Survey and Mapping Agency. It operates in a polar orbit at an altitude of 500 km and weighs approximately 2,500 kg. The simultaneous launch of "Tianhui-5C" and "Tianhui-5D" in July 2024 brought the cumulative number of satellites to 15 (Table 7-4). All satellites since "Tianhui-1 01,"⁵⁹ first launched in 2010, are currently operated by the People's Liberation Army (PLA).

⁵⁹ "Tianhui 1-01, 1-02, 1-03, 1-04 (TH 1-01, 1-02, 1-03, 1-04)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/tianhui-1.htm.

Table 7-4 Launch Status of "Tianhui" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Tianhui-1 01	2010-040A	August 24, 2010	Changzheng 2D (2)	Taiyuan	In operation
Tianhui-1 02	2012-020A	May 6, 2012	Changzheng 2D (2)	Taiyuan	In operation
Tianhui-1 03	2015-061A	October 5, 2015	Changzheng 2D (2)	Taiyuan	In operation
Tianhui-2 01	2019-024A	April 29, 2019	Changzheng 4B	Taiyuan	In operation
Tianhui-2 02	2019-024C				In operation
Tianhui-1 04	2021-067A	July 29, 2021	Changzheng 2D (2)	Taiyuan	In operation
Tianhui-2 Group02 01	2021-074A	August 18, 2021	Changzheng 4B	Taiyuan	In operation
Tianhui -2 Group02 02	2021-074B				In operation
Tianhui-4	2021-134A	December 29, 2021	Changzheng 2D (2)	Taiyuan	In operation
Tianhui-6 01	2023-030	March 9, 2023	Changzheng 4C	Taiyuan	In operation
Tianhui-6 02	2023-030				In operation
Tianhui-5A	2023-168 *	October 31, 2023	Changzheng 6A	Taiyuan	In operation
Tianhui-5B	2023-168 *				In operation
Tianhui-5C	2024-126 *	July 4, 2024	Changzheng 6A	Taiyuan	In operation
Tianhui-5D	2024-126 *				In operation

(5) Earth Observation Satellite "Yaogan"

"Yaogan (YG)" is the Chinese term for "remote sensing." Satellites in the Yaogan series carry optical imaging equipment, synthetic aperture radar (SAR), or electronic intelligence collection systems (ELINT or SIGINT). They are categorized by operational orbit, and their missions extend beyond reconnaissance to include crop surveys, environmental monitoring, disaster prevention, urban planning, and other applications.

The Yaogan series has launched 165 satellites since the first launch, "Yaogan-1," in 2006, with 159 currently operational (Table 7-5). Of the 165 satellites, only Yaogan-33, launched by a Changzheng 4C rocket in May 2019, failed, resulting in a launch success rate of 99.4%. A replacement, "Yaogan-33 R-1," was launched in December 2020.

For the December 2023 launch of "Yaogan-41," the Changzheng 5 rocket, capable of launching geostationary satellites, successfully placed it into its intended orbit. According to orbital data one year after launch, it operates in a low Earth orbit (LEO) at an altitude of 500 km with an orbital inclination of 35 degrees, completing a revolution in approximately 90 minutes. Its weight is estimated to exceed 10 tons. Most recently, in October 2024, China launched three satellites: "Yaogan-43 Group03 01 to 03." These satellites are believed to be SIGINT satellites flying in formation.

Table 7-5 Launch status of "Yaogan"

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Yaogan-1 (Jianbing-5)	2006-015A	April 26, 2006	Changzheng 4C	Taiyuan	Radar
Yaogan-2 (Jianbing-6)	2007-019A	May 25, 2007	Changzheng 2C	Jiuquan	
Yaogan-3	2007-055A	November 11, 2007	Changzheng 4C	Taiyuan	Radar
Yaogan-4	2008-061A	December 1, 2008	Changzheng 2D	Jiuquan	
Yaogan-5	2008-064A	December 15, 2008	Changzheng 4B	Taiyuan	
Yaogan-6 (Jianbing-7)	2009-021A	April 22, 2009	Changzheng 2C (3)	Taiyuan	Radar
Yaogan-7	2009-069A	December 9, 2009	Changzheng 2D	Jiuquan	
Yaogan-8 (Jianbing-9)	2009-072A	December 15, 2009	Changzheng 4C	Taiyuan	
Yaogan-9 A-C (Jianbing-8)	2010-009A	March 5, 2010	Changzheng 4C	Jiuquan	3 units
Yaogan-10	2010-038A	August 9, 2010	Changzheng 4C	Taiyuan	
Yaogan-11	2010-047A	September 22, 2010	Changzheng 2D	Jiuquan	
Yaogan-12	2011-066A	November 9, 2011	Changzheng 4B	Taiyuan	
Yaogan-13	2011-072A	November 29, 2011	Changzheng 2C (3)	Taiyuan	Radar
Yaogan-14	2012-021A	May 10, 2012	Changzheng 4B	Taiyuan	
Yaogan-15	2012-029A	May 29, 2012	Changzheng 4C	Taiyuan	
Yaogan-16 A-C	2012-066A	November 25, 2012	Changzheng 4C	Jiuquan	3 units
Yaogan-17 A-C	2013-046A	September 1, 2013	Changzheng 4C	Jiuquan	3 units
Yaogan-18	2013-059A	October 29, 2013	Changzheng 2 (3)	Taiyuan	
Yaogan-19	2013-065A	November 20, 2013	Changzheng 4C	Taiyuan	
Yaogan-20 A-C	2014-047A	August 9, 2014	Changzheng 4C	Jiuquan	3 units
Yaogan-21	2014-053A	September 8, 2014	Changzheng 4B	Taiyuan	
Yaogan-22	2014-063A	October 20, 2014	Changzheng 4C	Taiyuan	
Yaogan-23	2014-071A	November 14, 2014	Changzheng 2C (3)	Taiyuan	Radar
Yaogan-24	2014-072A	November 20, 2014	Changzheng 2D	Jiuquan	
Yaogan-25 A~C	2014-080A~C	December 10, 2014	Changzheng h 4C	Jiuquan	3 units
Yaogan-26	2014-087A	December 27, 2014	Changzheng 4B	Taiyuan	
Yaogan-27	2015-040A	August 27, 2015	Changzheng 4C	Jiuquan	
Yaogan-28	2015-064A	November 8, 2015	Changzheng 2D (2)	Taiyuan	
Yaogan-29	2015-069A	November 26, 2015	Changzheng 4C	Taiyuan	Radar
Yaogan-30	2016-029A	May 15, 2016	Changzheng 2D (2)	Jiuquan	
Yaogan-30, Group01 1-3	2017-058A ~ C	September 29, 2017	Changzheng 2C (3)	Xichang	3 units
Yaogan-30, Group02 1-3	2017-075A ~ C	November 24, 2017	Changzheng 2C (3)	Xichang	3 units
Yaogan-30, Group03 1-3	2017-085A ~ C	December 25, 2017	Changzheng 2C (3)	Xichang	3 units
Yaogan-30, Group04 1-3	2018-011A ~ C	January 25, 2018	Changzheng 2C (3)	Xichang	3 units
Yaogan-31 A-C	2018-034A~C	April 10, 2018	Changzheng 4C	Jiuquan	3 units
Yaogan-32 Group01 1	2018-077A	October 9, 2018	Changzheng 2C (3) Moon YZ1S	Jiuquan	
Yaogan-32 Group01 2	2018-077B	October 9, 2018	Changzheng 2C (3) Moon YZ1S	Jiuquan	
Yaogan-33	2019-F04	May 22, 2019	Changzheng 4C	Taiyuan	Launch Failure
Yaogan-30, Group05 1-3	2019-045A ~ C	July 26, 2019	Changzheng 2C (3)	Xichang	3 units
Yaogan-30, Group06 1-3	2020-021A ~ C	March 24, 2020	Changzheng 2C (3)	Xichang	3 units
Yaogan-30, Group07 1-3	2020-076A ~ C	October 26, 2020	Changzheng 2C (3)	Xichang	3 units
Yaogan-33 R-1	2020-103A	December 28, 2020	Changzheng 4C	Jiuquan	
Yaogan-31 D-F	2021-007A to C	January 29, 2021	Changzheng 4C	Jiuquan	3 units
Yaogan-31 G,H,J	2021-014A ~ C	February 24, 2021	Changzheng 4C	Jiuquan	3 units
Yaogan-31 K-M	2021-020A ~ C	March 14, 2021	Changzheng 4C	Jiuquan	3 units

Yaogan-34	2021-037A	April 30, 2021	Long March 4C	Jiuquan	
Yaogan-30 Group08 1-3	2021-039A ~ C	May 6, 2021	Changzheng 2C (3)	Xichang	3 units
Yaogan-30 Group09 1-3	2021-055A ~ C	June 18, 2021	Changzheng 2C (3)	Xichang	3 units
Yaogan-30 Group10 1-3	2021-065A to C	July 19, 2021	Changzheng 2C (3)	Xichang	3 units
Yaogan-32 Group02 01	2021-099A	November 3, 2021	Changzheng 2C (3)	Jiuquan	
Yaogan-32 Group02 02	2021-099B	November 3, 2021	Changzheng 2C (3)	Jiuquan	
Yaogan-35 Group 01 1-3	2021-101A ~ C	November 6, 2021	Changzheng 2D (2)	Xichang	3 units
Yaogan-34 02	2022-027A	March 17, 2022	Changzheng 4C	Jiuquan	
Yaogan-35 02A-C	2022-068A-C	June 23, 2022	Changzheng 2D (2)	Xichang	3 units
Yaogan-35 03A-C	2022-088A-C	July 29, 2022	Changzheng 2D (2)	Xichang	3 units
Yaogan-35 04A-C	2022-100A-C	August 19, 2022	Changzheng 2D (2)	Xichang	3 units
Yaogan-33 02	2022-106A	September 2, 2022	Changzheng 4C	Jiuquan	
Yaogan-35 05A~C	2022-109A-C	September 6, 2022	Changzheng 2D (2)	Xichang	3 units
Yaogan-36 01A-C	2022-120A-C	September 26, 2022	Changzheng 2D (2)	Xichang	3 units
Yaogan-36 02A-C	2022-133A-C	October 14, 2022	Changzheng 2D (2)	Xichang	3 units
Yaogan-34 03	2022-154A	November 15, 2022	Changzheng 4C	Jiuquan	
Yaogan-36 03A~C	2022-160A,C,E	November 28, 2022	Changzheng 2D (2)	Xichang	3 units
Yaogan-36 04A~C	2022-171A,C,E	December 8, 2022	Changzheng 2D (2)	Xichang	3 units
Yaogan-37	2023-006C	January 13, 2023	Changzheng 2D (2)	Jiuquan	
Yaogan-34 04	2023-048A	March 31, 2023	Changzheng 4C	Jiuquan	
Yaogan-36 05A~C	2023-106A,C,E	July 26, 2023	Changzheng 2D (2)	Xichang	3 units
Yaogan-39 01A~01C	2023-130A,B,E	August 31, 2023	Changzheng 2D (2)	Xichang	3 units
Yaogan-33 03	2023-136A	September 6, 2023	Changzheng 4C	Jiuquan	
Yaogan-40 01A~C	2023-139A,C,D	September 10, 2023	Changzheng 6A	Taiyuan	3 units
Yaogan-39 02A~021	2023-145A,D,E	September 17, 2023	Changzheng 2D (2)	Xichang	3 units
Yaogan-33 04	2023-149A	September 26, 2023	Changzheng 4C	Jiuquan	
Yaogan-39 03A~C	2023-152A,C,E	October 5, 2023	Changzheng 2D (2)	Xichang	3 units
Yaogan-39 04A~C	2023-163A,C,E	October 23, 2023	Changzheng 2D (2)	Xichang	3 units
Yaogan-39 05A~C	2023-194 *	December 10, 2023	Changzheng 2D (2)	Xichang	3 units
Yaogan-41	2023-197A	December 15, 2023	Changzheng 5	Wenchang	129.9°E
Yaogan-42 01	2024-063A	April 2, 2024	Changzheng 2D (2)	Xichang	
Yaogan-42 02	2024-075A	April 20, 2024	Changzheng 2D (2)	Xichang	
Yaogan-43 Group01 01-09	2024-148A ~ J	August 16, 2024	Changzheng 4B	Xichang	9 units
Yaogan-43 Group02 01-06	2024-156A ~ F	September 3, 2024	Changzheng 4B	Xichang	6 units
Yaogan-43 Group03 01-03	2024-190A ~ C	October 23, 2024	Changzheng 2C (3)	Xichang	3 units

(6) Fanhui Shi Weixing

China launched 23 “Fanhui Shi Weixing (FSW)” satellites, primarily for Earth observation purposes, from FSW-0 to FSW-4 (see note in Table 7-6) between 1974 and 2005, successfully recovering 21 of them (Table 7-6). The first FSW satellite, launched in 1974, failed to reach orbit. After 14 consecutive successful recoveries starting in 1975, the 15th launch, “FSW-15,” failed to recover for the first time, falling into the Pacific Ocean off the coast of Peru.

The recovery method involves decelerating the satellite using its retrograde engines during orbital departure, followed by descent via parachute. This method is identical to that used by Russia’s Soyuz spacecraft, and the manned “Shenzhou” spacecraft also employs the same procedure for returning to Earth. If the film from the onboard camera can be recovered on the ground and the captured images developed without exposure, it is considered a “successful recovery” for the reconnaissance mission. However, it appears that China’s leadership initially considered recovery within Chinese territory sufficient for success.

Table 7-6 Launch Status of "FSW"
(Includes satellites conducting microgravity science in addition to Earth observation)

Satellite Name	Launch Date	Recovery Date	Days	Mission	Rocket	Landing Site	Remarks
FSW	November 5, 1974	—	—	Earth Observation	Changzheng 2A	—	Launch Failure
FSW-1	November 26, 1975	November 29	3 days	Earth Observation	Changzheng 2A	Liuzhi, Guizhou Province	Fell into mountains Recovery successful
FSW-2	December 7, 1976	December 10	3 days	Earth Observation	Changzheng 2A		
FSW-3	January 26, 1978	January 29	3 days	Earth Observation	Changzheng 2A	Suining City, Sichuan Province	Recovery Successful
FSW-4	September 9, 1982	September 14	5 days	Earth Observation	Changzheng 2C		
FSW-5	August 19, 1983	August 24	5 days	Earth Observation	Changzheng 2C		
FSW-6	September 12, 1984	September 17	5 days	Earth Observation	Changzheng 2C	Neijiang, Sichuan Province	Landed on riverbed, recovery successful
FSW-7	October 21, 1985	October 26	5 days	Earth Observation	Changzheng 2C		
FSW-8	October 6, 1986	October 11	5 days	Earth Observation	Changzheng 2C		
FSW-9	August 5, 1987	August 10	5 days	Earth Observation	Changzheng 2C		
FSW-10	September 9, 1987	September 17	8 days	Earth Observation	Changzheng 2C	Suining City, Sichuan Province	Recovery Successful
FSW-11	August 5, 1988	August 13	8 days	Earth Observation	Changzheng 2C		
FSW-12	October 5, 1990	October 13	8 days	Earth Observation	Changzheng 2C		
FSW-13	August 9, 1992	August 25	16 days (+1 day)	Earth Observation (Microgravity Experiment)	Changzheng 2D		
FSW-14	October 6, 1992	October 13	7 days (-1 day)	Earth Observation (Microgravity Experiment)	Changzheng 2C		
FSW-15	October 8, 1993	—	—	Earth Observation	Changzheng 2C	Eastern Pacific	Retro Engine: Recovery Failed Due to Retrofire
FSW-16	July 3, 1994	July 18	15 days	Earth Observation (Microgravity Experiment)	Changzheng 2D		
FSW-17	October 20, 1996	November 3	14 days	Earth Observation (Microgravity Experiment)	Changzheng 2D		
FSW-18	November 3, 2003	November 21	18 days	Earth Observation (Microgravity Experiment)	Changzheng 2D		
FSW-19	August 29, 2004	September 25	27 days	Earth Observation (Microgravity Experiment)	Changzheng 2C	Suining City, Sichuan Province	Recovery Successful
FSW-20	September 27, 2004	October 15	18 days	Earth Observation (Microgravity Experiment)	Changzheng 2C		
FSW-21	August 2, 2005	August 29	27 days	Earth Observation (Microgravity Experiment)	Changzheng 2C		
FSW-22	August 29, 2005	September 16	18 days	Earth Observation (Microgravity Experiment)	Changzheng 2D		

Note: The "FSW" type is primarily classified into five categories based on orbital endurance: FSW0 (3–5 days, 9 units), FSW1 (8 days, 5 units), FSW2 (15 days, 3 units), FSW3 (18 days, 3 units), and FSW4 (27 days, 2 units).

The development and manufacturing of all 23 FSW satellites were carried out by the China Academy of Space Technology (CAST). All launches took place at the Jiuquan Satellite Launch Center, with Suining City, located in the mountains of Sichuan Province, selected as the primary landing site. Behind China's steady accumulation of successful recoveries were incidents of recovery problems and landings significantly off the intended target area. While information on China's response to such incidents is limited, the Hong Kong magazine Bauhinia Network's "The Untold Story of China's FSW Recovery" details the handling of five FSW satellites that experienced recovery issues, summarized below.

- **"FSW1"** : The planned landing target was Daping County, Suining City, Sichuan Province, but the actual impact location could vary due to minor timing differences in retro-thruster ignition. For the first recoverable satellite, successfully retrieved in 1975, the impact site was near a small coal mine in Liuzhi District, Guizhou Province—a straight-line distance of 420 km from the target. After the scheduled landing time passed, no reports came from Sichuan Province, leaving the recovery team searching

frantically. A report finally arrived from Guizhou: coal miners had witnessed an object falling like a fireball. Four miners took shelter in a tunnel just before impact, and one later reported it. Unaware of what a "satellite" was, they helped indirectly. The recovery team arrived in Liuzhi District after traveling overnight and successfully retrieved the light-tight box containing the critical photographic film without exposure. As a result, the recovery was reported as "landing in a special district of Guizhou Province (Liuzhi Special District), mission successful," despite landing in an unplanned area.

- **"FSW6"** : On September 17, 1984, FSW6 landed in the middle of a 100-meter-wide river in Neijiang City, Sichuan Province. The parachute cord broke, and the satellite sank to the riverbed. Helicopters and divers were mobilized, and it took seven days to recover the satellite, with fishermen from two nearby boats playing a key role. The photographic film, the primary payload, was recovered undamaged, resulting in a "successful recovery." Six days later, on October 1, the fishermen were invited to Beijing to participate in the celebrations for the 35th anniversary of the founding of the People's Republic of China.
- **"FSW-13"** : Launched in August 1992 as the first flight of the FSW-2 satellite type, with a planned flight duration of 15 days, the satellite was equipped with an engine to maintain altitude. Orbital control proceeded smoothly until the 11th day, but on the 12th day, communication was suddenly lost, and the satellite began to lose altitude. The then Commission for Science, Technology and Industry for National Defense (COSTIND) convened an emergency meeting and decided to delay recovery by one day, as allowing the satellite to fall as planned would have resulted in a landing in forested terrain, complicating search and recovery. The decision led to a successful recovery.
- **"FSW14"** : Launched in October 1992, FSW14 employed the older FSW-1 satellite model. Its simultaneous launch with the Swedish scientific satellite "Freja" drew global attention. A brief 5-second rocket malfunction caused the re-entry vehicle's orbital altitude to be slightly higher than intended. The predicted impact site eight days later was the Daxue Mountains, crossed by the Chinese Red Army's First Front Army during the Long March. The satellite control center proposed recovering it one day earlier. Unlike FSW-13, whose recovery was delayed, this mission was shortened by one day. Following ground commands, the satellite completed all tasks, including photography and tests, by the seventh day and landed precisely in the designated area.
- **"FSW20"** : Launched in 2004, FSW20 was successfully recovered but crashed through the roof of a private residence, falling indoors and killing the experimental organisms (ants) it carried. The residents were out at the time and unharmed.

(7) "Land Survey Satellite," "Land Exploration" Satellite, Earth Science Satellite "Guangmo"

In addition to the satellites mentioned above, the Land Survey Satellite, Land Exploration Satellite, and Earth Science Satellite have each been launched. In December 2017, CASC launched two "Ludi Kancha Weixing (LKW)"⁶⁰ satellites in succession, followed by two more in 2018. These are high-resolution Earth observation satellites, likely intended for military purposes (Table 7-7).

⁶⁰ "LKW 1, 2, 3, 4", Gunter's Space page, https://space.skyrocket.de/doc_sdat/lkw-1.htm.

Table 7-7 Launch Status of "Land Survey Satellites"

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Land Survey Satellite 1	2017-050A	December 3, 2017	Changzheng 2D (2)	Jiuquan	In operation
Land Survey Satellite 2	2017-084A	December 23, 2017	Changzheng 2D (2)	Jiuquan	In operation
Land Survey Satellite 3	2018-006A	January 13, 2018	Changzheng 2D (2)	Jiuquan	In operation
Land Survey Satellite 4	2018-025A	March 17, 2018	Changzheng 2D (2)	Jiuquan	In operation

The Land Exploration Satellite (Ludi Tance Weixing, LTW)⁶¹ carries an L-band SAR and weighs 3,200 kg. CASC launched three units between 2022 and 2023 (Table 7-8).

Table 7-8 Launch Status of "Land Exploration"

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site
Land Exploration-1 01A	2022-007A	January 26, 2022	Changzheng 4C	Jiuquan
Land Exploration-1 01B	2022-018A	February 26, 2022	Changzheng 4C	Jiuquan
Land Exploration-4 01	2023-120A	August 12, 2023	Changzheng 3B	Xichang

The Chinese Academy of Sciences (CAS) launched the Earth Science Satellite "Guangmu"⁶² aboard a Long March 6 rocket in November 2021. It is designed to address scientific challenges in human-environment interactions and to precisely observe traces of human activity through satellite imagery (Table 7-9).

Table 7-9 Launch status of "Guangmu"

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Guangmu-1	2021-100A-	2021/11/5	Changzheng 6	Taiyuan	In operation

7.3.2 Ocean Observation Satellites

Ocean observation satellites monitor sea surface color, temperature, environmental conditions, salinity, and other factors, and are also used to track ocean pollution.

The "Haiyang-1" (HY-1) series consists of four satellites for ocean color observation, while the "Haiyang-2" (HY-2) series includes four satellites for ocean dynamics observation. The Haiyang-3A (HY-3A) satellite is equipped with a C-band synthetic aperture radar (C-SAR) with 1-meter ground resolution for disaster prevention, environmental protection, and maritime area management. Additionally, the Ocean-4 satellite is used for detecting ocean salinity. The launch of "Haiyang-3B" (HY-3B) is planned for around 2025 (Table 7-10).

⁶¹ "Ludi Tance 1-01A, 1-01B (L-SAR 01A, 01B)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/ludi-tance-1-01.htm

⁶² "Guangmu 1 (SDGSAT 1)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/guangmu-1.htm.

Table 7-10 Launch Status of "Haiyang" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Remarks
Haiyang-1A	2002-024A	May 15, 2002	Changzheng 4B	Ocean color observation, operation terminated
Haiyang-1B	2007-010A	April 11, 2007	Changzheng 2C (3)	Ocean color Observation, Operation Ended
Haiyang-2A	2011-043A	August 15, 2011	Changzheng 4B	Ocean Dynamics, Operational
Haiyang-1C	2018-068A	September 7, 2018	Changzheng 2C (3)	Ocean Color Observation, In Operation
Haiyang-2B	2018-081A	October 24, 2018	Changzheng 4B	Ocean Dynamics, In Operation
Haiyang-1D	2020-036A	June 10, 2020	Changzheng 2C (3)	Ocean Color Observation, In Operation
Haiyang-2C	2020-066A	September 21, 2020	Changzheng 4B	Ocean Dynamics, In Operation
Haiyang-2D	2021-043A	May 19, 2021	Changzheng 4B	Ocean Dynamics, In Operation
Haiyang-3A	2023-176A	November 17, 2023	Changzheng 2C (3)/YZ-1S	C-band Synthetic Aperture Radar
Haiyang-4A	2024-208A	November 13, 2024	Changzheng 4B	Ocean Salinity Detection
Haiyang-3B	TBD	Around 2025	Changzheng 2C (3)/YZ-1S	Radar, under development

The small Earth observation satellites "Hainan-1"⁶³ and "Wenchang-1,"⁶⁴ operated by the Sanya Research Center of the Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences (Hainan Province), were manufactured by Beijing Weina Star Technology Co., Ltd. (Minospace). A constellation of 10 small Earth observation satellites was planned between 2020 and 2022, including two "Sanya-1" satellites and two "Sansha-1" satellites. Two "Hainan" satellites and two "Wenchang" satellites were launched in 2022, but subsequent launches of "Sanya," "Sansha," and other satellites have not occurred (Table 7-11).

Table 7-11 Launch Status of "Hainan" and "Wenchang" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Remarks
Hainan-1 01-02	2022-019*	February 27, 2022	Changzheng 8 (2)	2 units
Wenchang-1 01-02	2022-019*	February 27, 2022	Changzheng 8 (2)	2 units

CAST launched two "Bufeng"⁶⁵ satellites in 2019 for sea surface wind observation to support maritime typhoon warnings (Table 7-12).

Table 7-12 Launch Status of "Bufeng" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Bufeng-1A	2019-032A	June 5, 2019	Changzheng 11H	Ocean	In operation
Bufeng-1B	2019-032B				

⁶³ "Hainan-1 01", Gunter's Space page, https://space.skyrocket.de/doc_sdat/hainan-1-01.htm.

⁶⁴ "Wenchang-1 01, 02", Gunter's Space page, https://space.skyrocket.de/doc_sdat/wenchang-1.htm.

⁶⁵ "Bufeng 1A, 1B", Gunter's Space page, https://space.skyrocket.de/doc_sdat/bufeng-1.htm.

In January 2015, China and France signed a cooperation agreement on the "Chinese-France Ocean Satellite (CFOSAT)."⁶⁶ Launched in October 2018, CFOSAT carries two main payloads: the Surface Waves Investigation and Monitoring (SWIM) instrument provided by France and the Wind-Scatterometer (SCAT) provided by China. In June 2019, the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), CNSA, and CNES agreed to use CFOSAT data to improve the accuracy of weather forecasting in Europe and to monitor climate change, formalizing the collaboration through a cooperation agreement (Table 7-13).

Table 7-13 Launch Status of the "China-France Ocean Satellite"

Satellite Name	International Designator	Launch Date	Launch Vehicle	Remarks
China-France Ocean Satellite	2018-083A	October 29, 2018	Changzheng 2C (3)	In operation

In June 2021, the College of Ocean and Earth Sciences at Xiamen University launched the "Haisi-2" satellite to collect information on ocean surface winds, waves, internal waves, and coastal areas. Prior to this, in June 2020, CASC's Dongfanghong Satellite Co., Ltd. and Xiamen University signed a cooperation agreement for the joint development of small satellites for ocean observation purposes (Table 7-14).

Table 7-14 Launch Status of "China Ocean Satellites"

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site
Haisi-1	2020-102B	December 22, 2020	Changzheng 8	Wenchang
Haishi-2	2021-050C?	June 11, 2021	Changzheng 2D (2)	Taiyuan

7.3.3 Atmospheric Observation and Meteorological Satellites

China has also launched numerous atmospheric observation and meteorological satellites, described as follows.

For meteorological observation, China has launched four polar-orbiting meteorological satellites (Fengyun-1), seven improved polar-orbiting satellites (Fengyun-3), eight geostationary meteorological satellites (Fengyun-2), and two improved geostationary satellites (Fengyun-4). Currently, the National Satellite Meteorological Center (NSMC) of the China Meteorological Administration (CMA) operates a total of 10 satellites: six polar-orbiting and four geostationary satellites (Tables 7-15 and 7-16). In March 2012, the CMA announced plans to launch 14 meteorological satellites by 2025 to enhance its meteorological satellite services.

China provides weather data acquired by Fengyun satellites to Asia-Pacific countries through "FengYunCast." By 2007, China had provided satellite data receiving stations free of charge to 18

⁶⁶ "CFOSAT (Zhongfa Haiyangxue Weixing)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/cfosat.htm

countries—Bangladesh, Indonesia, Iran, Mongolia, Pakistan, Thailand, Peru, North Korea, Kyrgyzstan, Laos, Malaysia, Myanmar, Nepal, the Philippines, Sri Lanka, Tajikistan, Uzbekistan, and Vietnam—and conducted training for their use.

Table 7-15 Launch Status of Polar-Orbiting Meteorological Satellites “Fengyun-1” and “Fengyun-3”

Satellite Name	International Designator	Launch Date	Launch Vehicle	Remarks
Fengyun-1 A	1988-080A	September 6, 1988	Changzheng 4	Operation Ended
Fengyun-1 B	1990-081A	September 3, 1990	Changzheng 4	Operation Ended
Fengyun-1 C	1999-025A	May 10, 1999	Changzheng 4B	Destroyed by missile after mission completion
Fengyun-1 D	2002-024B	May 15, 2002	Changzheng 4B	End of operation
Fengyun-3 A	2008-026A	May 27, 2008	Changzheng 4C	Operation Ended
Fengyun-3 B	2010-059A	November 4, 2010	Changzheng 4C	In operation
Fengyun-3 C	2013-052A	September 23, 2013	Changzheng 4C	In operation
Fengyun-3 D	2017-072A	November 14, 2017	Changzheng 4C	In operation
Fengyun-3 E	2021-062A	July 4, 2021	Changzheng 4C	In operation
Fengyun-3 F	2023-111A	August 3, 2023	Changzheng 4C	In operation
Fengyun-3 G	2023-055A	April 16, 2023	Changzheng 4B	In operation

Table 7-16 Launch Status of Geostationary Meteorological Satellites “Fengyun-2 and Fengyun-4”

Satellite Name	International Designator	Launch Date	Launch Vehicle	Remarks
Fengyun-2 A	1997-029A	June 10, 1997	Changzheng 3	Operation Ended
Fengyun-2 B	2000-032A	June 25, 2000	Changzheng 3	Operation Ended
Fengyun-2 C	2004-042A	October 19, 2004	Changzheng 3A	Operation Ended
Fengyun-2 D	2006-053A	December 8, 2006	Changzheng 3A	Operation Ended
Fengyun-2 E	2008-066A	December 23, 2008	Changzheng 3A	Operation Ended
Fengyun-2 F	2012-002A	January 13, 2012	Long March 3A	Operation Ended
Fengyun-2 G	2014-090A	December 31, 2014	Changzheng 3A	In operation (99.6°E)
Fengyun-4 A	2016-077A	December 11, 2016	Changzheng 3B/G2	In operation (86.5°E)
Fengyun-2 H	2018-050A	June 5, 2018	Changzheng 3A	In operation (79.3°E)
Fengyun-4 B	2021-047A	June 2, 2021	Changzheng 3B/G3	In operation (104.7°E)

The atmospheric observation satellite “Yunhai,” developed by the Shanghai Academy of Spaceflight Technology (SAST), had eight units launched by the end of 2019 (Table 7-17).

Table 7-17 Launch Status of "Yunhai" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Remarks
Yunhai-1 01	2016-068A	November 11, 2016	Changzheng 2D (2)	In operation
Yunhai-2 01-06	2018-112A ~ G	December 29, 2018	Changzheng 2D (2) / YZ-3	In operation, 6 units
Yunhai-1 02	2019-063A	September 25, 2019	Changzheng 2D (2)	In operation?
Yunhai-1 03	2022-115A	September 20, 2022	Changzheng 2D (2)	In operation
Yunhai-3 01	2022-151A	November 9, 2022	Changzheng 6A	In operation
Yunhai-1 04	2023-159A	October 15, 2023	Changzheng 2D (2)	In operation
Yunhai-2 07-12	2024-052*	March 21, 2024	Changzheng 2D (2)	In operation, 6 units
Yunhai-3 02	2024-058A	March 26, 2024	Changzheng 6A	In operation

The meteorological observation satellite "Tianmu" was jointly developed and manufactured by companies in Chongqing and Shenzhen. It uses the delay of GPS signals caused by weather conditions (radio occultation) to enhance the accuracy of navigation positioning signals (positioning augmentation). To date, 22 units have been launched (Table 7-18).

Table 7-18 Launch Status of "Tianmu" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Tianmu-1 01~02	2023-003 *	January 8, 2023	Gushenxing 1	Jiuquan	In operation, 2 units
Tianmu-1 03~06	2023-039A ~ D	March 22, 2023	Kuaizhou 1A	Jiuquan	In operation, 4 units
Tianmu-1 07~10	2023-101A ~ D	July 20, 2023	Kuaizhou 1A	Jiuquan	In operation, 4 units
Tianmu-1 11~14	2023-205A ~ D	December 25, 2023	Kuaizhou-1A	Jiuquan	In operation, 4 units
Tianmu-1 19~22	2023-0208 ~ D	December 27, 2023	Kuaizhou-1A	Jiuquan	In operation, 4 units
Tianmu-1 15~18	2024-004A ~ D	January 5, 2024	Kuaizhou-1A	Jiuquan	In operation, 4 units

Tianjin Yunyao Aerospace Technology Co., Ltd. launched 42 weather observation satellites, named "Yunyao," in ten launches beginning in January 2024. Of these, two launches involving nine satellites failed, resulting in a launch success rate of 78.6% (Table 7-19).

Table 7-19 "Yunyao" Satellite Launch Status

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Yunyao-1 18~20	2024-009*	January 11, 2024	Yinli 1	Ocean	In operation, 3 units
Yunyao-1 14, 25-26	2024-105*	May 30, 2024	Gushenxing 1 (3)	Jiuquan	In operation, 3 units
Yunyao-1 15-17	2024-F03	July 10, 2024	Shuangqixizn 1 (2)	Jiuquan	Failure, 3 units
Yunyao-1 15-17	2024-153*	August 29, 2024	Gushenxing 1 (3)	Ocean	In operation, 3 units
Yunyao 1 21- 22	2024-174*	September 24, 2024	Zhongke 1	Jiuquan	In operation, 2 units
Yunyao-1 31-36	2024-205*	November 11, 2024	Zhongke 1	Jiuquan	In operation, 6 units
Yunyao -1	2024-F05	December 27, 2024	Zhongke 1	Jiuquan	Failure, 6 units
Yunyao-1 37-40	2025-013*	January 20, 2025	Gushenxing 1 (3)	Jiuquan	In operation, 4 units
Yunyao-1 55-60	2025-055*	March 17, 2025	Gushenxing 1 (3)	Jiuquan	In operation, 6 units
Yunyao-1 43-48	2025-059*	March 21, 2025	Gushenxing 1 (3)	Jiuquan	In operation, 6 units

7.3.4 Commercial Earth Observation Satellites

(1) Chang Guang Satellite Technology Co., Ltd. "Jilin"

The small Earth observation satellite constellation "Jilin (JL)," planned by Chang Guang Satellite Technology Co., Ltd. in Jilin Province, aims to deploy 137 satellites into orbit by 2030, completing a global satellite network. Its ultimate goal is to acquire and provide users with high-resolution image data within 10 minutes, 24/7, and in all weather conditions. As of 2024, the number of satellites deployed has already reached 141 (Table 7-20). Of these, five launch failures occurred, resulting in a launch success rate of 96.5%.

Table 7-20 "Jilin" Satellite Launch Status

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Jilin-1	2015-057D	October 7, 2015	Long March 2D	Jiuquan	
Jilin-1 03	2017-002A	January 9, 2017	Kuaizhou-1A	Jiuquan	
Jilin-1 04- 06	2017-074A ~ C	November 21, 2017	Changzheng 6	Taiyuan	3 units
Jilin-1 07-08	2018-008E, F	January 19, 2018	Changzheng 11	Jiuquan	2 units
Jilin-1 Guangpu 01-02	2019-005B, E	January 21, 2019	Changzheng 11	Jiuquan	2 units
Jilin-1 Gaofen 03	2019-032F?	June 5, 2019	Changzheng-1 1H	Ocean	
Jilin-1 Gaofen 02A	2019-075A	November 13, 2019	Kuaizhou-1A	Jiuquan	
Jilin-1 Gaofen 02B	2019-086A	December 7, 2019	Kuaizhou-1A	Taiyuan	
Jilin-1 Kuanfu 01	2020-003A	January 15, 2020	Changzheng-2 D (2)	Taiyuan	
Jilin-1 Gaofen 02 E	2020-F06	July 10, 2020	Kuaizhou-11	Jiuquan	Failure
Jilin-1 Gaofen 02 C	2020-F08	September 12, 2020	Kuaizhou-1A	Jiuquan	Failure
Jilin-1 Gaofen 3B 1-6, 3C 1-3	2020-065A ~ J	September 15, 2020	Changzheng 11H	Ocean	9 units
Jilin-1 Kuanfu 01B, Gaofen-03D 01-03	2021-061A ~ D	July 3, 2021	Changzheng 2D (2)	Taiyuan	4 units
Jilin-1 Mofang 01A	2021-F05-1	August 3, 2021	Shuangquxian-1	Jiuquan	Failure
Jilin-1 Gaofen 02D	2021-086A	September 27, 2021	Kuaizhou-1A	Jiuquan	
Jilin-1 Gaofen 02F	2021-097A	October 27, 2021	Kuaizhou-1A	Jiuquan	
Jilin-1 Mofang 02A	2022-019C	February 27, 2022	Changzheng 8 (2)	Wenchang	
Jilin-1 Mofang 02A	2022-019C, H, L,	February 27, 2022	Changzheng 8 (2)	Wenchang	10 units
Jilin-1 Gaofen 03D 10-18	M, Q~T, W, Y				
Jilin-1 Gaofen 04A	2022-046A ~ E	April 30, 2022	Changzheng 11H	Ocean	5 units
Jilin-1 Kuanfu 01C	2022-048A ~ H	May 5, 2022	Changzheng 2D (2)	Taiyuan	8 units
Jilin-1 Gaofen 03D-27~33					
Jilin-1 Mofang 01A (R)	2022-F02	May 13, 2022	Shuangquxian -1	Jiuquan	Failure
Jilin-1 Gaofen 03D-35~43	2022-098A, C ~ R	August 10, 2022	Changzheng 6	Taiyuan	15 units
Jilin-1 Hongwai A01~06					
Jilin-1 Gaofen 03D-08, 03D-51~54	2022-155A ~ E	November 16, 2022	Gushenxing-1	Jiuquan	5 units
Jilin-1 Gaofen 03D-44~50	2022-167D, E, H,	December 9, 2022	Jielong-3	Ocean	8 units
Jilin-1 Pingtai 01A01	J, L, N, P, Q				
Jilin-1 Gaofen-03D-34					
Jilin-1 Hongwai-A07-08	2023-007*	January 15, 2023	Changzheng 2D (2)	Taiyuan	6 units
Jilin-1 Mofang -02A-03, 04, 07					
Jilin-1 Gaofen 3D 19-26	2023-085*				8 units
Jilin-1 Gaofen 3D 01-30	2023-085*	June 15, 2023	Changzheng 2D (2)	Taiyuan	30 units
Jilin-1 Pintai 2A 01-02	2023-085*				2 units
Jilin-1 Kuanfu 02A	2023-127A	August 25, 2023	Gushenxing -1	Jiuquan	
Jilin-1 Gaofen 04B	2023-F10	September 21, 2023	Gushenxing 1	Jiuquan	Failure
Jilin-1 Kuanfu 02 01-06	2024-169*	September 20, 2024	Changzheng 2D (2)	Taiyuan	6 units
Jilin-1 SAR 01A	2024-174 *	September 24, 2024	Zhongke-1	Jiuquan	
Jilin-1 Gaofen 05B	2024-205*	November 11, 2024	Zhongke-1	Jiuquan	
Jilin-1 Pintai 02A-03	2024-205*	November 11, 2024	Zhongke-1	Jiuquan	

(2) Zhuhai Orbita Control Engineering Co., Ltd. "Zhuhai"

In June 2017, Zhuhai Orbita Control Engineering Co., Ltd. (Oubite) launched the first two satellites of the "Zhuhai-1" satellite constellation (Table 7-21). The company is developing this constellation, with satellite development and manufacturing carried out by Aerospace Dongfanghong Satellite Co., Ltd. (Spacesat), a subsidiary of the China Academy of Space Technology (CAST). The constellation consists of four hyperspectral satellites and twelve video imaging satellites. Two Zhuhai satellites were launched in 2017, five in 2018, and another five in 2019, with a total of 12 satellites now operational.

Table 7-21 "Zhuhai" Satellite Launch Status

Satellite Name	International Designator	Launch Date	Launch Vehicle	Remarks
Zhuhai-1 OVS1A	2017-034B	June 15, 2017	Changzheng 4B	In operation
Zhuhai-1 OVS1B	2017-034D			In operation
Zhuhai-1 OHS 2A	2018-040A	April 26, 2018	Changzheng 11	In operation
Zhuhai-1 OVS 2A	2018-040B			In operation
Zhuhai-1 OHS 2B	2018-040C			In operation
Zhuhai-1 OHS 2C	2018-040D			In operation
Zhuhai-1 OHS 2D	2018-040E			In operation
Zhuhai-1 OVS 3A	2019-060A	September 19, 2019	Changzheng 11	In operation
Zhuhai-1 OHS 3A	2019-060C			In operation
Zhuhai-1 OHS 3B	2019-060D			In operation
Zhuhai-1 OHS 3C	2019-060E			In operation
Zhuhai-1 OHS 3D	2019-060F			In operation

(3) China Siwei Survey and Mapping Technology Co., Ltd. "Gaojing" and "Siwei Gaojing"

The Earth observation satellites "Gaojing" and "Siwei Gaojing" form a constellation of high-resolution optical observation satellites with 50 cm resolution, operated by China Siwei Survey and Mapping Technology Co., Ltd. (formerly Siwei Shijing Technology (Beijing) Co., Ltd.). To date, a total of 14 satellites have been launched: four "Gaojing" and ten "Siwei Gaojing." Currently, ten satellites are operational (Table 7-22).

Two "Gaojing" satellites launched in 2016 failed to reach their intended orbit due to a malfunction of the Changzheng 2D rocket. They later reached orbit using their own propulsion, but their remaining fuel reserves were lower than planned. In 2018, two more "Gaojing" satellites were launched simultaneously, establishing a four-satellite constellation. However, the first two satellites eventually exhausted their fuel, ending formation flight operations. All four satellites ceased operations by 2021. The company began operating the "Siwei Gaojing" satellites in 2022, launching ten satellites by March 2025. It is currently positioned as a specialized subsidiary under CASC.

Table 7-22 Launch Status of "Gaojing" and "Siwei Gaojing"

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Gaojing-1 01	2016-083A	December 28, 2016	Changzheng 2D (2)	Taiyuan	Failed to reach planned orbit; operations completed in 2021
Gaojing-1 02	2016-083B				
Gaojing-1 03	2018-002A	January 9, 2018	Changzheng 2D (2)	Taiyuan	Operations completed in 2021, 2 units
Gaojing-1 04	2018-002B				
Siwei Gaojing-1 01	2022-043A	April 29, 2022	Changzheng 2C (3)	Jiuquan	2 units
Siwei Gaojing-1 02	2022-043B				
Siwei Gaojing-2 01	2022-082A	July 15, 2022	Changzheng 2C (3)	Jiuquan	2 units
Siwei Gaojing-2 02	2022-082C				
Siwei Gaojing-3 01	2024-072A	April 15, 2024	Changzheng 2D (2)	Jiuquan	
Siwei Gaojing 2-03	2024-218B	November 24, 2024	Changzheng 2C (3)	Jiuquan	2 units
Siwei Gaojing-2 04	2024-218C				
Siwei Gaojing-1 03	2025-040A	February 27, 2025	Changzheng 2C (3)	Jiuquan	2 units
Siwei Gaojing-1 04	2024-040B				
Siwei Gaojing-3 02	2025-051A	March 15, 2025	Changzheng 2D (2)	Jiuquan	

(4) Xi'an Aerospace Investment Co., Ltd. "Xi'an Hangtou"

"Xi'an Hangtou" satellite numbers range from 06 to 112, indicating plans to build a constellation of over 100 Earth observation satellites in a 430 km polar orbit. Additionally, the "Jilin-1 High-Resolution 03D-09" satellite, launched in August 2022, is also known as "Xi'an Hangtou-1" (Table 7-23).

Table 7-23 "Xi'an Hangtou" Launch Status

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Xi'an Hangtou 06	2023-117*	August 10, 2023	Gushenxing 1	Jiuquan	4 units
Xi'an Hangtou 88	2023-117*				
Xi'an Hangtou 104	2023-117*				
Xi'an Hangtou 112	2023-117*				

(5) Changsha Tianyi Space Technology Research Institute Co., Ltd. "Tianyi"

Since 2016, Changsha Tianyi Space Technology Research Institute in Hunan Province has been raising funds from prospective satellite owners across China. Their goal is to manufacture commercial radar satellites using 8 kg CubeSats (defined by satellite standards as 6 units, with 1 unit [1U] equal to a 10×10×10 cm cube). They have launched satellites under various names (Table 7-24). Although not initially designed as Earth observation satellites, the project conducted research and development on key technologies such as small, lightweight structures, precise attitude control using compact engines, and small synthetic aperture radar (SAR). With the simultaneous launch of "Tianyi 16" and "Tianyi 17" in 2019, the institute declared that the project level of completion had been reached. Small SAR satellites have limited battery capacity; therefore, missions focused on local Earth observation are feasible by

continuously charging in a sun-synchronous orbit and concentrating radar illumination on specific regions.

Table 7-24 Launch Status of the "Tianyi" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Xiaoxiang-1 (Tianyi-1)	2016-066B	November 9, 2016	Changzheng 11	Jiuquan	6U, 3kg
Xiaoxiang-2 (Tianyi-2)	2018-008A	January 19, 2018	Changzheng 11	Jiuquan	6U, 8kg
Xiaoxiang-6 (Quantutong-1, Tianyi-6)	2018-008C	January 19, 2018	Changzheng 11	Jiuquan	6U, 8kg
Xiaoxiang-1 02 (Tianyi-4)	2018-083C?	October 29, 2018	Changzheng 2C (3)	Jiuquan	6U, 8kg
Tianfuguoxing-1 (Tianyi-1 03)	2018-083D?	October 29, 2018	Changzheng 2C (3)	Jiuquan	6U, 8kg
Changsha Gaoxin (Tianyi-7)	2018-083H	October 29, 2018	Changzheng 2C (3)	Jiuquan	6U, 8kg
Xiaoxiang (6?)	2018-102D?	December 7, 2018	Changzheng 2D (2)	Jiuquan	6U, 8kg
Douyu-666 (Tianyi 10)	2018-102D?	December 7, 2018	Changzheng 2D (2)	Jiuquan	6U, 8kg
Xinjiang Jiaotong	2018-102?	December 7, 2018	Changzheng 2D (2)	Jiuquan	6U, 8kg
Xiaoxiang-1 03 (Tianyi-1 04)	2019-005C	January 21, 2019	Changzheng 11	Jiuquan	6U, 8kg
Xiaoxiang-1 04	2019-032B?	June 5, 2019	Changzheng 11H	Ocean Launch	6U, 8kg
Tianyi-1 07	2019-058A	August 30, 2019	Kuaizhou-1A	Jiuquan	6U, 8kg
Xiaoxiang-1 08	2019-072D	November 3, 2019	Changzheng 4B	Taiyuan	6U, 8kg
Tianyi-16	2019-087E?	December 7, 2019	Kuaizhou-1A	Taiyuan	6U, 9kg
Tianyi-17	2019-087F?	December 7, 2019	Kuaizhou-1A	Taiyuan	6U, 9kg
Baoyun-1	2021-117 *	December 7, 2021	Gushenxing-1	Jiuquan	6U, 8kg
Chaohu-1 (Tianxian Xingzuo)	2022-019*	February 27, 2022	Changzheng 8 (2)	Wenchang	6U, 8kg
Tianyi 26	2023-081*	June 7, 2023	Zhongke-1/Yao-2	Jiuquan	6U, 8kg
Fucheng-1	2023-081*	June 7, 2023	Zhongke-1/Yao-2	Jiuquan	300kg
Tianyi 33	2023-193 *	December 8, 2023	Zhuque-2	Jiuquan	50kg
Tianyi 41 (Shenqi)	2024-173 *	September 24, 2024	Jielong 3	Ocean	6U, 8kg

(6) Other

Other commercial Earth observation satellites are described below.

Ningxia Jingui Information Technology Co., Ltd. (Headquarters: Zhongwei City, Ningxia Hui Autonomous Region) plans to conduct commercial remote sensing operations using 30 "Ningxia" satellites (also known as "Zhongzi").⁶⁷ The entire project was contracted to China Great Wall Industry Corporation (CGWIC), which launched ten satellites into formation flight orbits in two launches by 2021. Satellite manufacturing was carried out by Spacesat (Aerospace Dongfanghong Satellite Co., Ltd.). The satellites' mission is SIGINT, collecting terrestrial radio signals (Table 7-25).

⁶⁷ "Zhongzi 1-01, ..., 2-05, (Ningxia-1, Zhuzhou-1)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/zhongzi.htm.

Table 7-25 "Ningxia" Satellite Launch Status

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Ningxia-1 01-05	2019-076A ~ E	November 13, 2019	Changzheng 6	Taiyuan	5 units
Ningxia-2 01-05	2021-064A ~ E	July 9, 2021	Changzheng 6	Taiyuan	5 units

Beijing Minospace Technology Co., Ltd. has launched nine Earth observation satellites from its Taijing series since April 2021 (Table 7-26). It has also launched ten Xingshidai satellites and eight Tianyan satellites (Tables 7-26, 7-27, and 7-28).

Table 7-26 "Taijing" Satellite Launch Status

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Taijing-2 No. 01	2021-033J?	April 27, 2021	Changzheng 6	Taiyuan	
Taijing No. 3 01	2022-019*	February 27, 2022	Changzheng 8 (2)	Wenchang	
Taijing-1 01-02	2022-095A - B	August 9, 2022	Ceres-1	Jiuquan	2 units
Taijing-1 03, 2-02, 04, 3-02, 4-03	2024-016*	January 23, 2024	Zhongke-1	Jiuquan	5 units

Table 7-27 Launch Status of "Xingshidai" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Xingshidai 5	2019-052C?	August 17, 2019	Jielong 1	Jiuquan	
Xingshidai 10	2021-061E	July 3, 2021	Changzheng 2D (2)	Taiyuan	
Xingshidai 17	2022-019*	February 27, 2022	Changzheng 8 (2)	Wenchang	
Xingshidai 16	2023-103*	July 22, 2023	Gushenxing-1	Jiuquan	
Xingshidai 18-20	2024-024*	February 3, 2024	Jielong 3	Ocean	3 units
Xingshidai 15, 21, 22	2024-173 *	September 24, 2024	Jielong 3	Ocean	3 units

Table 7-28 Launch Status of the "Tianyan" Satellite

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Tianyan 02 (Xingshidai 8)	2019-093J?	December 20, 2019	Changzheng 4B	Taiyuan	2 units
Tiangang-01 (Yizheng-1)	2019-093H?				
Tianyan 05 (Xingshidai 12)	2020-079L	November 6, 2020	Changzheng 6	Taiyuan	
Tianyan 16	2023-189 *	December 4, 2023	Gushenxing-1	Jiuquan	
Tian'yan 22	2024-095*	May 21, 2024	Kai-shu 11	Jiuquan	
Tianyan 15	2024-173 *	September 24, 2024	Jielong 3	Offshore	
Tianyan 24 (Liangping 1)	2024-205*	November 11, 2024	Zhongke-1	Jiuquan	
Tianyan 23	2025-051*	March 15, 2025	Changzheng 2D (2)	Jiuquan	

Beijing Zero-Space Technology Co., Ltd. (Beijing Zero G Lab) plans to launch 165 “Jinzijing (JZJ)” Earth observation satellites to achieve 24-hour global online monitoring and further aims to launch 200–300 radar and optical satellites by 2025. However, as of the end of 2024, only 10 satellites have been launched (Table 7-29).

Table 7-29 “Jinzijing” Satellite Launch Status

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Jinzijing-1 01, 02	2021-033G?, H?	April 27, 2021	Changzheng 6	Taiyuan	2 units
Jinzijing-2	2021-091K?	October 14, 2021	Changzheng 2D (2)	Taiyuan	
Jinzijing-1 03, 05	2021-117B, E	December 7, 2021	Gushenxing 1	Jiuquan	2 units
Jinzijing-1 05, 06	2022-167*	December 9, 2022	Jielong 3	Offshore	2 units
Jinzijing-3, 4, 6	2023-007*	January 15, 2023	Changzheng 2D (2)	Taiyuan	3 units

Launched in 2005, “Beijing-1” (also known as China-DMC+4) is a 166-kilogram small satellite jointly developed by Surrey Satellite Technology Ltd. (SSTL) and Tsinghua University. Together with satellites from Nigeria (two), the UK, and Spain, it forms the Disaster Monitoring Constellation (DMC), which remains operational today.

Twenty First Century Aerospace Technology Co., Ltd. (21st Century AT), now based in Singapore, launched six follow-on satellites as Chinese satellites starting in 2021. Additionally, four British satellites named “Beijing” were launched in 2015 and 2018; however, these are owned by SSTL, the company managing the DMC, and are not considered Chinese satellites (Table 7-30).

Table 7-30 Launch Status of “Beijing” Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Remarks
Beijing-1 (China DMC+4)	2005-043A	October 27, 2005	Kosmos-3M	Mass 166 kg
Beijing 3	2021-050A	June 11, 2021	Changzheng 2D (2)	
Beijing 3B	2022-103A	August 24, 2022	Changzheng 2D (2)	
Beijing 3C 01-04	2024-094 *	May 10, 2024	Changzheng 2D (2) / YZ-3	4 Units

The “Qilu-1,”⁶⁸ a joint project between China Great Wall Industry Corporation and Shandong Industrial Technology Research Institute, is a radar satellite. The “Qilu-2”⁶⁹ and “Qilu-3” are optical satellites with rectangular bodies, while the “Qilu-4”⁷⁰ is an optical satellite with a polygonal body (Table 7-31). The “Zhixing” satellites, equipped with AI and developed by Zhongke Xingrui Technology Beijing Co., Ltd. (Shenzhen), have been launched four times to date, with one launch failure (Table 7-32). Regarding the “Sixiang” series, Beijing Sixiang Aishu Technology Co., Ltd. developed the first satellite, while Galaxy

⁶⁸ “Qilu 1”, Gunter’s Space page, https://space.skyrocket.de/doc_sdat/qilu-1.htm.

⁶⁹ “Qilu 2”, Gunter’s Space page, https://space.skyrocket.de/doc_sdat/qilu-2.htm

⁷⁰ “Qilu 4”, Gunter’s Space page, https://space.skyrocket.de/doc_sdat/qilu-4.htm

Power (Beijing) Space Technology Co., Ltd. developed the second and third satellites. All three were launched together on July 23, 2023 (Table 7-33). Additionally, Galaxy Space Communication Co., Ltd. (Galaxy Space) launched four radar satellites, the "Hongtu" (PIESAT), in groups of four on three occasions, totaling 12 satellites (Table 7-34).

Table 7-31 Launch Status of "Qilu" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Qilu 1, 4	2021-033A ~ B	April 27, 2021	Changzheng 6	Taiyuan	2 units
Qilu 2, 3	2023-007*	January 15, 2023	Changzheng 2D (2)	Taiyuan	2 units (same type)

Table 7-32 Launch Status of "Zhixing" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Zhixing-3 A	2022-050?	May 9, 2022	Changzheng 7	Taiyuan	
Zhixing-1 B	2022-F06	December 14, 2022	Zhuque-2	Jiuquan	Failure
Zhixing-2 A	2024-024*	February 3, 2024	Jielong 3	Taiyuan	
Zhixing-1 C	2024-085*	May 7, 2024	Changzheng 6C	Taiyuan	

Table 7-33 Launch Status of the "Sixiang" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Sixiang 01 - 03	2023-104*	July 23, 2023	Changzheng 2D (2)	Taiyuan	

Table 7-34 Launch Status of the "Hongtu" Satellite

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Hongtu-1 01-04	2023-047A	March 30, 2023	Changzheng 2D (2)	Taiyuan	4 units
Hongtu-2 01-04	2024-203*	November 9, 2024	Changzheng 2C (3)	Jiuquan	4 units
Hongtu-2 09-12	2024-241*	December 16, 2024	Changzheng 2D (2)	Jiuquan	4 units

7.3.5 Other Earth Observation Satellites

In addition to the Earth observation satellite series mentioned above, single-mission Earth observation satellites include "Atmosphere 1" and "Atmosphere 2," launched in 1990, as well as "Tansuo 1" (TS-1, also known as Test [Shiyan]-1 [SY-1]) and "Tansuo 2" (TS-2, also known as Test-2 [SY-2]). Table 7-35 lists the major single-mission Earth observation satellites launched since 2015.

Table 7-35 Launch Status of Individual Earth Observation Satellites

Satellite Name	International Designator	Launch Date	Operating Agency
Lingqiao A	2015-057B	October 7, 2015	Chang Guang Satellite Company
Lingqiao B	2015-057C	October 7, 2015	Chang Guang Satellite Company
Foshan 1	2021-033C?	April 27, 2021	Jihua Laboratory
Zhongan Guotong 1	2021-033D?	April 27, 2021	Hunan Hangsheng Satellitg Technology Co.,Ltd.
Xingyuan 2	2022-023G	March 5, 2022	Beijing Xingyuan Aerospace Technology Co.
Daqi 1	2022-039A	April 15, 2022	Unknown (Developed by SAST)
Tianxing 1	2022-066A	June 22, 2022	Unknown
Land Ecosystem Carbon Monitoring Satellite	2022-090A	August 4, 2022	CAST
Jinta	2023-049A	April 2, 2023	Hunan Hangsheng Satellitg Technology Co.
Tianxing-1 02	2024-008 *	January 11, 2024	Unknown
Haiwangxing 01	2024-085*	May 7, 2024	Unknown
Tianfu Gaoten 2	2024-153*	August 29, 2024	Unknown
Fudan 1	2024-173 *	September 24, 2024	Unknown
Jitianxing A-01	2024-173 *	September 24, 2024	Unknown
High-Speed Laser Diamond Constellation Test System G01-01 to 05	2024-238A	December 12, 2024	Unknown, 5 units

7.4 Joint Project with Europe: “Dragon Project”

Europe conducts world-leading research and applications in Earth observation, and many countries seek to enhance their own capabilities through joint research with Europe. Since 2004, China has participated in the “Dragon Plan” with the European Space Agency (ESA)⁷¹, renewing it every four to five years for a total of five phases. China, with the Ministry of Science and Technology (MOST) as the lead agency, has utilized data from ESA’s environmental observation satellite “Envisat” for disaster prevention and other purposes. These efforts have yielded results in monitoring China’s air pollution, early detection of forest fires, water resource management, and ecosystem observation. Additionally, joint projects on land, sea, and atmosphere have been conducted, including research on forest areas along the China–Russia border and flood monitoring using Envisat.

The sixth phase of the Dragon Program commenced in 2024.⁷¹ Research themes largely align with one of the 12 public benefit areas—such as disasters, health, energy, climate, water, meteorology, ecosystems, agriculture, and biodiversity—defined by the Global Earth Observation System of Systems (GEOSS) (Table 7-36).

Table 7-36 Projects under the Sixth Phase “Dragon Project”

Application Field	Research Theme	European PI Affiliation	Chinese PI Affiliation
Atmosphere	Monitoring and analysis of air quality in China’s population-dense regions	The Royal Netherlands Meteorological Institute (KNMI)	China University of Geosciences
	Toward understanding aerosol–cloud radiative interactions using 3D satellite observations	The Royal Netherlands Meteorological Institute (KNMI)	Lanzhou University
	Monitoring greenhouse gases from space	University of Edinburgh (UK)	Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP)
Calibration and Validation	Multi-sensor remote sensing for calibration, validation, and data evaluation of high spectral resolution LiDARs aboard Chinese and European spacecraft	Leibniz Institute for Tropospheric Research (TROPOS) (Germany)	Ocean University of China
	Verification and application of observations from multiple low-orbit satellites for monitoring the Earth’s magnetic and plasma environment	Leibniz Institute for Atmospheric Physics (IAP) (Germany)	Wuhan University

⁷¹ ESA-MOST Dragon Cooperation, <https://dragon6.esa.int/>.

Climate Change	DTE-CLIMATE: A digital twin Earth approach for monitoring and modeling climate change impacts on water, energy, and carbon cycles in Eurasia	University of Twente (Netherlands)	Institute of Tibetan Plateau Research, Chinese Academy of Sciences (ITP)
	Multi-sensor remote sensing for climate change resilience of cultural heritage	University of Bern (Switzerland)	Wuhan University
	Remote sensing materials for environmental impact: Application to cultural heritage deterioration	National and Kapodistrian University of Athens (Greece)	Nanjing University of Information Science and Technology
Hydrology and Cryosphere	Continuous improvements to SMOS products and their added value	Center for the Study of the Biosphere from Space (CESBIO) (France)	National Space Science Center, Chinese Academy of Sciences (NSSC)
	Seasonal changes in Asian high-mountain glaciers from 2016 to 2026 and their fate by 2100	Graz University of Technology (Austria)	The Aerospace Information Research Institute, Chinese Academy of Sciences Center for Space Information Innovation Sciences (AIR)
	Transition from cryosphere remote sensing and ecohydrological modeling to mountain meteorology	Institute of Science and Technology Austria (ISTA)	The Aerospace Information Research Institute, Chinese Academy of Sciences Center for Space Information Innovation Sciences (AIR)
Data Analysis	Investigation of the Earth's magnetism using Swarm and MSS-1 data	University of Leeds (UK)	Macao University of Science and Technology
	STAI4CH: Spatiotemporal assessment of anthropogenic impacts and sustainability measures for cultural heritage along ancient and modern waterways	National Research Council of Italy	Wuhan University
	FUCEO: Exploring synergies between Chinese and European EO missions through data fusion	European Space Agency	Institute of Forestry Science and Information, Chinese Academy of Forestry (CAF)
Ecological System	Mapping key grassland degradation variables based on multiple remote sensing datasets	University of Leeds, Department of Geography (UK)	The Aerospace Information Research Institute, Chinese Academy of Sciences (AIR)
	Microwave and optical remote sensing of salt lakes from space	University of Strasbourg (France)	Beijing University of Chemical Technology (BUCT)
	Toward forest quality assessment using remote sensing	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Institute of Forestry Science and Information, Chinese Academy of Forestry (CAF)
	China-ESA Forest Observation	Forest Research (UK)	Chinese Academy of Forestry
	Resilient wetlands and the relationship between humans and water in watersheds	Toulouse III – Paul Sabatier University (France)	Jiangxi Normal University
	Marine value-added products through remote sensing microwave measurements	Sapienza University of Rome (Italy)	Nanjing University

Ocean and Coastal Areas	Synergistic monitoring and prediction of ocean dynamic environments using multiple satellite data	French Research Institute for Exploitation of the Sea (IFREMER) (France)	State Oceanic Administration (SOA), Second Institute of Oceanography (MNR)
	AI-based EO data mining and artificial intelligence for assessing natural and man-made disaster situations and evaluating risks in coastal areas using conventional and new synthetic aperture radar (SAR) technologies	Institute for Electromagnetic Sensing of the Environment (IREA) (Italy)	East China Normal University
	SAR monitoring of small-scale dynamics in marginal seas	University of Hamburg (Germany)	The Aerospace Information Research Institute, Chinese Academy of Sciences (AIR)
	Eddies in the Lofoten Basin and their impact on Atlantic heat transport toward the Arctic	Nansen Environmental and Remote Sensing Center (NERSC) (Norway)	Shanghai Jiao Tong University (SJTU)
	Monitoring ocean dynamics and marine environmental hazards using multiple satellite data	French Institute for Ocean Science (France)	National Satellite Ocean Application Service
Solid Earth and Disaster Mitigation	Co-detection of surface deformation related to natural phenomena and human activities using multi-source remote sensing data	National Institute of Geophysics and Volcanology (Italy)	Northeastern University
	Remote sensing for landslide monitoring and infrastructure impact assessment	University of Alicante (Spain)	Chang'an University
	Acquisition from SAR data stacks in geophysical and geodetic natural scenarios	Polytechnic University of Milan (POLIMI) (Italy)	Wuhan University
	Synergistic use of space technologies for comprehensive Earth surface monitoring: Detecting various types of deformation and optimizing water resources for agricultural use	University of Trás-os-Montes and Alto Douro (UTAD) (Portugal)	University of Science and Technology of China, School of Earth and Space Sciences
	Electromagnetic anomaly detection and deformation monitoring using generative and predictive AI approaches	University of Ulster (UK)	Institute of Earthquake Forecasting, China Earthquake Administration (CEA)
	Dynamic deformation monitoring and health diagnosis of infrastructure and surrounding geological environments using multi-source Earth observation data	Polytechnic University of Catalonia (UPC) (Spain)	Wuhan University
	Multi-sensor InSAR railway structure monitoring: Toward generating product-level deformation results	Delft University of Technology (Netherlands)	Yunnan University

	Optical and thermal Copernicus: Driving factors influencing China's EO data food security and quality	Institute of Methodologies for Environmental Analysis (IMAA) (Italy)	The Aerospace Information Research Institute, Chinese Academy of Sciences (AIR)
Sustainable Agriculture and Water Resources	Quantifying the impact of combined high-temperature and drought extremes on agriculture and water resources from Earth observation	Helmholtz Center for Environmental Research (Germany)	Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences Institute of Geographic Sciences and Natural Resources Research of Sciences
	Applicability and accuracy of satellite data at various spatiotemporal scales for sustainable agricultural water management	Polytechnic University of Milan (POLIMI) (Italy)	The Aerospace Information Research Institute, Chinese Academy of Sciences, Space Information Innovation Research (AIR)
	Synergistic effects of thermal and solar-induced fluorescence remote sensing for crop water stress monitoring in the North China Plain, Iberian Peninsula, and Luxembourg	Luxembourg Institute of Science and Technology	China Agricultural University
Urbanization and Environment	EO-AI4ResilientCities: Enhancing Urban Resilience through insights from Earth observation and AI	Royal Institute of Technology, Sweden	Nanjing University
	Utilizing Earth Observation for urban safety: Addressing thermal risks and geologic hazards	National and Kapodistrian University of Athens	Capital Normal University

8 Satellite Communications and Broadcasting Field

The rise of the United States' "Starlink," developed by SpaceX, has intensified competition for internet satellite market share. China has been stepping up efforts since around 2023 to build a system capable of competing with "Starlink" by combining geostationary satellites, low-Earth orbit satellites, and polar-orbit satellites. In 2024, China launched three geostationary satellites and 54 polar-orbit satellites in succession, clearly demonstrating its intention to counter the United States.

Meanwhile, technological advances have also been made in the construction of fixed communications and broadcasting satellite systems, including expanded coverage areas and increased communication capacity. Satellites such as "Zhongxing-6C" and "Zhongxing-9B" were successfully launched to provide continuous and stable support for television broadcasting services. The successful launches of "Zhongxing-16" and "APStar6D" have also increased satellite communication capacity to 50 Gbps, ushering China into an era of high-throughput satellite communications. In addition, the mobile communications and broadcasting satellite system, which supports services such as messaging and data transmission, has been improved. The "Tiantong-1 02" and "Tiantong-1 03" satellites were launched and are now operating alongside the "Tiantong-1 01" satellite. The data relay satellite system has likewise been enhanced, with the launches of "Tianlian-1 05" and "Tianlian-1 03" significantly improving overall performance. Satellite communications and broadcasting ground systems have also been continuously upgraded, strengthening the provision of information services that integrate space and Earth on a global scale, including satellite communications and broadcasting, internet connectivity, and the Internet of Things (IoT).

Going forward, the plan is to promote the establishment of satellite communication systems in which satellites in high and low orbits operate in coordination by 2030, advance the verification and commercialization of new communications satellite technologies, and build a second-generation data relay satellite system.

8.1 Internet Satellite

China is also seeking to build a large satellite constellation for internet connectivity services to compete with "Starlink," which has launched numerous satellites as part of its proprietary satellite internet communications business. According to a report released by the China Internet Network Information Center (CNNIC) in January 2025 on internet usage in China at the end of 2024, the number of internet users (netizens) exceeded 1.1 billion, accounting for 78.6% of the total population, indicating the rapid emergence of a new era of the digital economy. Currently, terrestrial optical cables are the primary network infrastructure, but satellite networks are expected to expand rapidly due to their high transmission speeds and ability to provide internet access in outdoor and remote environments.

The section below describes the internet satellites launched by four companies and one university: China Satellite Network Group Co., Ltd. (abbreviated as Guowang or China SatNet), Shanghai Yuanxin Satellite

Technology Co., Ltd., Beijing Guodian High-Tech Co., Ltd., Beijing Hede Aerospace Technology Co., Ltd., and the National University of Defense Technology.

The only state-owned enterprise in China that provides internet connection services is Guowang, which was established in April 2021. Development of the satellite system is handled by the China Academy of Space Technology (CAST), which is subordinate to CASC. In 2018, CAST launched the test satellite "Hongyan-1," while CASIC launched "Hongyun-1." CAST launched nine technology test satellites in 2023, followed by Guowang's launch of three geostationary satellites. In 2024, three geostationary satellites, "Weixing Hulianwang Gaogui" (high-orbit internet satellites), were launched in succession using the Long March 3B/G3 rocket. Weixing Hulianwang Gaogui-01, launched in February, was positioned at 33 degrees east longitude; Weixing Hulianwang Gaogui-02, launched in August, was positioned at 153 degrees east longitude; and Weixing Hulianwang Gaogui-03, launched in October, was positioned at 77 degrees west longitude. This rapidly established a satellite constellation covering densely populated regions worldwide at intervals of 110 to 130 degrees. The satellite bus is Dongfanghong-4E, and the launch mass of each satellite was 5,550 kg. Subsequently, "low-orbit internet satellites" were launched in December 2024 and February 2025 (Table 8-1).

Table 8-1 Status of internet satellite launches by Guowang

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Hongyan-1	2018-118F	December 29, 2018	Long March 2D (2) /YZ-3	Jiuquan	Altitude 1,100 km
Hongyun-1	2018-108A	December 19, 2018	Long March 11	Jiuquan	Altitude 1,100 km
Internet technology test satellite 1	2023-095*	July 9, 2023	Long March 2C (3) /YZ-1S	Jiuquan	SSO
Internet technology test satellite 2	2023-095*	July 9, 2023	Long March 2C (3) /YZ-1S	Jiuquan	LEO
Internet technology test satellite 02A-C	2023-181*	November 23, 2023	Long March 2D (2) /YZ-3	Xichang	LEO, 3 units
Internet technology test satellite 03	2023-190A	December 5, 2023	Jielong 3	Jiuquan	
Internet technology test satellite 04A-C	2023-212*	December 30, 2023	Long March 2C (3)/YZ-1S	Xichang	LEO, 3 units
High-orbit internet satellite 01	2024-040A	February 29, 2024	Long March 3B/G3	Xichang	33 degrees east longitude
High-orbit internet satellite 02	2024-135A	August 1, 2024	Long March 3B/G3	Xichang	153 degrees east longitude
High-orbit internet satellite 03	2024-181A	October 12, 2024	Long March 3B/G3	Xichang	77 degrees west longitude
Internet technology test satellite 05A	2024-226A	November 30, 2024	Long March 12	Jiuquan	
Low-orbit internet satellite 01-01-10	2024-240A-K	December 16, 2024	Long March 5	Wenchang	10 units
Low-orbit internet satellite 02-01-09	2025-030*	February 11, 2025	Long March 8A	Taiyuan	9 units

Shanghai Spacecom Satellite Technology Co., Ltd. aims to build the "Qianfan Constellation" of 14,000 internet satellites and has been launching small polar-orbit satellites, known as "Qianfan Polar Orbit," in rapid succession. Since launches began in 2024, the total number of satellites has reached 90 as of March

11, 2025. This project is also known as the "G60 Starlink" project (Table 8-2).⁷²

Table 8-2 Status of "Qianfan Polar Orbit" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Qianfan Polar Orbit G 01 1-18	2024-140A-T	August 6, 2024	Long March 6A	Taiyuan	18 units
Qianfan Polar Orbit G 02 1-18	2024-185A-T	October 15, 2024	Long March 6A	Taiyuan	18 units
Qianfan Polar Orbit G 03 1-18	2024-232A-T	December 5, 2024	Long March 6A	Taiyuan	18 units
Qianfan Polar Orbit G 06 1-18	2025-0160A-T	January 23, 2025	Long March 6A	Taiyuan	18 units
Qianfan Polar Orbit G 05 1-18	2025-046A-T	March 11, 2025	Long March 6A	Hainan	18 units

Beijing Guodian High-Tech Co., Ltd. aims to build a system that enables real-time tracking of goods' locations by attaching internet-connected tags to goods during logistics transportation. By 2024, the company had launched 29 IoT satellites, "Tianqi," which relay data for this system (Table 8-3).

Table 8-3 Status of "Tianqi" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Tianqi-1	2018-083G?	October 29, 2018	Long March 2C (3)	Jiuquan	
Tianqi-3	2019-032D?	June 5, 2019	Long March 11 H	At the sea	
Tianqi-2	2019-052B?	August 17, 2019	Jielong 1	Jiuquan	
Tianqi-4A	2019-087C?	December 7, 2019	Kuaizhou 1A	Taiyuan	
Tianqi-4B	2019-087D?	December 7, 2019	Kuaizhou 1A	Taiyuan	
Tianqi-5	2020-003D	January 15, 2020	Long March 2D (2)	Taiyuan	
Tianqi-12	2021-039D	May 6, 2021	Long March 2C (3)	Xichang	
Tianqi-10	2020-051C	July 25, 2020	Long March 4B	Taiyuan	
Tianqi-6	2020-076D	October 26, 2020	Long March 2C (3)	Xichang	
Tianqi-11	2020-080A	November 7, 2020	Ceres 1	Jiuquan	
Tianqi-8	2020-102D	December 22, 2020	Long March 8	Wenchang	
Tianqi-9	2021-033E?	April 27, 2021	Long March 6	Taiyuan	
Tianqi-12	2021-039D	May 6, 2021	Long March 2C (3)	Xichang	
Tianqi-14	2021-055D	June 18, 2021	Long March 2C (3)	Xichang	
Tianqi-15	2021-065D	July 19, 2021	Long March 2C (3)	Xichang	
Tianqi-19	2022-019*	February 27, 2022	Long March 8 (2)	Wenchang	
Tianqi-13	2023-003*	January 8, 2023	Ceres 1	Jiuquan	
Tianqi-21 - 24	2023-135*	September 5, 2023	Ceres 1	At the sea	4 units
Tianqi-25 - 28	2024-102*	May 28, 2024	Ceres 1 S	At the sea	4 units
Tianqi-29 - 32	2024-170*	September 20, 2024	Kuaizhou 1A	Xichang	4 units

⁷² Naoki Tsukamoto. "China builds second internet satellite No.1 after 'Guowang'", UchiBiz January 9, 2024, <https://uchubiz.com/article/new36258/>.

Satellites that collect information from the Automatic Identification System (AIS) have also been launched. The International Convention for the Safety of Life at Sea requires AIS to be installed on international passenger ships and cargo ships above a certain size, and AIS information is routinely used for communication between ships and with control stations. The main data consist of GPS-derived information showing a ship's current location, along with additional details such as the ship's name, destination, and cargo. Satellites equipped with AIS receivers collect signals transmitted from vessels at sea and sell the acquired data to customers. This information enables insurance companies to track ship movements worldwide. Suspicious vessels can also be identified by cross-referencing AIS data with images from Earth observation satellites.

Beijing Hede Aerospace Technology Co., Ltd. has launched a series of AIS satellites called "Hede" (a translation of the company name "Head") since 2017. By August 2023, the company had launched 14 satellites, each weighing 45 kg, designated from "Hede-1" to "Hede-5," all of which are currently in operation (Table 8-4).

Table 8-4 Status of "Hede" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Hede-1	2017-072B	November 14, 2017	Long March 4C	Taiyuan	
Hede-2A	2019-087A?	December 7, 2019	Kuaizhou 1A	Taiyuan	2 units
Hede-2B	2019-087B?				
Hede-4	2020-034B	May 31, 2020	Long March 2D (2)	Jiuquan	
Hede-5	2020-039C	June 17, 2020	Long March 2D (2)	Jiuquan	
Hede-2E	2021-091E?	October 14, 2021	Long March 2D (2)	Taiyuan	2 units
Hede-2F	2021-091H?				
Hede-2G	2022-090B	August 4, 2022	Long March 4B	Taiyuan	
Hede-2H	2022-167K	December 9, 2022	Jielong 3	At the sea	
Hede-3A - E	2023-121A-E	August 14, 2023	Kuaizhou 1A	Xichang	5 units

In addition, the People's Liberation Army National University of Defense Technology launched two "Tiantuo" satellites equipped with AIS receivers. There are two other satellites in the Tiantuo series (No. 2 and No. 5), but these do not carry AIS receivers (Table 8-5).

Table 8-5 Status of "Tiantuo" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Tiantuo-1	2012-021B	May 10, 2012	Long March 4B	Taiyuan	
Tiantuo-3	2015-049D	September 19, 2015	Long March 6	Taiyuan	

8.2 Geostationary Communications Satellites between Fixed Stations, etc.

The development of China's communications and broadcasting satellite technology began in August 1977, when China joined the International Telecommunications Satellite Organization (Intelsat) and began using international satellite communications. With the goal of acquiring the technologies required for the design, development, testing, launch, and operation of its own geostationary communications satellites, China launched the test communications satellite "Dongfanghong-2" in 1984. Next, in 1986, the "Dongfanghong-2A" bus, an improved version of the "Dongfanghong-2" bus, was used to launch the first geostationary communications satellite, the "Test Synchronous Telecommunications Satellite" (Shiyong Tongbu Tongxin Weixing; STTW), which became China's first operational geostationary communications satellite. "Dongfanghong-2A-1," launched in 1988, was renamed "Zhongxing-1," and by 1991, four satellites had been launched and stationed at three geostationary positions (87.5 degrees east, 98 degrees east, and 110.5 degrees east longitude).

Subsequently, the "Dongfanghong-3" satellite bus was developed. "Dongfanghong-3," launched in 1994 using this bus, was equipped with 24 transponders and became a fully functional geostationary communications satellite employing a three-axis attitude control system. The second satellite, launched in 1997, remained in operation beyond its designed lifespan of eight years. Furthermore, the "Dongfanghong-4" bus, which significantly increased the number of transponders compared with the "Dongfanghong-3" bus and had a designed lifespan of 15 years, was developed and first applied to "Sinosat-2," operated by Sino Satellite Communications Co., Ltd. (Sinosat), in 2006. Although the rocket launch was successful, the solar panels on "Sinosat-2" failed to deploy, rendering the satellite inoperable.

In May 2014, CAST announced the "Dongfanghong-4E," an enhanced version of the "Dongfanghong-4," and the new satellite bus "Dongfanghong-5." The "Dongfanghong-4E" is a large satellite bus incorporating advanced technologies to improve satellite performance, while the "Dongfanghong-5" bus was developed for next-generation large geostationary communications satellites and Earth observation satellites, incorporating many new technologies. In June 2017, "Zhongxing-9A" was launched using the "Dongfanghong-4," manufactured as "Sinosat-4," but failed to reach its intended orbit due to a malfunction in the third stage of the "Long March 3B/G2" rocket. Subsequently, in July, the satellite successfully achieved geostationary orbit using its own propulsion, but its operational lifespan was significantly shortened. In August 2019, "Zhongxing-18" was launched but was completely lost due to a malfunction of the satellite itself while in orbit.

China Satellite Group has launched various communications satellites, which are described below.

In March 2018, China Satellite Communications (China Satcom) announced plans to launch three high-throughput satellites over the following five years. In August 2024, it launched "Zhongxing-4A" using the "Long March 7A" rocket. China Communications and Broadcasting Satellite Corporation, established in 1983 as a state-owned enterprise under the jurisdiction of the then Ministry of Radio, Film, and Television (later the Ministry of Information Industry), was privatized in 2001 as China Satellite Communications and is currently affiliated with CASC.

China Satellite Communications operates 12 "Zhongxing" satellites and 6 "APStar" satellites. Satellite

communication Earth stations are located in three locations: Beijing, Dujiang (Sichuan Province), and Kashgar (Xinjiang Uygur Autonomous Region), with a tracking and control center (measurement and control) in Shahe (Hebei Province). The "APStar" tracking and control center (measurement and control center) is located in Hong Kong (Table 8-6).

Table 8-6 Status of "Zhongxing" and "APStar" satellite launches

Satellite Name	International Designator	Launch Date	Satellite Bus	Remarks
Zhongxing (Chinasat) 6B	2007-031A	July 5, 2007	Spacebus-4000C2	C38
Zhongxing (Chinasat) 9	2008-028	June 9, 2008	Spacebus-4000C2	Ku (television broadcast) 22
Zhongxing-10	2011-026A	June 20, 2011	DFH-4	C 30, Ku 16
Zhongxing-12 (APStar 7B)	2012-067A	November 27, 2012	DFH-4	Ku (television broadcast)
Zhongxing-11	2013-020A	May 1, 2013	DFH-4	C 26, Ku 19
Zhongxing-16 (Shijian 13)	2017-018A	April 12, 2017	DFH-4	Ka, high-throughput
Zhongxing-6C	2019-012A	March 9, 2019	DFH-4	C 25
Zhongxing-18 (Long March 3B/G2)	2019-053A	August 19, 2019	Completely lost	Malfunction in the orbit
Zhongxing-9B	2021-080A	September 9, 2021	DFH-4E	Ku (television broadcast)
Zhongxing-6D	2022-038A	April 15, 2022	DFH-4	C 25
Zhongxing-19	2022-148A	November 5, 2022	DFH-4E	Ka
Zhongxing-26	2023-022A	February 23, 2023	DFH-4	High-throughput, more than 100 GB
Zhongxing (Chinasat) 6E	2023-172A	November 9, 2023	DFH-4E	Ka, high-throughput
APStar-7	2012-013A	March 31, 2012	Spacebus-4000C2	C 28, Ku 28
APStar-9 (Mysat-1)	2015-059A	October 16, 2015	DFH-4	C 32, Ku 14
APStar-6C	2018-041A	May 3, 2018	DFH-4	C 26, Ku 19
APStar-5C (Telestar-18V)	2018-069A	September 10, 2018	SSL-1300	C, Ku, High-throughput
APStar-6D	2020-045A	July 9, 2020	DFH-4	Ka, High-throughput
APStar-6E	2023-005A	January 12, 2023	DFH-3E	High-throughput

All four "APStar" satellites operated by Asia Pacific Satellite Group (APT Satellite) that were not transferred to China Satellite Communications have ceased operations. Among these, the launches of "APStar-1" and "APStar-1A" were ordered by the UK government, and the satellites were transferred to China when Hong Kong was returned to China in 1997. "APStar-9A" was renamed twice from its original designation, becoming "Zhongxing-5A" upon transfer to China Satcom in 2010 and reverting to "APStar-9A" upon transfer to APT in 2013. It was decommissioned in June 2018 (Table 8-7).

Table 8-7 Status of the "APStar" satellite launches not transferred to China Satellite Communications

Satellite Name	International Designator	Launch Date	Launch Vehicle	Satellite Bus	Remarks
APStar-1	1994-043A	July 21, 1994	Long March 3	HS-376	Operation ended
APStar-1A	1996-039A	July 3, 1996	Long March 3	HS-376	Operation ended
APStar-2R	1997-062A	October 16, 1997	Long March 3B	SSL-1300	Operation ended
APStar-9A	1998-033A	May 30, 1998	Long March 3B	A2100A	Operation ended

China Communications Satellite Corporation operates the “Zhongxing” satellites for military communications and television broadcasting to the armed forces. It previously operated television broadcasting satellites for civilian use, but its role changed following the establishment of China Satellite Communications (Table 8-8).

Table 8-8 Status of “Zhongxing” satellite launches by China Communications Satellite Corporation

Satellite Name	International Designator	Launch Date	Satellite Bus	Remarks
Zhongxing-20 (Shentong-1A)	2003-052A	November 14, 2003	DFH-3	C, Ku
Zhongxing-22 (Feng-Huo-1A)	2006-038A	January 25, 2006	DFH-3	C, UHF
Zhongxing-22A (Feng-Huo-2A)	2003-038A	September 13, 2006	DFH-3	C, UHF
Zhongxing-20A (Shentong-1B)	2010-064A	November 24, 2010	DFH-3	C, Ku
Zhongxing-2A (Shentong-2A)	2012-028A	May 26, 2012	DFH-4	C, Ku
Zhongxing-2C (Shentong-2C)	2015-063A	November 3, 2015	DFH-4	C, Ku
Zhongxing-1C (Feng-Huo-2C)	2015-073A	December 9, 2015	DFH-4	C, UHF
Zhongxing-2D (Shentong-2D)	2019-001A	January 10, 2019	DFH-4	C, Ku
Zhongxing-2E (Shentong-2E)	2021-071A	August 5, 2021	DFH-4	C, Ku
Zhongxing-3A (Feng-Huo-3A?)	2024-122A	June 29, 2024	DFH-4?	Military
Zhongxing-4A (Shentong-3A?)	2024-151A	August 22, 2024	DFH-4?	C, Ku

Sinosat does not own its own satellites but provides business communication services such as emergency communications, maritime communications, aircraft communications, and railway communications. “Xinnuo” operates a global communications network by using the satellite communication capabilities of its parent company, China Satellite Communications (Table 8-9).

Table 8-9 Status of “Xinnuo” satellite launches

Satellite Name	International Designator	Launch Date	Satellite Bus	Remarks
Sinosat-1 (Zhongxing-5B)	1998-044A	February 18, 1998	Spacebus 3000A	C 24, Ku 14
Sinosat-2	2006-048A	October 28, 2006	DFH-4	Ku 24
Sinosat-3 (Zhongxing-5C)	2007-021A	May 31, 2007	DFH-3	Ku 24
Sinosat-6 (Zhongxing-6A)	2010-042A	September 4, 2010	DFH-4	C 24, Ku 8, S 1
Sinosat-5 (Zhongxing-10)	2011-026A	June 20, 2011	DFH-4	C 30, Ku 16
Sinosat-4 (Zhongxing-9A)	2017-035A	June 18, 2017	DFH-4	Ku 24

In August 2016, CSL Mobile Limited launched the "Tiantong-1 01,"⁷³ a geostationary communications satellite for mobile communications, followed by the launches of "Tiantong-1 02" and "Tiantong-1 03." These satellites relay S-band mobile communications (Table 8-10).

Table 8-10 Status of "Tiantong" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Geostationary Position
Tiantong-1 01	2016-048A	August 5, 2016	Long March 3 B/G3	101.5 degrees east longitude
Tiantong-1 02	2020-082A	November 12, 2020	Long March 3 B/G3	125 degrees east longitude
Tiantong-1 03	2021-003A	January 19, 2021	Long March 3 B/G3	82 degrees east longitude

Asia Satellite Telecommunications Co., Ltd. (Asiasat) was established in British Hong Kong in 1990. To date, it has launched ten satellites and currently operates six satellites in geostationary orbit. "Asiasat-6," launched in September 2014, is jointly operated with Thaicom to help Thailand secure rights to the 120 degrees east geostationary orbit slot. While demand for communications services remains high, competition in internet satellite services has intensified. Asiasat's management policy is to avoid expanding space infrastructure and instead invest in ground-based fixed assets (Table 8-11).

Table 8-11 Status of "Asiasat" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Satellite Bus	Geostationary Position
Asiasat-4	2003-014A	April 12, 2003	Atlas 3B	HS-601HP	147.5 degrees east latitude
Asiasat-5	2009-042A	August 11, 2009	Proton-M/Briz-M	SSL-1300	100.5 degrees east latitude
Asiasat-7	2011-069A	November 25, 2011	Proton-M/Briz-M	SSL-1300	105.5 degrees east latitude
Asiasat-8	2014-046A	August 5, 2014	Falcon 9	SSL-1300	3 degrees east latitude
Asiasat-6/ Thaicom7	2014-052A	September 7, 2014	Falcon 9	SSL-1300	120 degrees east latitude
Asiasat-9	2017-057A	September 28, 2017	Proton-M/Briz-M	SSL-1300	122 degrees east latitude

ABS is headquartered in Bermuda, with additional offices in Hong Kong, the United States, the Philippines, Indonesia, the UAE (Dubai), and South Africa. Satellite control operations are conducted from Hong Kong. ABS was formerly known as Asia Broadcasting Satellite, but the company's website now uses the name "ABS (Agility Beyond Space)."

ABS owns three proprietary satellites, including ABS-2A, which are Chinese satellites. As of 2024, it operates five satellites in total, including previously used satellites from South Korea (Japan's Mobile Broadcasting Corporation (MBCO) shared a satellite, but services ended in 2009) and the United States (Table 8-12).

⁷³ "Tiantong-1 01, 02, 03, 04", Gunter's Space page, https://space.skyrocket.de/doc_sdat/tiantong-1.htm.

Table 8-12 Status of "ABS" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Geostationary Position	Foreign Satellite Origin
ABS-2	2014-006A	February 6, 2014	Ariane 5 ECA	75 degrees east latitude	
ABS-3A	2015-010A	March 2, 2015	Falcon 9	3 degrees west latitude	
ABS-2A	2016-038A	June 15, 2016	Falcon 9	75 degrees east latitude	
ABS-4	2004-007A	March 13, 2004	Atlas 3	61 degrees east latitude	MBSat 1 (2012)
ABS-6	1999-053A	September 26, 1999	Proton	159 degrees east latitude	LMI-1 (2010)

8.3 Communications Technology Test Satellite

Since the launch of the "Communications Technology Test 1" (Tongxin Jishu Shiyanyan-1, TJS-1) in September 2015, intended to conduct technology tests of Ka-band broadband communications, CAST and SAST have launched a total of 15 communications technology test satellites (Table 8-13). Three of these satellites, "TJS-1," "TJS-4," and "TJS-9," are also known as "Outpost" and are believed to be military satellites for signals intelligence (SIGINT).

The second satellite, TJS-2, launched in January 2017, was developed by SAST and was reported in the press at the time as a communications satellite for technology tests such as data communication. However, an examination of the satellite's exterior shows multiple telescope-like devices, suggesting it is equipped with an infrared sensor. Its alternate name is "Flame," and four satellites—including TJS-5, TJS-6, and TJS-13—were deployed to geostationary positions in the Eastern Hemisphere during the same mission, making it highly likely that TJS-2 serves as a missile early warning satellite.

Unlike the three satellites thought to be used for SIGINT, "TJS-3" and "TJS-5," launched in January 2020, are conducting missions such as formation flying. Additionally, "TJS-11," launched using the "Long March 5" rocket, is believed to be a large geostationary satellite conducting a verification mission for multi-band high-speed satellite communication technology. While the satellite bus is unknown, "Dongfanghong-5" is considered a likely candidate based on its size. The "Long March 5" rocket is also used for the "Yaogan-41" and low-orbit internet satellites. The transition to a new series of rockets, such as "Long March 5," which primarily use low-pollution engines, is expected to accelerate further, gradually replacing older rockets like the "Long March 2," "Long March 3," and "Long March 4," which rely on toxic fuels.

Table 8-13 Status of "TJS," communications technology test satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Geostationary Position	Mission
TJS-1 (Outpost-1)	2015-046A	September 12, 2015	Long March 3 B G2	155 degrees east latitude	SIGINT
TJS-2 (Flame-1)	2017-001A	January 5, 2017	Long March 3 B G2	66 degrees east latitude	Early warning?
TJS-3	2018-110A	December 24, 2018	Long March 3 C G2	148 degrees east latitude	Unknown
TJS-4 (Outpost-2)	2019-070A	October 17, 2019	Long March 3 B G2	83 degrees east latitude	SIGINT
TJS-5 (Flame-2)	2020-002A	January 7, 2020	Long March 3 B G2	107 degrees east latitude	Early warning?
TJS-6 (Flame-3)	2021-010A	February 4, 2021	Long March 3 B G2(2)	178 degrees east latitude	Early warning?
TJS-7	2021-077A	August 24, 2021	Long March 3 B E	99 degrees west latitude	Unknown
TJS-9 (Outpost-3)	2021-135A	December 29, 2021	Long March 3 B G3	137 degrees east latitude	SIGINT
TJS-10	2023-169A	November 3, 2023	Long March 7 A	174 degrees east latitude	Unknown
TJS-11	2024-037A	February 23, 2024	Long March 5	120 degrees east latitude	Communications technology
TJS-13 (Flame-4)	2024-227A	December 3, 2024	Long March 3 B G2(2)	Quasi-zenith orbit at 0.2 degrees west longitude?	Early warning?
TJS-12	2024-246A	December 20, 2024	Long March 3 B G2(2)	147 degrees east latitude	Unknown
TJS-14	2025-017A	January 23, 2025	Long March 3 B G2(2)	18 degrees east latitude	Unknown
TJS-15	2025-045A	March 9, 2025	Long March 3 B G2(2)	90.4 degrees east latitude	Unknown
TJS-16	2025-064A	March 29, 2025	Long March 7 A	In the process of becoming stationary	Unknown

8.4 Satellites That Support Social Activities

In China, a large number of satellites are operated for social activities such as amateur radio and business. Each of these is described below.

Amateur radio is a communication tool that allows people to connect with each other, regardless of age or prior acquaintance, as long as they are within radio wave range. While it is typically pursued as an individual hobby, a national license is required to establish a receiving station. Amateur radio is also used for communicating with astronauts on the space station and for aerial photography using drones. The main organization representing amateur radio in China is the Chinese Radio Amateurs Club (CRAC, formerly AMSAT China), which is part of the Radio Association of China (RAC) (Table 8-14).

Table 8-14 Status of satellite launches supporting amateur radio use

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Hope-1	2009-072B	December 15, 2009	Long March 4 C	Taiyuan	
Hope-2A	2015-049E	September 19, 2015	Long March 6	Taiyuan	
Hope-2B	2015-049F	September 19, 2015	Long March 6	Taiyuan	
Hope-2C	2015-049G	September 19, 2015	Long March 6	Taiyuan	
Hope-2D	2015-049H	September 19, 2015	Long March 6	Taiyuan	
Hope-2E	2015-049J	September 19, 2015	Long March 6	Taiyuan	
Hope-2F	2015-049K	September 19, 2015	Long March 6	Taiyuan	
CAS-3G	2016-049L	September 19, 2015	Long March 6	Taiyuan	
Fengtai Shaonian-1	2016-066F	November 9, 2016	Long March 11	Jiuquan	
Shaonian Xing (Youth Star)	2018-015H	February 2, 2018	Long March 2 D(2)	Jiuquan	
CAS-7B	2019-043A	July 25, 2019	Hyperbola-1	Jiuquan	
Hope-3	2021-131B	December 26, 2021	Long March 4 C	Taiyuan	
Hope-4	2022-152C	November 12, 2022	Long March 7	Wenchang	
Hope-5 (Fengtai Shaonian-2)	2022-167C	December 9, 2022	Jielong 3	At the sea	

Beijing Kaidun Technology Co., Ltd. launched and operates the communications technology test satellite "Kaidun-1" (Table 8-15). Using this platform, COMMSAT is developing communications satellites aimed at children. In December 2018, the company simultaneously launched seven "Ladybug" satellites, which are still in operation (Table 8-16). The company is working on one-step solutions, system integration, and the construction and operation of IoT satellite constellation systems using a "satellite + IoT" model. It planned to complete the construction of an IoT constellation consisting of 72 satellites by the end of 2022 and provide real-time satellite IoT services to customers worldwide.

Table 8-15 Status of Beijing Kaidun Technology's satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Kaidun-1	2017-002C	January 9, 2017	Kuaizhou 1A	Jiuquan	

Table 8-16 Status of COMMSAT's satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Ladybug-1 - 7	2018-102*	December 7, 2018	Long March 2 D(2)	Jiuquan	

Alibaba, China's largest e-commerce company, launched the communications technology test satellite "Candy Tin" in October 2018. "Candy Tin"⁷⁴ is a satellite communications payload that uses the upper stage of a rocket, which would become space debris in orbit after the satellite's operational life ends. Alibaba plans to build a constellation of small communications satellites using a large number of "Tianmao Guoji" satellites, but as of March 2025, no follow-on satellites have been launched (Table 8-17).

Table 8-17 Status of "Candy Tin" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Candy Tin	2018-081B	October 24, 2018	Long March 4 B	Taiyuan	

Galaxy Aerospace Technology Co., Ltd. conducted a test launch of "Yinhe-1"⁷⁵ in 2020 and launched six "Yinhe-2" satellites in 2022. In January 2025, it also launched a new satellite, "Tianlu," along with two additional satellites (Table 8-18).

Table 8-18 Status of "Yinhe" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Yinhe-1	2020-004A	January 16, 2020	Kuaizhou 1A	Jiuquan	
Yinhe-2 01-06	2022-023A-F	March 5, 2022	Long March 2 C(3)	Xichang	6 satellites
Tianlu-1	2025-012*	January 17, 2025	Long March 2 D	Jiuquan	

In addition, the Fourth Academy of CASIC launched the narrowband satellite communications technology test satellite "Xingyun Shiyan-1" aboard the "Kuaizhou 1A" rocket in January 2017. In May 2020, it launched the first two satellites of the "Xingyun-2" series⁷⁶ and conducted inter-satellite laser communications tests (Table 8-19).

Table 8-19 Status of "Xingyun Shiyan" and "Xingyun" satellite launches

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
Xingyun Shiyan-1	2017-002B	January 9, 2017	Kuaizhou 1A	Jiuquan	
Xingyun-2 01	2020-028A	May 12, 2020	Kuaizhou 1A	Jiuquan	
Xingyun-2 02	2020-028B				

⁷⁴ "Tangguo Guan (Candy Jar)". Gunter's Space page, https://space.skyrocket.de/doc_sdat/tangguo_guan.htm.

⁷⁵ "Yinhe 1, 2". Gunter's Space page, https://space.skyrocket.de/doc_sdat/yinhe-1.htm.

⁷⁶ "Xingyun-2 01, 02 (XY-2 01, 02)", Gunter's Space page, https://space.skyrocket.de/doc_sdat/xingyun-2.htm.

9 China's Navigation and Positioning Systems

China's navigation and positioning system was developed in three phases. In the first phase, the introductory system, "BeiDou-1" was positioned as "solving urgent needs" (meeting immediate demands), and it began service operations in 2000. In the second phase, "BeiDou-2" was positioned "considering long-term needs" (meeting long-term demands), with the launching of satellites in a Regional Navigation Satellite System (RNSS) in 2007. In phase three, by 2019, under the strategy of "regional first, then global," China had launched 37 "BeiDou-3" satellites, completing the construction of a Global Navigation Satellite System (GNSS).

At the completion of the RNSS, the positioning accuracy of the second-generation BeiDou NSS (BDNSS) in key areas, such as Beijing, was 10 m horizontally and 10 m vertically; however, in most other areas, the positioning was 20 m horizontally and 20 m vertically. Its velocity accuracy was 0.2 m/s or higher, and its timing accuracy was 50 ns (nanoseconds = one billionth of a second) in a passive mode. Its service coverage area extended from 55° E to 180° E longitude.

The current positioning accuracy of the BDNSS, which supports urban safety management, disaster emergency response, public transportation, and hazardous material transportation monitoring, is 2–3 m. In maritime environments, system accuracy of 3 cm horizontally and 4 cm vertically has been achieved. For example, during deep-sea drilling operations, if a typhoon occurs, the drilling rig must be temporarily withdrawn, with operations resumed at the same location after the typhoon has passed. Centimeter-level positioning accuracy is required to reposition the drilling rig with minimal deviation.

In November 2024, at a symposium held in Beijing to commemorate the 30th anniversary of the construction of the BDNSS, the China Satellite Navigation Office (CSNO) announced a "Development Plan for the BeiDou Navigation Satellite System through 2035."⁷⁷ The plan called for the construction of a next-generation BeiDou system (BDS) by 2035. Today, more than 130 countries reportedly use the BDS. Furthermore, elements of the system have been exported to over 140 countries and regions, and the system has been registered as a standard with 13 international organizations that cover civil aviation, maritime, mobile communications, and other sectors. Looking ahead, to ensure the stable operation of the BDS-3, China plans to launch three pilot satellites around 2027 to begin testing new technology and the construction of a next-generation system with more advanced technology, stronger functionality, and superior services.

Practical navigation and positioning satellites worldwide have contributed to a proliferation of civilian services, such as automotive navigation and timing authentication, with the U.S. prioritizing military applications while also opening signal access for civilian use. Russia's Global NSS (GLONASS) was fully developed in 2011 and continues to expand its practical applications. Europe completed its Galileo

⁷⁷ "我国将于 2035 年完成下一代北斗系统建设", Baidu, November 28, 2024, <https://baijiahao.baidu.com/s?id=1816942090895692379&wfr=spider&for=pc>.

positioning system in 2016, with 24 operating satellites. Japan added three Quasi-Zenith Satellites (Michibiki) in 2017, creating a four-satellite constellation with its original satellites, achieving "positioning augmentation" with at least one satellite constantly present over Japan. India completed its RNSS (IRNSS) in 2016, with the orbital deployment of its seventh satellite (thereafter changing its name to the "Navigation with Indian Constellation").

Considered beneficial for industrial development, many countries are focusing on the development of navigation and positioning satellite applications. Until now, services have primarily been provided using U.S. GPS. However, with Russian, European, and Chinese global positioning satellites achieving interoperability, the ability to comprehensively use these satellites to deliver high value-added devices and services to users quickly and cost-effectively has become a decisive factor in success or failure in the positioning and geographic information industry.

9.1 China's Organizations Associated with Its Satellite Navigation and Positioning Systems

There are two organizations in China working on its satellite navigation and positioning systems:

- **The China BeiDou Satellite Navigation Office (CSNO):** The CSNO is a joint office established by relevant ministries and agencies responsible for the BeiDou satellite system. It oversees the construction of the system, the promotion of its applications, and its industrialization.
- **The Ministry of Transport:** China's Ministry of Transport is an organization under the State Council responsible for supervising the transportation authorities for air, land, and sea. Its mandate is to ensure transportation safety and quality improvement through the BDS. In particular, for key transportation control operations, it jointly implements projects with the Equipment Development Department of the People's Liberation Army. In terms of maritime navigation, at the International Maritime Organization (IMO) meeting, the Ministry collaborated with the CSNO to propose the inclusion of BeiDou satellites in the Worldwide RNS (WWRNS). Consequently, it dispatched delegations to meetings of the Maritime Safety Committee.

9.2 Global Navigation Satellite Systems

China has advanced the use of the "BeiDou" satellite constellation for global positioning. Although the U.S. launched navigation and positioning satellites beginning in 1960, China launched its positioning services using the "dual-satellite" positioning "BeiDou-1" system in 2000 (Table 9-1). Initially, two geostationary satellites were positioned at 80° E and 140° E longitude. For users seeking to determine their locations, radio signals could be transmitted to the satellites via positioning terminals to obtain approximate positions. However, the short message transmission function that was provided became extremely popular and has been widely recognized as effective for safety confirmation during disasters, such as the Sichuan earthquake. As such, it was carried forward to second-generation and subsequent terminal devices.

Table 9-1 Launch of "BeiDou-1" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Orbit	Remarks
BeiDou-1A	2000-069A	October 30, 2000	Chang Zheng-3A	GEO	Operations terminated.
BeiDou-1B	2000-082A	December 20, 2000	Chang Zheng-3A	GEO	Operations terminated.
BeiDou-1C	2003-021A	May 24, 2003	Chang Zheng-3A	GEO	Operations terminated.
BeiDou-1D	2007-003A	February 2, 2007	Chang Zheng-3A	GEO	Operations terminated.

Between 2007 and 2012, China launched 16 second-generation "BeiDou-2" satellites. These comprised six Geostationary Orbit (GEO) satellites, five Inclined Geosynchronous Orbit (IGSO) satellites, and five Medium Earth Orbit (MEO) satellites. These launches enabled the early completion of the RNSS. In December 2012, free Positioning, Navigation, and Timing (PNT) services were officially launched for users in the Asia-Pacific region. The "BeiDou-2" satellite bus, the platform for the constellation, employed the "Dongfanghong-3," operating in the L-, C-, and S-band frequencies.

Among the GEO satellites, "BeiDou-2 G2," launched in 2009, failed to achieve a geostationary orbit. However, "BeiDou-3 G1Q" was launched in 2018 (Table 9-6), followed by "BeiDou-2 G8" in 2019 (Table 9-2).

Table 9-2 Launch of "BeiDou-2G" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Orbit	Remarks
BeiDou-2 G2	2009-018A	April 14, 2009	Chang Zheng-3C	GEO	Failed to achieve GEO
BeiDou-2 G1	2010-001A	January 16, 2010	Chang Zheng-3C	GEO	140°E longitude
BeiDou-2 G3	2010-024A	June 2, 2010	Chang Zheng-3C	GEO	80°E longitude
BeiDou-2 G4	2010-057A	October 31, 2010	Chang Zheng-3C	GEO	160°E longitude
BeiDou-2 G5	2012-008A	February 24, 2012	Chang Zheng-3C	GEO	59°E longitude
BeiDou-2 G6	2012-059A	October 25, 2012	Chang Zheng-3C	GEO	84°E longitude
BeiDou-2 G7	2016-037A	June 12, 2016	Chang Zheng-3C/G2	GEO	110°E longitude
BeiDou-2 G8	2019-027A	May 17, 2019	Chang Zheng-3C/G2	GEO	80°E longitude

The IGSO satellites were first launched with "BeiDou-2 I1" in July 2010. The "I" denotes inclination. These satellites travel in a figure-eight-shaped trajectory within the same longitude band, covering a range of approximately 55° N to 55° S latitude. The orbit is nearly circular, with the intersection of the figure-eight-pattern near the equator. In December 2010, "BeiDou-2 I2" was launched, followed by "BeiDou-2 I3" in April 2011, completing a three-satellite configuration in the 115° E longitude band. This configuration established a constellation capable of providing continuous 24-hour coverage over China. The four satellites launched between July 2011 and March 2016 operated at a central longitude of approximately 95° E and included a mix of "BeiDou-2 I4," "BeiDou-3 I1," and "BeiDou-3 I2" satellites (Table 9-3). To launch "BeiDou-3 I1" among the IGSO satellites, the "Chang Zheng-3C/YZ1" (with a GTO payload capacity of over 3,900 kg) was used. "BeiDou-3 I2," with a mass of 4,200 kg, was launched using the "Chang Zheng-3B/G2" (with a GTO payload capacity of 5,500 kg).

Table 9-3 Launch of Inclined Geosynchronous Orbit "BeiDou-2 IGSO" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Orbit	Remarks
BeiDou-2 I1	2010-036A	July 31, 2010	Chang Zheng-3A	IGSO	110°E longitude (East)
BeiDou-2 I2	2010-068A	December 17, 2010	Chang Zheng-3A	IGSO	(East)
BeiDou-2 I3	2011-013A	April 9, 2011	Chang Zheng-3A	IGSO	(East)
BeiDou-2 I4	2011-038A	July 26, 2011	Chang Zheng-3A	IGSO	95°E longitude (West)
BeiDou-2 I5	2011-073A	December 1, 2011	Chang Zheng-3A	IGSO	(West)
BeiDou-3 I1-S	2015-019A	March 30, 2015	Chang Zheng-3C/YZ1	IGSO	(West) Type I
BeiDou-3 I2-S	2015-053A	September 9, 2015	Chang Zheng-3B/G2	IGSO	(West) Type2
BeiDou-2 I6	2016-021A	March 29, 2016	Chang Zheng-3A	IGSO	(West)
BeiDou-2 I7	2018-057A	July 9, 2018	Chang Zheng-3A	IGSO	(East)
BeiDou-3 I1	2019-023A	April 21, 2019	Chang Zheng-3B/G2	IGSO	(East) Type2
BeiDou-3 I2	2019-035A	June 24, 2019	Chang Zheng-3B/G2	IGSO	(East) Type2
BeiDou-3 I3	2019-073A	November 4, 2019	Chang Zheng-3B/G2	IGSO	(East) Type2

Among the MEO satellites, "BeiDou-2 M1," launched in 2007, successfully entered orbit; however, its operation was terminated early because of on-orbit failures. Four additional satellites were subsequently launched; however, they were later replaced by "BeiDou-3 M" satellites as part of the effort to achieve a constellation of 35 GNSS satellites (Table 9-4).

Table 9-4 Launch of Medium Earth Orbit "BeiDou-2M" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Orbit	Remarks
BeiDou-2 M1	2007-011A	April 13, 2007	Chang Zheng-3A	MEO	Operations terminated
BeiDou-2 M3	2012-018A	April 29, 2012	Chang Zheng-3B/G1	MEO	In operation
BeiDou-2 M4	2012-018B				In operation
BeiDou-2 M2	2012-050A	September 18, 2012	Chang Zheng-3B/G1	MEO	In operation
BeiDou-2 M5	2012-050B				Operations terminated

In 2019, China completed its BeiDou navigation and positioning system with global coverage. By 2024, 40 "BeiDou-3" satellites had been launched, comprising four GEO satellites, 31 MEO satellites, and five IGSO satellites, with "BeiDou-2" continuing to operate. Within the "BeiDou-3" constellation, the MEO component began launching during phase three in July 2015 with the "BeiDou-3 M" satellite series (Table 9-5).

Table 9-5 Launch of Medium Earth Orbit "BeiDou-3M" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Orbit	Remarks
BeiDou-3 M1-S	2015-037A	July 25, 2015	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M2-S	2015-037B				
BeiDou-3 M3-S	2016-006A	February 1, 2016	Chang Zheng-3C/YZ-1	MEO	In operation
BeiDou-3M1	2017-069A	November 5, 2017	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M2	2017-069B				
BeiDou-3 M3	2018-018A	February 13, 2018	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M4	2018-018B				
BeiDou-3 M5	2018-062A	July 29, 2018	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M6	2018-062B				
BeiDou-3 M7	2018-003A	November 1, 2018	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M8	2018-003B				
BeiDou-3 M9	2018-029A	March 29, 2018	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M10	2018-029B				
BeiDou-3 M11	2018-067A	August 25, 2018	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M12	2018-067B				
BeiDou-3 M13	2018-072A	September 19, 2018	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M14	2018-072B				
BeiDou-3 M15	2018-078A	October 15, 2018	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M16	2018-078B				
BeiDou-3 M17	2018-093A	November 18, 2018	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M18	2018-093B				
BeiDou-3 M19	2019-090A	December 16, 2019	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M20	2019-090B				
BeiDou-3 M21	2019-078A	November 23, 2019	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M22	2019-078B				
BeiDou-3 M23	2019-061A	September 22, 2019	Chang Zheng-3B/YZ-1	MEO	In operation
BeiDou-3 M24	2019-061B				
BeiDou-3 M25	2023-207A	December 26, 2023	Chang Zheng-3B/G3Z	MEO	In operation
BeiDou-3 M26	2023-207B				
BeiDou-3 M27	2024-168A	September 19, 2024	Chang Zheng-3B/G3Z	MEO	In operation
BeiDou-3 M28	2024-168B				

Regarding GEO satellites, four "BeiDou-3G" satellites had been launched by 2023 (Table 9-6).

Table 9-6 Launch of Geostationary Orbit "BeiDou-G" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Orbit	Remarks
BeiDou-3 G1Q	2018-085A	November 1, 2018	Chang Zheng-3B/G3	GEO	145°E longitude
BeiDou-3 G2	2020-017A	March 9, 2020	Chang Zheng-3B/G3	GEO	145°E longitude
BeiDou-3 G3	2020-040A	June 23, 2020	Chang Zheng-3B/G3	GEO	145°E longitude
BeiDou-3 G4	2023-066A	May 17, 2023	Chang Zheng-3B/G3	GEO	160 °E longitude

9.3 Positioning Augmentation Satellites

Positioning augmentation satellites (i.e., Satellite-Based Augmentation Systems) transmit information on delays in GPS signals caused by weather and other factors to ground-based stations or GPS receivers, thereby improving positioning accuracy. These satellites have been launched by Geely Future Mobility Constellation and Centi Space. As of 2024, Geely Future Mobility Constellation had launched 30 "Jili Xingzuo" satellites (also known as GeeSAT),⁷⁸ with 74 satellites planned in the initial constellation (Table 9-7).

Table 9-7 Launch of "GeeSAT" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
GeeSAT 1: 01-09	2022-058A	June 2, 2022/6/2	Chang Zheng-2C (3)	Xichang	9 satellites
GeeSAT 2: 01-11	2024-023*	February 2, 2024	Chang Zheng-2C (3)	Xichang	11 satellites
GeeSAT 3: 01-10	2024-159*	September 5, 2024	Chang Zheng- 6	Taiyuan	10 satellites

Centi Space has been launching "CentiSpace" satellites (also known as Xiangrikui)⁷⁹ to conduct positioning augmentation using meteorological observation data. In January 2025, 10 of these satellites were launched simultaneously aboard the "Jielong-3" launch vehicle (Table 9-8).

Table 9-8 Launch of "CentiSpace" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Remarks
CentiSpace 1 S1	2018-075A	September 29, 2018	Kuaizhou-1A	Jiuquan	
CentiSpace 1 S2	200-F06	July 10, 2020	Kuaizhou-11	Jiuquan	Launch failed
CentiSpace 1 S3-S4	2022-108A-B	September 6, 2022	Kuaizhou-1A	Jiuquan	2 satellites
CentiSpace 1 S5-S6	202-126A-B	October 7, 2022	Chang Zheng-11H	Sea Launch	2 satellites
CentiSpace 1 S7-S16	2025-007 *	January 13, 2025	Jielong-3	Sea Launch	10 satellites

⁷⁸ "GeeSAT 1-01, ..., 74" , Gunter's Space page, https://space.skyrocket.de/doc_sdat/geesat-1.htm.

⁷⁹ "CentiSpace-1 S1, ..., S5 (Xiangrikui 1, ..., 6)" , Gunter's Space page, https://space.skyrocket.de/doc_sdat/centispace-1.htm.

10 Technical Test Fields

Technical tests are conducted to ensure the successful launch of satellites. These tests focus on critical functions and partially verify challenging technologies when developing practical satellites for various mission fields. Consequently, numerous technology-testing satellites have been launched. Major institutions, such as CASC (China Aerospace Science and Technology Corporation), which implements space development for the central government, and its affiliated large research institutes, including CAST (China Academy of Space Technology), SAST (Shanghai Academy of Spaceflight Technology), and CALT (China Academy of Launch Vehicle Technology), along with institutes under CASIC (China Aerospace Science and Industry Corporation) and CAS (Chinese Academy of Sciences), have launched technology test satellites to conduct element tests prior to launching large satellites.^{80, 81, 82} Universities and companies have also launched numerous ultra-small satellites, known as CubeSat for fields such as space science, Earth observation, and communications and broadcasting. These launches serve educational purposes and provide platforms for talent development.

10.1 Technology Test Satellites Related to the Central Government

CAST, SAST, and CALT have developed numerous technology test satellites, including the "Shijian," "Shiyan," "Technology Test Satellite," and "Iridium(s)" satellites (for launch testing). Each is described below, excluding the technology test satellites for the aforementioned space transportation systems.

Launched in 2021, the "Shijian 21" satellite successfully completed its mission to relocate the "BeiDou-2 G" satellite, which had become space debris due to a malfunction, from geostationary orbit to an orbit 300 km higher. This mission required the unique capabilities of a technology test satellite to perform the necessary rendezvous and transfer operations with a malfunctioning satellite in a geostationary orbit (Table 10-1).

Table 10-1 Launch Status of "Shijian" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Mission
Shijian-2 B-C	1981-093A-B	September 19, 1981	Fengbao 1	Jiuquan	2 units, Space Environment
Shijian-7	2005-024A	July 5, 2005	Changzheng 2D	Jiuquan	Unknown
Shijian-11 1	2009-061A	November 12, 2009	Changzheng 2C	Jiuquan	Early Warning Experiment
Shijian-12	2010-027A	June 15, 2010	Changzheng 2D	Jiuquan	Rendezvous with Shijian 6F
Shijian-11 3	2011-030A	July 6, 2011	Changzheng 2C	Jiuquan	SIGINT
Shijian-11 2	2011-039A	July 29, 2011	Changzheng 2C	Jiuquan	SIGINT

⁸⁰ CASC, Organizational Structure—China Aerospace Science and Technology Corporation, <https://www.spacechina.com/n25/n142/n152/n12989/index.html>.

⁸¹ China Academy of Aerospace Navigation Technology, <https://baike.baidu.com/item/中国航天导航技术研究院/62060339>

⁸² CASIC, Organizational Structure, <http://www.casic.com.cn/n12377374/n12378149/index.html>

Shijian-11 4	2011-F02	August 18, 2011	Changzheng 2C	Jiuquan	Launch Failure
Shijian-9 A-B	2012-056A-B	October 14, 2012	Changzheng 2 CSMA	Taiyuan	2 units, unknown
Shijian-11 5	2013-035A	July 15, 2013	Changzheng 2C (2)	Jiuquan	SIGINT
Shijian-15	2013-037C	July 19, 2013	Changzheng 4C	Taiyuan	Space Debris
Shijian-16	2013-057A	October 25, 2013	Changzheng 4B	Jiuquan	Space Environment Survey
Shijian-11 6	2014-014A	March 31, 2014	Changzheng 2C (2)	Jiuquan	SIGINT
Shijian-11 7	2014-059A	September 28, 2014	Changzheng 2C (3)	Jiuquan	SIGINT
Shijian-11 8	2014-066A	October 27, 2014	Changzheng 2C (3)	Jiuquan	SIGINT
Shijian-16 2	2016-043A	June 29, 2016	Changzheng 4B	Jiuquan	Space Environment Survey
Shijian-17	2016-065A	November 3, 2016	Changzheng 5/YZ2	Wenchang	Rocket Evaluation
Shijian-18	2017-F03	July 2, 2017	Changzheng 5	Wenchang	Launch Failure
Shijian-20	2019-097A	December 27, 2019	Changzheng 5	Wenchang	"Dongfanghong-5" Bus Test Experimental, Geostationary, Mass 8 tons and above
Shijian-21	2021-094A	October 24, 2021	Changzheng 3B/G2	Xichang	Transfer Beidou-2G into disposal orbit
Shijian-21 Sub-satellite	2021-094C				
Shijian-6 5A	2021-122A	December 10, 2021	Changzheng 4B	Jiuquan	ELINT
Shijian-6 5B	2021-122B				
Shijian-23	2023-002A	January 8, 2023	Changzheng 7A	Wenchang	Communication
Shijian-19	2024-177A	September 27, 2024	Changzheng 2D (2)	Jiuquan	Recoverable

"Shijian" missions are often operational, while "Shiyan" missions, which are frequently related to space environment research, have surged since 2021. "Shiyan 9," the second payload on the "Changzheng-7 A" rocket, was launched after the first launch failed. The mission aimed to evaluate performance. The payload was placed into a figure-eight orbit with an inclination of 18°. However, the intended orbit may have been geostationary but instead ended up in a quasi-zenith orbit. "Shiyan 16" and "Shiyan 17" were launched simultaneously with another satellite by the "Changzheng 6" rocket from Taiyuan. A similar launch occurred in 2023 with "Yaogan 40," although its SSO altitude and orbital inclination differed. "Shiyan 25" conducted flight tests in an extremely low (Very Low) orbit. The "Lixing" satellite performed an ultra-low flight at an altitude of 109 km, which disappeared after four days. However, "Shiyan 25" is still flying with a perigee of 270 km (Table 10-2).

Table 10-2 Launch Status of "Shiyan" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Mission
Shiyan-1 (Tance 1)	2004-046A	November 18, 2004	Changzheng 2C	Xichang	
Shiyan-2 (Tance 2)	2004-068B	November 20, 2011	Changzheng 2D	Jiuquan	
Shiyan-3	2008-056B	November 5, 2008	Changzheng 2D	Jiuquan	Earth Observation
Shiyan-4	2011-068B	November 20, 2011	Changzheng 2D	Jiuquan	Earth Observation
Shiyan-7 A	2013-037A	July 19, 2013	Changzheng 4C	Taiyuan	Robot Arm
Shiyan-5	2013-067A	November 25, 2013	Changzheng 2D (3)	Jiuquan	Earth Observation
Shiyan-6	2018-094B	November 19, 2018	Changzheng 2C (3)	Jiuquan	Space Environment
Shiyan-6 02	2020-043A	July 4, 2020	Changzheng 2D (2)	Jiuquan	Space Environment
Shiyan-9	2021-019A	March 11, 2021	Changzheng 7A	Wenchang	8-shaped orbit
Shiyan-6 03	2021-028A	April 8, 2021	Changzheng 4B	Taiyuan	Space Environment
Shiyan-10	2021-087A	September 27, 2021	Changzheng 3B/G2 (2)	Xichang	Power System Malfunction
Shiyan-11	2021-112A	November 24, 2021	Kuaizhou-1A	Jiuquan	Unknown
Shiyan-12 01-02	2021-129A to B	December 23, 2021	Changzheng 7A	Wenchang	2 units
Shiyan-13	2022-004A	January 17, 2022	Changzheng 2D (2)	Taiyuan	Unknown
Shiyan-14-15	2022-118A ~ B	September 24, 2022	Kuaizhou 1A	Taiyuan	2 units, Earth observation
Shiyan-16 A-B, Shiyan-17	2022-121A-C	September 26, 2022	Changzheng 6	Taiyuan	3 Satellites, Earth Observation
Shiyan-20 C	2022-142A	October 29, 2022	Changzheng 2D (2)	Jiuquan	Unknown, Unknown
Shiyan-20 A-B	2022-169A ~ B	December 12, 2022	Changzheng 4C	Xichang	2 units, unknown
Shiyan-21	2022-172A	December 16, 2022	Changzheng 11	Xichang	Unknown
Shiyan-10 02	2022-178A	December 29, 2022	Changzheng 3B/G2 (2)	Xichang	Unknown
Shiyan-22 A-B	2023-006A-B	January 13, 2023	Changzheng 2D (2)	Jiuquan	2 rockets, unknown
Shiyan-19	2023-034A	March 15, 2023	Changzheng 11	Jiuquan	Unknown
Shiyan-24 A-B	2023-081*	June 7, 2023	Zhongke-1/Yao-2	Jiuquan	2 units, unknown
Shiyan-25	2023-087A	June 20, 2023	Changzheng 6	Taiyuan	VLEO
Shiyan-24 C1-3	2023-206A -C	December 25, 2023	Changzheng 11H	Ocean Launch	3 units, unknown
Shiyan-23	2024-089 *	May 10, 2024	Changzheng 4C	Jiuquan	Space Environment
Shiyan-26 A-C	2024-205*	November 11, 2024	Zhongke-1	Jiuquan	3 Satellites

The "New Technology Test (Xin Jishu Shiyan, XJS) Satellite" is launched in pairs or sets of four to test inter-satellite communication links. The launch site is Xichang, located at an altitude of approximately 400 km with an orbital inclination of 35° (Table 10-3).

Table 10-3 Launch Status of "Xin Jishu Shiyan" Satellites

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Mission
Xin Jishu Shiyan Satellite A-B	2018-054A- B	June 27, 2018	Changzheng 2C (3)	Xichang	2 units, satellite-to-satellite link experiment
Xin Jishu Shiyan Satellite C-F	2020-014A- D	February 18, 2020	Changzheng 2D (2)	Xichang	4 units, satellite-to-satellite link experiment
Xin Jishu Shiyan Satellites G-H	2020-032A-B	May 29, 2020	Changzheng 11	Xichang	2 units, satellite-to-satellite link experiment

The "Tianping" mission involves comparing data observed on Earth by ground-based equipment with data observed simultaneously from orbit and performing calibrations to minimize errors (Table 10-4).

Table 10-4 Launch Status of "Tianping" Satellite

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Mission
Tianping-1 A-B	2018-094C, E	November 19, 2018	Changzheng 2C (3)	Jiuquan	2 units, ground equipment calibration
Tianping-2 A-C	2022-032A, C, D	March 30, 2022	Changzheng 11	Jiuquan	3 units, ground equipment calibration
Tianping-3 A01	2024-189*	October 22, 2024	Changzheng 6	Taiyuan	3 units, ground equipment calibration
Tianping-3 B01-02	2024-189*				

Table 10-5 Launch Status of Small Satellites by China Academy of Space Technology (CAST)

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Mission
Dongfanghong (DFH)-1	-	1970	Changzheng 1	Jiuquan	Launch Technology Demonstration
Banfei Small Satellite (BX)	-	2008	Changzheng 2F	Jiuquan	Shenzhou-7 Photography

CALT is an organization that conducts technical research on launch vehicles but rarely develops satellites. However, it produced a dummy satellite for launch tests of Motorola's low-orbit communications satellite, "Iridium." Most of the 66-satellite "Iridium" constellation, also known as "Big LEO," was launched in groups of five by Russia's "Proton" rocket. However, to achieve the desired configuration of seven satellites per orbital plane required two additional satellites. China's launch services were selected to minimize costs. Prior to launching twelve "Iridium" satellites with six "Changzheng-2 C" rockets (the first launch occurred in 1997), dummy satellites were used to demonstrate technology for launching two satellites simultaneously (Table 10-6). Although Motorola likely covered the manufacturing costs of the dummy satellites as the company had no use for them, it is believed that China retained ownership and launched them.

Table 10-6 Satellite Launch Status of China Academy of Launch Vehicle Technology (CALT)

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Mission
IRIDIUM MFS 1, 2	1997-048A-B	September 1, 1997	Changzheng 2C/FP	Taiyuan	Launch Performance Verification

The "Chuangxin" small satellite, jointly developed by the Innovation Academy for Microsatellites of the Chinese Academy of Sciences (CAS) and the Shanghai Academy of Spaceflight Technology of the China Aerospace Science and Technology Corporation (CASC), has been launched seven times to date. Aiming to demonstrate communication technologies, two "Chuangxin 16" satellites were launched in 2022 (Table 10-7).

Table 10-7 Launch Status of "Chuangxin" by Innovation Academy for Microsatellites of Chinese Academy of Sciences (CAS)

Satellite Name	International Designator	Launch Date	Launch Vehicle	Launch Site	Mission
Chuangxin-1 01	2003-049B	October 21, 2003	Changzheng 4B	Taiyuan	SSO
Chuangxin-1 02	2008-056A	November 5, 2008	Changzheng 2D	Jiuquan	SSO
Chuangxin-1 03	2011-068A	November 20, 2011	Changzheng 2D	Jiuquan	SSO
Chuangxin-3	2013-037C	July 19, 2013	Changzheng 4C	Taiyuan	SSO
Chuangxin-1 04	2014-051A	September 4, 2014	Changzheng 2D	Jiuquan	
Chuangxin-16 A	2022-102A	August 23, 2022	Kuaizhou-1A	Xichang	LEO
Chuangxin-16 B	2022-102B				

10.2 Corporate Technology Test Satellite

In recent years, there has been increased activity in regional-level space utilization and satellite launches beyond state-owned enterprises, such as CASC and CASIC, leading to the formation of local space industry clusters. In addition to the satellites shown in Table 10-8, technically advanced companies such as Chang Guang Satellite Technology Co., Ltd. in Jilin Province, Zhuhai Companies in Shenzhen, Guangdong Province, and Tianyi Research Institute in Wuhan, Hunan Province have manufactured Earth observation satellites. Furthermore, satellite businesses have emerged, in which companies that are unable to develop satellites independently raise investment funds by granting the right to name a satellite during its launch or by selling satellite imagery. The outstanding satellites launched through these ventures have been mentioned earlier.

Table 10-8 Launch Status of Corporate Technology Test Satellites

Satellite Name	International Designation	Launch Date	Launch Vehicle	Launch Site	Operating Agency
Pulsar Navigation Test Satellite (XPNPV)	2016-066A	November 9, 2016	Changzheng 11	Jiuquan	Shenzhen Aerospace Dongfanghong HIT Satellite Ltd.
Pina 2-01	2016-066C				
Pina 2-02	2016-066D				
Lishui-1 (LS)	2016-066E				Zhejiang Lanya Technology Co., Ltd.
Kexing 1Q	2016-066G	November 9, 2016	Changzheng 11	Jiuquan	Guangdong Kechuang Aerospace Technology Co., Ltd.
Lingqiao Verification Satellite	2015-057A	October 7, 2015	Changzheng 2D	Jiuquan	Chang Guang Satellite Technology Co.,Ltd.

10.3 University Technology Test Satellite

China's aerospace engineering universities are overseen by several ministries and agencies, including the Ministry of Industry and Information Technology (MIIT), Central Military Commission, Chinese Academy of Sciences (CAS), and Ministry of Education (MOE), which have launched various technology test satellites (Table 10-9). Small satellites can be categorized by weight as minisatellites weighing 1,000 kg or less, microsattellites (cubes with 50 cm sides weighing 50 kg or less), and nanosatellites (cubes with 10 cm sides weighing less than 1 kg). Microsatellites and nanosatellites, in particular, can be constructed relatively easily, even by students, with examples of high school and even elementary school students successfully launching satellites.

Table 10-9 Launch Status of University Technology Test Satellites

Developing Institution	Satellite Name	International Designation	Launch Date	Launch Vehicle	Launch Site
Harbin Institute of Technology	Kuaizhou-1	2013-053A	September 25, 2013	Kuaizhou-1	Jiuquan
	Kuaizhou-2	2014-073A	November 21, 2014	Kuaizhou-1	Jiuquan
	Zidingxiang 2	2015-049M	September 19, 2015	Changzheng 6	Taiyuan
	Zidingxiang 1	1998-067ME	April 18, 2017	Atlas 5	CCAS
	Longjiang 3	2023-082A	June 9, 2023	Kuaizhou-1A	Jiuquan
	Gaofanshipin	2024-085*	May 7, 2024	Changzheng 6C	Taiyuan
	Kuanfuguangxue	2024-085*	May 7, 2024	Changzheng 6C	Taiyuan
Nanjing University of Aeronautics and Astronautics	Tianxun 1	2011-066B	November 9, 2011	Changzheng 4B	Taiyuan
	Tianwang-1 B	2015-051C	September 25, 2015	Changzheng 11	Jiuquan
	Tianwang-1 C	2015-051D	September 25, 2015	Changzheng 11	Jiuquan
Beijing University of Aeronautics and Astronautics	Student Small Satellite 1	2021-091G?	October 14, 2021	Changzheng 2D (2)	Taiyuan
Northwestern Polytechnical University	Aoxiangzhixing	2016-042B	June 25, 2016	Changzheng 7/YZ-1A	Wenchang
	Aoxiang-1	1998-067MQ	April 18, 2017	Atlas 5	CCAS
National University of Defense Technology	Shouji	2015-049N	September 19, 2015	Changzheng 6	Taiyuan
	Xingchen 1-4	2015-049S ~ V	September 19, 2015	Changzheng 6	Taiyuan
	NUDTSat (QB50 CN06)	2017-036Z	June 23, 2017	PSLV	SHAR
Tsinghua University	Qinghua 1	2000-033B	June 8, 2000	Cosmos-3M	Plesetsk
	Naxing 1	2004-012B	April 18, 2004	Changzheng 2C	Xichang
	Lingqiao	2014-051B	September 4, 2014	Changzheng 2D	Jiuquan
	Zijing 1	2015-049Q	September 19, 2015	Changzheng 6	Taiyuan
	Qinghua Kexue	2020-054B	August 6, 2020	Changzheng 2D (2)	Jiuquan
	Naxing-3 A-B	2024-110 *	June 6, 2024	Gushenxing 1 (3)	Jiuquan

Zhejiang University	Pixing	2007-019B	May 25, 2007	Changzheng 2C	Jiuquan
	Pixing-1 A-1	2010-047B	September 22, 2010	Changzheng 2D	Jiuquan
	Pixing-1 A-2	2010-047C	September 22, 2010	Changzheng 2D	Jiuquan
	Pixing-3 A	2020-039B	June 17, 2020	Changzheng 2D (2)	Jiuquan
	Zheda Pixing-2 A-B	2015-049B ~ C	September 19, 2015	Changzheng 6	Taiyuan
Wuhan University	Luojia-2 01	2023-069*	May 21, 2023	Changzheng 2C (3)	Jiuquan
	Luojia-1 01	2018-048B	June 2, 2018	Changzheng 2D (2)	Jiuquan
	Luojia-3 01	2023-007*	January 15, 2023	Changzheng 2D (2)	Taiyuan
	Qimingxing 1	2022-019*	February 27, 2022	Changzheng 8 (2)	Wenchang
	Luojia-4 01	2024-173 *	September 24, 2024	Jielong 3	Ocean
	Luojia-3 02	2024-095*	May 21, 2024	Kuaizhou-11	Jiuquan
Nanjing University of Aeronautics and Astronautics	Tianxun-1	2011-066B	November 9, 2011	Changzheng 4B	Taiyuan
ShanghaiTech University	Tianwang-1A-C	2015-051B-D	September 25, 2015	Changzheng 11	Jiuquan
Xidian University and Technology Consortium et al.	Silu-1 01	2017-021F	April 20, 2017	Changzheng 7	Wenchang
Beijing Normal University	Jingshi-1 (Binglu-1)	2019-059B	September 12, 2019	Changzheng 4B	Taiyuan
Space Engineering University	Taikong Shiyang 1	2021-050D?	June 11, 2021	Changzheng 2D (2)	Taiyuan
Nanjing University of Science and Technology	Nanjing Ligong 2	1998-067MB	April 18, 2017	Atlas 5	CCAS
	Tianyuan 1	2021-091J?	October 14, 2021	Changzheng 2D (2)	Taiyuan
	Zhou Enlai	2018-008B	January 19, 2018	Changzheng 11	Jiuquan
Shanghai Jiao Tong University	Student Small Satellite 2A	2021-091L?	October 14, 2021	Changzheng 2D (2)	Taiyuan

The Beijing Institute of Technology (BIT), which is under the jurisdiction of the Ministry of Industry and Information Technology (MIIT), has not yet launched a satellite. However, it successfully transported and retrieved a space experiment payload destined for the International Space Station (ISS) using SpaceX's Dragon spacecraft. The University of Science and Technology of China (USTC), administered by the Chinese Academy of Sciences (CAS), is leading the development of the quantum cryptography key communication satellite "Mozi," though CAS is handling the satellite launch itself. Zhejiang University, under the Ministry of Education (MOE), is developing "Pixing" and "Zheda Pixing." "Pi" stands for "pico" (10^{-12}). A satellite with a side length of about 1 cm could be called a "picosatellite"; however, the 10 cm "Zheda Pixing" is closer in size to a nanosatellite.

Universities worldwide actively engage in student satellite development as part of their science and engineering education programs. In Japan, for example, a satellite design contest for university students has been held annually since 1993. This initiative has evolved from an era when some universities only conducted desk-based designs and model building to a current phase in which students from numerous universities and technical colleges build, launch, and operate actual satellites.

11 International Cooperation

China is actively engaging in international space cooperation at both bilateral and multilateral levels. This effort is driven not only by universal goals such as “working together with the international community to provide global public goods and services and contribute to humanity’s response to common challenges” (White Paper on China’s Space Program) but also by its role in China’s foreign economic opening-up strategy, which aims to “strengthen space cooperation that contributes to the construction of the ‘Belt and Road’ Initiative, ensuring that the benefits of space development reach countries along the Belt and Road, particularly developing countries.” The “Belt and Road” Initiative is a broad regional economic cooperation framework proposed by the Chinese government in 2013. In the space sector, services such as satellite positioning, satellite communications, meteorology, and Earth observation have been offered to emerging and developing countries along the Belt and Road from an early stage.

In the Asia-Pacific region, China has advanced both bilateral cooperation with Belt and Road countries and multilateral space collaboration. The Asia-Pacific Space Cooperation Organization (APSCO), established in 2008 under Chinese leadership, has consistently carried out activities such as joint satellite observation and capacity-building programs for participating countries. China also emphasizes space cooperation through frameworks such as BRICS, the Shanghai Cooperation Organization (SCO), and the G20. As the Global South gains prominence, China seeks to strengthen partnerships with these countries through the development and use of space. China has taken steps to offer joint experiments on the Chinese Space Station (CSS) and to encourage participation from developing and emerging countries in the future International Lunar Research Station (ILRS). These efforts reflect China’s long-standing commitment to South-South cooperation, aimed at promoting mutual assistance among developing nations.

China also prioritizes cooperation with the United Nations. While collaborating with the United Nations Office for Outer Space Affairs (UNOOSA) on the long-term sustainability of space activities and the development and use of space resources, China is also working to strengthen relationships across multiple areas. This includes cooperation on the use of the CSS—with experimental projects solicited from UN Member States in 2019 and conducted in 2023 after the CSS became operational—as well as agreements to establish a “Space Information Corridor,” which provides space-based information such as communications, positioning, and Earth observation satellite data to countries along the Belt and Road.

The specific status of China’s international cooperation efforts is described below.

11.1 Space-Related International Organizations

China is a member of the following space-related international organizations:

- **The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER):** UN-SPIDER provides Earth observation images to countries affected by natural disasters. At China’s invitation, a Beijing office was established.
- **International Charter on Space and Major Disasters:** Member countries include the United States, European countries, Russia, Japan, China, India, Canada, Brazil, Argentina, Algeria, the Republic of

Korea, and Nigeria. When the Charter is activated in response to a major disaster, member countries provide images of the affected areas. The China National Space Administration (CNSA) serves as a weekly duty operator on a rotating basis.

- **Inter-Agency Debris Coordination Committee (IADC):** The CNSA officially joined the Committee in June 1995 as China's representative.
- **International Committee on Global Navigation Satellite Systems (ICG):** An informal forum of countries operating global navigation satellite systems, including China (BeiDou), the United States (GPS), Russia (GLONASS), and Europe (Galileo).
- **Consultative Committee for Space Data Systems (CCSDS):** This committee examines international standardization for space data communication systems.
- **Coordination Group for Meteorological Satellites (CGMS):** China participates through the China Meteorological Administration and the CNSA. Japan is represented by the Japan Meteorological Agency and JAXA, and the World Meteorological Organization (WMO) also participates, facilitating consultation between meteorological agencies and organizations developing meteorological satellites.
- **World Space Week Association:** World Space Week is held annually from October 4 to October 10 to commemorate the launch of the world's first artificial satellite, Sputnik 1, by the former Soviet Union on October 4, 1957.
- **Group on Earth Observations (GEO):** As of March 2025, 116 countries and 154 organizations participate.
- **International Telecommunication Union (ITU):** In the space sector, the ITU manages satellite frequencies, coordinating transmission frequencies and radio-wave directions for geostationary satellites.
- **Committee on Space Research (COSPAR):** China joined COSPAR on March 1, 1993, and established CN-COSPAR. The CN-COSPAR office is located at the National Space Science Center (NSSC) of the Chinese Academy of Sciences (CAS).
- **United Nations Committee on the Peaceful Uses of Outer Space (COPUOS):** COPUOS is composed of 102 countries, including China, Japan, the United States, and Russia.
- **International Astronautical Federation (IAF):** The IAF organizes the International Astronautical Congress (IAC), an annual international conference.

11.2 Bilateral Cooperation

Bilateral cooperation has been established with most major countries, excluding the United States, through cooperation agreements and other arrangements. Between 2016 and 2020, China signed 46 space cooperation agreements or memorandums of understanding (MOUs) with 19 countries and regions, as well as four international organizations. These efforts have promoted international collaboration in space science, technology, and applications, actively advancing the utilization of outer space. However, no new cooperation agreements have been announced since 2020. Currently, bilateral cooperation agreements exist with space agencies in approximately 130 countries. For example, in space science, China has collaborated with Japan on research using data from the solar observation satellite Hinode (launched in 2006).

The cooperation agreements also cover satellite development. Projects include the China–Brazil Earth Resources Satellite (CBERS) jointly developed with Brazil, the French ocean observation satellite (Sino–French Ocean Satellite), and the astronomical observation satellite (Sino–French Astronomical Satellite). Recent developments include the signing of a Space Cooperation Outline between China and Russia for 2018–2022 in November 2017, a Memorandum of Understanding⁸³ on Space Cooperation between the CNSA and Luxembourg's Minister of Economy and Deputy Prime Minister in January 2018, and the fifth Space Subcommittee meeting held in November 2018 under bilateral cooperation between China and Ukraine.

Bilateral cooperation with countries along China's Belt and Road Initiative, as well as with other Global South countries participating in the initiative, is also being actively promoted.

11.3 Multilateral Cooperation

As representative examples of China's multilateral cooperation in the space sector, this section focuses on APSCO⁸⁴ led by China and the BRICS.

APSCO is an intergovernmental organization comprising countries in the Asia-Pacific region and surrounding areas. It aims to promote multifaceted cooperation among member states in space science, technology, and applications, enhance each member's space capabilities, and support sustainable development. As of 2024, 11 countries—Bangladesh, China, Egypt, Indonesia, Iran, Mexico, Mongolia, Pakistan, Peru, Thailand, and Turkey—are official members. Additionally, two countries outside the Asia-Pacific region, Ukraine and Brazil, participate as associate members, with their experts contributing to APSCO initiatives.

The establishment of APSCO was proposed by China, Pakistan, and Thailand and approved by 16 countries at the Asia-Pacific Multilateral Conference on Space Technology Applications (AP-MCSTA), held in Beijing in November 1992 during the International Space Year. Since then, the Director of the Department of International Cooperation of CNSA (equivalent to the Director of International Affairs Division) has played a central role in promoting APSCO's formation.

The "Convention of the Asia-Pacific Space Cooperation Organization," which serves as APSCO's legal foundation, was signed in October 2005 and formally came into force in December 2008 following domestic ratifications by the participating countries. APSCO's operational mechanisms and project implementation approaches are modeled after those of the European Space Agency (ESA), and it refers to itself as the "Asian version of the ESA."

In July 2009, APSCO and the Chinese government signed the "Host Country Agreement," establishing arrangements for secretariat staff, office facilities, and funding, which were completed by the end of 2009. The APSCO headquarters, located in southwest Beijing within the Fourth Ring Road, was completed in December 2009. As the world's second-largest economy by GDP, China is a space power comparable to

⁸³ "China National Space Administration and Luxembourg Ministry of the Economy Sign Memorandum of Understanding on Cooperation," Chinese Government Website, January 17, 2018. https://www.gov.cn/xinwen/2018-01/17/content_5257590.htm.

⁸⁴ Asia-Pacific Space Cooperation Organization. <http://www.apsco.int/>.

the United States and Russia, with a rapidly developing space industry. Because other member states have not yet developed mature space technologies, China plays a leading role in coordinating APSCO activities. Chinese government agencies, including the CAS, the National Disaster Reduction Center, the China Meteorological Administration, and the China Earthquake Administration, have expressed strong support for APSCO cooperation. Key APSCO positions, such as Executive Director and Deputy Executive Director, are filled on a rotating basis among member states. Each member contributes to APSCO's annual budget and sends staff, while Chinese personnel handle daily operations in each department.

APSCO also engages with the United Nations in line with its founding convention. It participates as an observer in COPUOS and maintains cooperative relations with the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), located in Thailand, coordinating activities among Asian and Pacific countries in areas such as Earth observation. APSCO also participates in meetings and activities at the Beijing Office of the UN-SPIDER.

BRICS was launched in 2009 as "BRIC" by Brazil, Russia, India, and China and became "BRICS" with South Africa's participation in 2011. By January 2024, five additional countries—Iran, Egypt, the United Arab Emirates, Ethiopia, and Indonesia—had joined, bringing the total number of participating countries to ten. In the space sector, the BRICS Joint Committee on Space Cooperation was established. In August 2021, BRICS space agencies signed a cooperation agreement to share remote sensing satellite data, with data sharing beginning in May 2022. In July 2023, Russia called on BRICS countries to cooperate in constructing a space station.

China has also advanced bilateral space cooperation within BRICS with Russia, India, Brazil, and South Africa. For example, in April 2016, the Director of the CNSA met with the Director of the Indian Space Research Organization (ISRO). In response to China's invitation to participate in the ILRS, which is planned with Russia for the 2030s, South Africa has expressed its intention to join alongside APSCO. BRICS participants in the ILRS currently include Russia, China, South Africa, Indonesia, Egypt, and the UAE—six countries in total. The ILRS is often seen as a competitor to the United States-led Artemis Program.

China is also advancing the construction of a Space Information Corridor, which provides comprehensive space-based information—communications, positioning, and Earth observation—to countries along the Belt and Road, in cooperation with the UNOOSA (June 2018). Additionally, the "Qianfan Constellation" satellite internet project, often referred to as China's version of Starlink, is underway. This space-based digital infrastructure is expected to strengthen the information and communication systems of countries along the Belt and Road, as well as BRICS and other Global South nations, enhancing China's presence and influence.

12 Conclusion

During the 13th Five-Year Plan (2016–2020) and the 14th Five-Year Plan (2021–2025), China's space development significantly enhanced its technological capabilities, bringing them to a world-leading level. The following sections outline the major trends by sector from 2025 onward, concluding with a final summary.

The year 2025 marks the final year of the National Medium- and Long-Term Development Plan for Civil Space Infrastructure. In the fields of Earth observation satellites and satellite communications, next-generation improvement plans are expected to take shape based on a comprehensive ten-year review. In satellite communications, as competition for satellite Internet market share intensifies, the immediate challenge is to establish a distinctive Chinese broadband communication network by combining geostationary and polar-orbiting satellites to meet user needs, particularly in terms of maximizing communication capacity and speed. In navigation and positioning, an upgrade plan extending through 2035 has already been announced, and a large research institute at the China Aerospace Science and Technology Corporation (CASC) is expected to further advance the navigation and positioning system by leveraging its workforce of 5,200 personnel.

Regarding the first foreign astronaut to board the Chinese space station, it was announced in February 2025 that Pakistan would be the target country. In the next phase, the frequency of foreign astronauts boarding the station is expected to increase, and each crewed launch will attract considerable attention. As a historical precedent, the former Soviet Union allowed astronauts from communist bloc countries and certain friendly Western nations, including Japan, to stay aboard the Salyut and Mir space stations during eight-day crew rotation periods. China and Pakistan have agreed to conduct similar missions on a commercial basis under a cooperation agreement. The selection of Pakistani astronaut candidates alone is expected to take approximately one year.

In lunar exploration, China has already landed on the far side of the Moon and successfully returned samples. In the emerging era of competition for lunar resources, China could potentially dominate lunar resource exploration if the United States and Russia fail to keep pace. Moreover, the successful deployment of the Long March 9 and Long March 10 launch vehicles will be critical to establishing a permanent lunar surface base. In the field of space science, attention is focused on how missions such as astronomical observations will develop toward 2050.

Across all sectors, as the number of satellite launches continues to increase, establishing stable operations for reusable rockets will be essential. The Long March 8R, currently under development, is planned to insert satellites into orbit without separating auxiliary boosters, with both the boosters and the main rocket body returning to the ground. If approximately 25 reuses per rocket can be achieved, the technology would be considered comparable to that of SpaceX.

For China to continue developing its space program smoothly and achieve its goal of becoming a "space power," stable government investment must be maintained even amid a sluggish national economy. At the same time, commercial space activities by the private sector should be encouraged to further expand the space industry. In parallel, resource-conserving, energy-efficient, and effective approaches will be required

to ensure sustainable space activities. Cultivating next-generation talent will also become an increasingly important challenge. By addressing these issues, steadily implementing its plans, and strategically expanding the utilization of space infrastructure led and developed by China, the country is expected to continue increasing its global influence.

Appendix: China's Space Development Research Institutions

China's space development was initially centered on the Ministry of Aerospace Industry, a central government ministry. In June 1993, CASC was established as a state-owned enterprise, with its assets placed under the supervision of the State Council and rocket and satellite development and manufacturing designated as its primary business. CASC owns nine large academies and more than 130 subordinate units, including research institutes, factories, companies, and organizations. Notable subsidiaries include China Great Wall Industry Corporation, engaged in rocket manufacturing and launch services, and China Satellite Communications Co., Ltd. (China Satcom), which operates satellite communications and broadcasting services in China. China Aerospace Machinery and Electronics Corporation (CAMEC) was also transferred from the Ministry of Aerospace Industry as a state-owned enterprise and is engaged in the development and manufacture of missile weapon systems, cruise missile systems, solid-fuel rockets, and space-related equipment. Organizations and facilities responsible for rocket launch control and satellite tracking and control fall under the jurisdiction of the Equipment Development Department (EDD) of the Central Military Commission (CMC). There are four rocket launch sites located in Jiuquan, Xichang, Taiyuan, and Wenchang, and sea-based launches are also conducted from the Yellow Sea.

1 Ministry of Industry and Information Technology

The Ministry of Industry and Information Technology (MIIT) is a cabinet-level department responsible for space affairs within the State Council, China's highest national administrative body. It oversees the State Administration of Science, Technology, and Industry for National Defense (SASTIND) and the China National Space Administration (CNSA). A Vice Minister concurrently serves as Director of SASTIND, Director of the CNSA, and Director of the China Atomic Energy Authority (CAEA).

SASTIND is responsible for industries related to space, aviation, shipbuilding, and weaponry, and leads the construction of the China High-Resolution Earth Observation System, one of the government's priority programs, together with EDD. The CNSA oversees China's overall space activities and represents the Chinese government in disseminating information abroad and concluding cooperation agreements with foreign countries. It has approximately 100 staff members, and its office is located in the Haidian District of Beijing.

2 China Aerospace Science and Technology Corporation

The CASC is one of the two major corporate groups that serve as key drivers of China's space industry, alongside CASIC. As of December 2017, it had a total workforce of approximately 170,000 people, and its

core business focused on the development of launch vehicles and satellites. After undergoing several name changes, including China Aerospace Corporation, it adopted its current name in December 2017.

Under CASC, there are nine large academies (scientific research and production complexes), nine specialized corporations, 15 listed companies, and numerous small and medium-sized enterprises and directly subordinated units.

2.1 Large Academies

- **China Academy of Launch Vehicle Technology (CALT):** CALT has developed the “Long March 2-8” and “Long March 11” launch vehicles. It is currently developing the “Long March 9” and “Long March 10” launch vehicles for crewed lunar exploration missions. Numerous local research institutes and manufacturing enterprises are organized into various groups under CALT.
- **Shanghai Academy of Spaceflight Technology (SAST):** SAST manufactures the “Long March 4” and “Long March 6” launch vehicles and meteorological satellites.
- **China Academy of Space Technology (CAST):** CAST has extensive experience in manufacturing various types of satellites, including communication satellites, Earth observation satellites, navigation and positioning satellites, lunar exploration probes, and technology demonstration satellites. It oversees companies related to satellite manufacturing, such as China Spacesat Co., Ltd.
- In addition, there are other academies as follows:
 - **Academy of Aerospace Solid Propulsion Technology (AASPT)**
 - **Academy of Aerospace Liquid Propulsion Technology (AALPT)**
 - **Sichuan Aerospace Industry Corporation (SCAIC)**
 - **China Academy of Aerospace Electronics Technology (CAAET)**
 - **China Academy of Aerospace Navigation Technology** (official abbreviation unknown; appears not to have been determined)
 - **China Academy of Aerospace Aerodynamics (CAAA)**

2.2 Specialized Corporations

- **China Satellite Communications Co., Ltd. (China Satcom):** Established in December 2001, China Satcom took over the operation of the Zhongxing series, a practical communications satellite series. Subsequently, its basic telecommunications division was absorbed by China Telecom, while the remaining satellite communications division became a subsidiary of CASC and adopted its current name. It has 17 subsidiaries, each responsible for specific business areas, including fixed satellite communications, mobile satellite communications, television broadcasting, GPS applications, and research institutes. China Satcom absorbed the Hong Kong-based APT Satellite Holdings Limited and operates a total of 18 satellites, consisting of 12 Zhongxing satellites and six APStar satellites. As the launch of the APStar-6E satellite took place during the integration process, on-orbit handover from the satellite manufacturer, China Great Wall Industry Corporation, was conducted with a Hong Kong-based entity.
- **China Great Wall Industry Corporation:** A leading space development company responsible for

the manufacture and launch of the Long March 2-5 and Long March 7 launch vehicles, as well as the manufacture of the Dongfanghong-4 satellite bus.

- **China Lucky Group Corporation:** A manufacturing company engaged in the production of chemical products and medical electronic equipment.
- **China Siwei Surveying and Mapping Technology Co., Ltd.:** The company operates the SuperView Neo satellite constellation.
- **Others:** Beijing Shenzhou Aerospace Software Technology Co., Ltd., Shenzhen Academy of Aerospace Science and Innovation, and three financial services companies.

2.3 Listed Companies

- **15 listed companies (abbreviated names):** China Spacesat, HT-SAAE, Aerospace Power, Aerospace Electronics, China Aerospace Wanyuan, CASC, APT Satellite, Aerospace CH UAV, Lucky Film, Aerospace Engineering, Aerospace Hi-Tech, Aerospace Intelligent Manufacturing Technology, China Satcom, Shaanxi Zhongtian Rocket, and Shenzhou Aerospace Software.
- **Others:** China Center for Resources Satellite Data and Application (CRESDA) and Shenzhen Aerospace Science and Technology Innovation Research Institute.

2.4 Directly Subordinated Units

These include the China Academy of Aerospace Standardization and Product Assurance, China Astronautics Publishing House, Aerospace Communication Center, Chinese Society of Astronautics, and Aerospace Talent Development & Exchange Center.

3 China Aerospace Science and Industry Corporation

The China Aerospace Science and Industry Corporation (CASIC) is one of the two major corporate groups that serve as key drivers of China's space industry, alongside CASC, with a particularly high concentration of missile-related sectors. As of December 2017, its total workforce was approximately 150,000 people. The company's core business centers on missile development and the development and manufacture of aerospace equipment, while also encompassing other sectors such as information technology, finance, and construction. Following the division of the China Aerospace Corporation into two separate entities in July 1999, it transitioned through CAMEC before adopting the name China Aerospace Science and Industry Corporation. In December 2017, the entity was renamed China Aerospace Science and Industry Corporation Limited.

CASIC owns directly subordinated units, including 24 research institutes (scientific research and development bases), operating enterprises, eight listed companies, and several unlisted companies.

3.1 Academies and Companies

- **CASIC Academy of Defense Technology:** Responsible for the overall design of spacecraft projects.
- **CASIC Academy of HiWING Technology:** Primary business areas include power systems, automation equipment, radar systems, and computer applications.
- **CASIC Academy of Launch Vehicle Technology:** Focuses on the development and manufacturing of solid-propellant rockets and satellites.
- **CASIC Academy of Dynamic Machinery Technology:** Engaged in the development and manufacture of solid rocket motors.
- **CASIC Academy of Information Technology:** Focuses on research and product development for satellites, satellite applications, information technology, and telemetry, tracking, and control technologies.

In addition to the academies listed above, the following companies are also involved:

China Space Sanjiang Group Co., Ltd., Jiangnan Group Co., Ltd., Institute of Intelligence Science and Technology, China Aerospace Systems Engineering Co., Ltd., China Aerospace Construction Group Co., Ltd., Hunan Aerospace Co., Ltd., China Huateng Industry Co., Ltd., Shenzhen Aerospace Industry Technology Research Institute, China Aerospace Automobile Co., Ltd., Aerospace Communications Holdings Co., Ltd., Aerosun Corporation, CASICloud-Tech Co., Ltd., CASIC Digital Technology Co., Ltd., Henan Aerospace Industry Co., Ltd., Aerospace Precision Products Co., Ltd., CASIC Finance Co., Ltd., CASIC Assets Management Co., Ltd., CASIC Technology Support Center, and CASIC Laboratory.

3.2 Listed Companies

- **Eight listed companies:** Aisino Corporation, Aerosun Corporation, Aerospace Industry Development Co., Ltd., Beijing Aerospace Changfeng Co., Ltd., Aerospace Hi-Tech Holding Group Co., Ltd., Guizhou Space Appliance Co., Ltd., Wuhan Raycus Fiber Laser Technologies Co., Ltd., and Aerospace Nanhu Electronic Information Technology Co., Ltd.

3.3 Other Companies

- CASIC 061 Base, Yunnan Aerospace Industry Co., Ltd., China Aerospace Materials Center, Nanjing Electronic Equipment Research Institute, Beijing Aerospace Measurement & Control Technology Co., Ltd., Huadi Computer Group Co., Ltd., CASIC Magnetolectric Co., Ltd., and the Institutional Service Center.

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China's space development activities for becoming a "Space Science Superpower"

Published in March 2026

ISBN 978-4-86829-048-3

This report is a translated version of the original Japanese report, *"Uchu kagaku kyokoku" wo mezasu chugoku no uchu kaihatsu* – China's space development activities for becoming a "Space Science Superpower", published in March 2025 by the Japan Science and Technology Agency (JST) Asia and Pacific Research Center (APRC). (APRC-FY2024-RR-08)

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