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BRIEF

The Long March Into Space

While private actors drive the space industry in the West, China's state-led approach continues to bear fruit.

The *Tianhe* ("Heavenly Harmony") core module of China's planned permanently occupied space station. Screenshot from China News Network.

Human activity in space is undergoing a transformation. For most of the 20th century, this frontier was dominated by state-backed space programs with specific and limited scientific, military, or prestige-building goals. Now, private citizens are reaching orbit under their own power. Much ink has been spilled over new private space companies in the West, especially SpaceX and Blue Origin. Projections suggest increasingly reusable super heavy-lift launch vehicles could reduce cost-to-orbit by several orders of magnitude.[1] Though the stories of the American and Russian national space programs from the Space Race to the modern day are still recognized as important, the industry is no longer driven by governments, but rather by private actors. The reverse is true, however, of perhaps the most important rising power in the space industry: China.

Since the 1990s, the Chinese government has consistently directed resources into developing a national space industry. Organized by a series of interlocking civilian and military bureaucracies, China's space industry has achieved enough technical and economic milestones to now compete with the West. China has sent men to orbit, returned samples from the Moon using a rendezvous maneuver akin to the Apollo Program, and landed a rover on Mars. Chinese state-run rocket and satellite manufacturers have brought down costs, through economies of scale and rigorous quality control, to well below that achievable by traditional American and European aerospace companies, competing instead with SpaceX and Russia. The China Great Wall Industry Corporation, providing medium-lift satellite

launch as a service, is priced at around $70 million per launch. This compares to the SpaceX Falcon 9 at around $62 million and the old Russian Protons at around $65 million (being phased out in favor of the more reliable Angara, currently $100 million but planned to dip to under $60 million by 2024). French Arianespace and American United Launch Alliance have prices often over double the cheaper providers, and the ambitious plans of Arianespace to maintain competitiveness would still only bring them down to $100-110 million.[2]

The bureaucracies of the Chinese space industry have proven capable of high levels of technical competence, rapid build-up of launch and manufacturing infrastructure, and emulation of well-conceived foreign technology. After an initial period of restriction, China's government has also allowed for the development of an increasing number of well-funded private space companies in China, with goals ranging from creating new types of rockets to building communication satellite constellations.

While the bedrock of the modern Chinese space industry comes from dedicated efforts to replicate the earlier achievements of foreign powers, the goal of China's "long march" into space is not merely to replicate earlier achievements, but to surpass them. Missteps have been avoided and resources spent with care: the Chinese did not pursue a space shuttle program, like the Americans and Russians both did before abandoning them over cost and safety concerns. China's ambitions remain lofty. Active development is underway for a super-heavy carrier rocket—capable of lifting over 50 tons to low earth orbit—and reusable rockets, and manned space missions grow more and more complex.

The Central Planners

Much of the work China does in space is managed through the bureaucracy of the central government in Beijing. At first glance, the center of the Chinese space program looks to be the China National Space Administration (CNSA). Their stamp is on the big flashy missions, when those get reported in the Western press at all. The name deliberately evokes NASA. Even their logo is telling: a blue arrowhead facing skyward, more reminiscent of *Star Trek*'s Starfleet insignia than the patriotic red and yellow of most Chinese government agencies.

However, CNSA is not quite the Chinese analog to NASA. The core planning, launch infrastructure, rocket and satellite design, and manufacturing is done elsewhere. The role of CNSA is primarily to provide legitimacy for the Chinese space program as a civilian effort and facilitate collaboration with foreign countries.[3] For example, China's Chang'e-4 mission—the first ever soft-landing rover reporting back data from the far side of the Moon—carried scientific payloads developed in the Netherlands, Sweden, Germany, and Saudi Arabia. Having the best instrumentation makes the scientific

achievements of such a mission a bit more substantial, but the real point is to build prestige and goodwill. China was isolated and barred from such collaborations for decades, and after the first Chinese launch of a US-made satellite in 1990, the quick re-imposition of restrictions on US-China space collaborations made clear that suspicion would continue to be the norm. International projects are seen as proof that China is recognized and respected.

Another branch of China's effort to publicize its space program as peaceful are the Space Activities white papers published by the State Council Information Office, also known as the Central Office of Foreign Propaganda (although Chinese Communist Party officials became increasingly sensitive to the connotations of such a translation starting in the 1990s). Released in 2000, 2006, 2011, and 2016, the white papers document recent achievements and future plans with a very positive slant. The inner workings of the Foreign Propaganda office are a closely guarded secret, but the agency is known to have grown in recent years as the demands of controlling information have grown more strenuous.

Much of the more important civilian decision-making occurs at the level of the State Administration of Science, Technology and Industry for National Defense (SASTIND), to which CNSA is subordinate.[4] At this level, a military focus in the Chinese space industry becomes more clear. SASTIND, via the Ministry of Industry and Information Technology (MIIT), reports to the State Council—the highest civilian authority—but its explicit mission is to supply the People's Liberation Army (PLA). Advances in manufacturing that will enhance prosperity are secondary to providing advanced military equipment.[5] It is to those ends that the agency directs funding for space projects and determines high-level policy. SASTIND was created in 2008 as a reformed version of an older bureaucracy.

The military bent of the Chinese space industry goes deeper than SASTIND. Important parts of the space industry and its infrastructure are run directly by the Central Military Commission, an entity co-equal with the State Council. CNSA does not handle the manned space program; that is instead the purview of the China Manned Space Agency (CMSA)—part of the Equipment Development Department of the Central Military Commission. Under the PLA—which itself ultimately answers to the Central Military Commission—there is also the Strategic Support Force, focusing on space, cyber, and electronic warfare. The Strategic Support Force Space Systems Department builds and maintains the four primary launch sites in China, including the decades-old Jiuquan launch site in Inner Mongolia and the new Wenchang launch site built on Hainan Island in the South China Sea.

The government bodies managing the space industry at first appear scattered and bifurcated between parallel and potentially rivalrous civilian and military command structures. Mechanisms are in place,

however, to align policy across the different parts of the sprawling bureaucracy. One key mechanism is the "leading small group," a type of informal but powerful body created directly by the Central Committee of the Chinese Communist Party to coordinate and implement policy decisions. There are many varieties in the structure, purpose, and lifespan of such groups, but they tend to lack bureaucratic documentation, stem ultimately from the Party and thus transcend civilian or military hierarchies, meet infrequently, and play a decisive role in their area of focus.[6]

A Space Leading Group, made up of senior officials within the military, civilian, and party space agencies and driving forward the industry as a whole, is attested to in multiple sources, and seems to have existed at one point.[7] It is less clear whether a Space Leading Group still exists today as a single entity, or whether there are multiple groups associated with the different projects and priorities of the growing industrial aims of the state. The fact remains, however, that a true accounting of the power within the Chinese bureaucracy is woefully incomplete without accounting for small leading groups, even as they are even more elusive in their structure and function than mainline agencies.

There are also more transparent ways in which the official structure is not the whole picture. The particular configuration of the bureaucracy at a given moment is often new, while those who work in it have done so for decades. In the Plenary Sessions of the Central Committee, agencies are often strategically created, divided, and transmuted.

Production Lines for Rockets and Scientists

The technical design and manufacturing for rockets and satellites is handled by the many subsidiaries of two gargantuan state-owned enterprises that sit at the heart of the Chinese defense industry: the China Aerospace Science and Technology Corporation (CASC) and the China Aerospace Science and Industry Corporation (CASIC). Both CASC and CASIC also build ground equipment and, importantly, missiles. Together their revenues exceed 70 billion US dollars and they directly employ over 300,000 people, comparable to the combined workforces of Lockheed Martin, Boeing, and Northrop Grumman.

CASC and CASIC share predecessors—the China Aerospace Corporation (1993-1999), and before that the Ministry of Space (and later Aerospace) Industry (1982-1993).[8] As with all state-owned enterprises in China, CASC and CASIC are owned by the State-owned Assets Supervision and Administration Commission of the State Council, but in recent decades the central government has taken a relatively hands-off approach to management.

CASC is the main contractor for China's space program and builds the primary launchers used for major missions, spacecraft, and satellites. In Q1-Q3 of 2021, CASC launched over 130,000 kg of payload into orbit across 33 successful launches, second only to SpaceX's 271,000 kg. Excluding SpaceX, CASC delivered about as much mass to orbit as all other launch providers in the world put together.[9] Technical complexity and locked-in design decisions from the 1990s mean the cost advantage of reusable rockets is several years away at best, but CASC has instead driven down costs and increased reliability through scale of production. By 2019 the cost per launch for the Long March 3B medium-lift rocket was reduced from $70 million to $50 million per launch. Each launch can carry 5,500 kg to geostationary orbit—and more for lower orbits.[10]

CASC provides launch services, as well as more full-service satellite design and support, to foreign countries through their China Great Wall Industry Corporation (CGWIC) subsidiary, established in 1980. CGWIC launches are competitive both on price and reliability. In the medium-lift category, only the SpaceX Falcon 9 and the Russian Proton-M are cheaper per kilogram, and the Proton-M has lost popularity after multiple failed launches in recent years, though the new Russian Angara launchers may also be competitive with the Long March series.

CASIC plays a secondary but important role: it builds a series of light launchers as well as a range of satellites. The two are headquartered in Beijing but have factories and R&D centers across the country. In recent years there has been a large build-up of manufacturing in the port city of Tianjin, near Beijing, from which large launchers and payloads can be shipped by sea to the Wenchang launch site 1800 miles down the coast.

Research and development is spearheaded by research institutes or academies operating as subsidiaries of the large state-owned enterprises and affiliated with the China Academy of Science. The most important of these are the China Academy of Launcher Technology, the China Academy of Space Technology, and the Shanghai Academy for Spaceflight Technology. The China Academy of Science has also been intimately involved in the long-term planning of space projects and the direction of the larger industry. The China Academy of Engineering, a younger institution, also plays a role in many programs.

Key universities include the National University of Defense Technology, directly administered by the Central Military Commission, along with seven main civilian universities. These institutions are the biggest pipeline for future technical leaders in the space industry, where much of the senior leadership remains highly technically literate. The current director of CNSA, for example, is a physicist by training who spent most of his career at the Chinese Academy of Engineering Physics.

Capitalism with Chinese Characteristics

The Chinese space industry is no longer made up entirely of state institutions. Private industry was once entirely banned from acting in an area so critical to national security and where secrets are so closely guarded. Beginning, however, in 2002, private companies were allowed to do limited work in the industry. The 2014 "Guiding Opinion of the State Council on Innovating the Investment and Financing Mechanisms in Key Areas and Encouraging Social Investment" laid out the space industry as one of the strategic sectors requiring more and better private financing. Finally, China's fourth Space Activities white paper in 2016 called for an increase in cooperation between the government and private investors.[11]

As of 2018, the Institute for Defense Analyses (IDA) identified 50-60 fully private space companies, as well as 20-30 university spin-offs and state-owned enterprise subsidiaries with substantial shares held by private interests.[12] More recent estimates show continued growth, with over 100 fully private companies, most commonly focused on satellite component manufacturing, launch vehicle manufacturing, and data analytics.

Some founders in the Chinese commercial space sector harbor aspirations of emulating the scope of private American space companies. In interviews, Zhang Changwu—the founder of one of the most well-known private launcher companies in China—talks explicitly about the Chinese commercial space industry matching the achievements of SpaceX in a few years. His company, LandSpace, is funded by Chinese venture capitalists that Zhang likely knew through his previous career in finance. LandSpace was co-founded by two senior engineers from the state-owned enterprise-academy-state agency complex, and focuses on all-new liquid fuel rockets. With quick pivots, ambitions beyond the prescriptions of the state, and eyes on ultimately competing with major players in the global space industry, Zhang is emblematic of a new generation in the Chinese space industry.[13]

One area in which the state is likely to allow increased private activity moving forward is in satellite constellations. Many Chinese private companies are working on plans to provide satellite broadband, 5G, and various other data and location services. Satellite and launch companies can raise money from Chinese venture capital firms, angel investors, local governments, universities, banks, stock markets, and corporate strategic investments: as of 2018, estimates of total funding raised since the floodgates opened in 2014 range from 600-900 million US dollars. The central government also steps up to fund what are seen as strategic industries. In 2017, for example, the China Internet Investment Fund was created by the Central Cyberspace Affairs Commission and the Ministry of Finance, with a target of investing $14.5 billion in coming years. Chinese policymakers want to have an alternative to SpaceX's

Starlink, and startups such as Beijing Commsat have received massive funding to pursue satellite Internet in collaboration with the state-owned giants.[14]

The wider ambitions of some Chinese startups are unlikely to succeed, however. Private actors are supposed to play a supporting role to the state-owned enterprises and the civilian and military authorities, not supplant their core prerogatives. The state-owned enterprises have more than 100 billion USD in assets and dominate the leading edge of almost all space technologies. A private company currently has no realistic path to disrupting the major institutions that central government policy is tailored to support.

Larger Forces at Work

Local governments in China have a great deal of power to allocate resources, as well as the power to influence central government decision-makers. Local jobs, infrastructure, and technological development make it desirable to bring state-owned enterprise factories or R&D facilities to one's region, and there can sometimes be room for personal profit as well. Some regions are much more powerful than others, namely the coastal provinces and major metropolitan centers such as Beijing, Shanghai, Guangzhou, Chengdu, Xi'an, Changsha, and Wuhan. Private companies, state-owned enterprises, and civilian and military central government bodies are all swayed by local governments and the resources and political favors they offer.

The space industry also benefits from the broader industrial development policies undertaken over recent decades. China is currently the world's premier manufacturing power and, as a result, infrastructure and workers with the right types of skills are widely available. Expanding manufacturing capacity, even for vehicles and instruments as extraordinarily complex and precise as those needed for space, is faster and cheaper when material production is so central to society. Chinese industrialization has explicitly focused on building this sort of capacity.[15]

The space industry is a cornerstone of some of the ambitious domestic and geopolitical plans of Xi Jinping's government. Xi sits at the top of the twin bureaucracies that run the space program, and leads the Central Committee that can create "leading groups" to push specific policy goals across bureaucracies. Providing communications satellites and even launch vehicles has been an important part of the multi-continental Belt and Road Initiative (BRI).[16] Meanwhile, Made in China 2025 is an ambitious plan to make even the most advanced technologies domestically. The Chinese space industry is already remarkably self-sufficient, in part due to decades of isolation from peer powers, but there are further advances in domestic technology underway, from advanced computer chips to sensing instruments to capital equipment.

The Chinese space industry is both politically important as a means to regional development within the country and as a means to the broader goals of the state. This means it is almost certain that strong support from the state will continue; in fact it is likely to increase. This is especially true if development in the West makes it clear that there is a large commercial market of which a share could be claimed.

Operating the Machine: the Manned Space Program

The effectiveness of the array of institutions involved in coordinating China's space industry can be more clearly understood by seeing them in action. In 1992, the Politburo of the Chinese Communist Party approved Project 921: the China Manned Space Program. There were to be three phases: a crewed mission to space, a temporary space station, and ultimately a permanent space station. This roadmap is still live today, almost 30 years later: in April 2021, the core module of the Tiangong permanent low-orbit space station—still under construction—was successfully launched into orbit.

The Human Spaceflight Project Office was created in 1992 under the General Armaments Department to coordinate officials of the Chinese Academy of Sciences, CNSA, the China Aerospace Corporation, and the China Electronics Technology Group Corporation (CETC). Beneath this, eight technical committees took on each of the eight key systems needed for Project 921. Each committee had both an administrative manager—a high ranking official—and senior technical leaders. The China Manned Space Agency was created to strengthen the management of the program.[17]

The program proceeded at a slow but steady pace. Each mission built on the last, further advancing technical capabilities and adding new achievements to bolster China's credibility as a space power. First Shenzhou 1-4, between 1999 and 2002, succeeded in a variety of unmanned test flights, then Shenzhou 5-7, between 2003 and 2008, succeeded in increasingly complex manned flights. Tiangong 1 in 2011 launched a prototype space station, followed by Shenzhou 8-10 in 2011 to 2013 performing first an unmanned test docking, then crewed visits. Tiangong 2, a second prototype space station, was successfully launched in 2016 and deorbited as planned in 2019. Shenzhou 11-13 between 2016 and 2021 sent crew for increasingly long and complex visits to the space stations.

Most human spaceflight has come out of the Jiuquan Launch Site, but the completion of the massive new Wenchang Space Launch Site was necessary for the larger rockets needed for the new space station. Construction was approved by the State Council and the Central Military Commission in 2007, and the first test flight happened in 2016. Closer to the equator and easily accessible by sea, the completion of the launch site is critical to many ambitious goals in both the manned space program and planetary exploration.

Throughout the decades of the manned space program, China has had three different paramount leaders and bureaucratic structure has been constantly adjusted. The China Aerospace Corporation was broken apart into CASC and CASIC in 1999 and the General Armaments Department was dissolved and replaced with the Equipment Development Department in 2016. The Human Spaceflight Project Office was renamed to the China Manned Space Engineering Office. Details of plans changed: some initial timeline estimates were over-ambitious and some missions were deemed unnecessary. Nevertheless, the core mission remained the same and proceeded apace.

The latest burst of new private companies following the 2014 edict have not yet matured to the point where their contributions could be meaningfully assessed, though many of them seek to act as contractors for large state-owned enterprise projects, such as the manned missions. Part of the ultimate value of a robust ecosystem of private satellite component manufacturers, satellite data analysis companies, and even launch providers is that their services and expertise can eventually feed back into the state-led national space program.

The lack of major failures and the relatively low costs that come with the modest and cautious approach have kept the manned space program relatively uncontroversial. The approach is not an exciting one, but the government goes out of its way to sell the program domestically. Shenzhou 8, the unmanned visit to the first Chinese space station, carried digital copies of 40,000 different Chinese citizen's dreams of the future, collected by one of the state newspapers affiliated with the space program.

There is even propaganda about the leadership of the program. General Li Shangfu, the Chief Commander of the Manned Space Program since 2017 and the director of the Equipment Development Department of the Central Military Commission, has had fluff pieces published about him in the Chinese press. His name, containing the word "Fu", "can be described as [...] the blessing of the motherland and the blessing of the people." His youthful dreams of space are described, and as the general in charge of the "weapon of the country," Li is described as being "absolutely politically reliable."[18]

The Future

China has articulated plans for the near future: the completion of the permanent space station, more rovers to Mars and other planets, and talk of a manned Moon mission once the super-heavy carrier rocket is ready. The longer term vision is to be the preeminent power in space.

The near-term goals are likely to be achieved. Even a manned Moon mission is very much possible, so long as the state is willing to expend the resources necessary. The international prestige of going to the Moon would likely help China and be perceived as a humiliation of the United States domestically, if not also abroad. However, it is unclear how much appeal this sort of symbolic act would have. Past Chinese leaders have often opted for more understated but militarily useful investments when dealing with limited resources. Furthermore, the conditions that created the "Space Race" of the early Cold War simply do not exist now.

The longer-term, more nebulous future is more interesting to examine. The institutions of the Chinese space industry are clearly quite competent now, but with such an unwieldy bureaucracy, a highly skilled administrator is required at the top. Chinese state-owned enterprises and private companies are proficient in assimilating foreign technology, even quite advanced technology. The cutting edge of many technologies still eludes China, however, and foreign countries and companies are growing more hesitant to share technology while Chinese firms increasingly face sanctions. There also looms the risk of economic slowdown, which could mean drastically cut budgets if other priorities suddenly become critical. The Chinese space program proved its ability to operate with minimal foreign assistance and shoestring budgets for many years and it may need to do so again.

Successful SpaceX launch vehicles or satellite constellations will likely be replicated by Chinese actors, perhaps slowly at first, but likely more quickly as the Chinese space industry continues to catch up in terms of general technological capacity. China's state-led approach to building a space industry continues to be highly successful—if not for the singular success of SpaceX, the United States might already be left in the dust when it comes to launching satellites to orbit at scale. Private companies in China gladly fill the expanding areas in which the state allows them to operate, while the well-oiled machine of the core state-owned enterprises and civilian and military agencies gradually builds up new technical competence at the leading edge. For now, it appears that the long march into space will neither slow down nor stop.

Endnotes

[1]NASA system architect Casey Handmer provides a solid analysis of the misunderstood potential of SpaceX's Starship and what is will mean for the space industry

[2]Chinese launch prices have likely come down further since they were reaffirmed at $70 million in 2013, and the prices Musk has quoted since 2016 may not be the same as what customers are paying today. It is likely that Russia will be able to execute on planned price reductions, given their history as a consistent low-cost launch provider. Prices also may not be representative of the cost of the

launch—SpaceX in particular is able to take substantial profits because, with their reusable stages, their costs are very low. On the other hand, CASC may provide launch services to domestic companies or the Chinese space program and military for well under the price foreigners pay via CGWIC.

[3]The CNSA website, archived from 2008, makes this more explicit than newer official statements: "The Ninth NPC assigned CNSA as an internal structure of the Commission of Science, Technology and Industry for National Defense (COSTIND). China National Space Administration assumes the following main responsibilities: signing governmental agreements in the space area on behalf of organizations, inter-governmental scientific and technical exchanges; and also being in charge of the enforcement of national space policies and managing the national space science, technology and industry." It is likely that the efforts of the Chinese space industry are in fact "managed" by a single coordinated group, but not by the public relations and international collaboration agency. The secretive small leading group model discussed later is the way such things are handled.

[4]Julienne, M. (2021). China's Ambitions in Space. IFRI.

[5]Again, SASTIND in 2014 was very clear about its purpose on the English version of the State Council website

[6]Alice Miller, 2015, Hoover Institution

[7]Few sources provide fine-grained detail. A 1993 paper by Chen Yanping (Space Policy, Volume 9 Issue 1, p48), claims that the Space Leading Group was created in April 1989 and was responsible for coordinating space activities across the government, with the following members: "the Prime Minister of the State Council, the Chairman of the Commission of Science, Technology and Industry for National Defence, the Vice Chairman of the State Committee of Science and Technology, the Minister of Aerospace Industry, the Vice Minister at the Ministry of Foreign Affairs and the Vice Chairman of the State Committee of Central Planning." Brain Harvey in his 2019 book "China in Space: The Great Leap Forward" (p152) claims the group was founded in 1991 and provides a different list of members, possibly updated to reflect changes in the intervening years. Joan Johnson-Freese interviewed many senior officials for her 1998 book "The Chinese Space Program: A Mystery Within a Maze," but was unable to find anyone even at the most senior levels who would so much acknowledge that the group existed.

[8]The CASC website provides a timeline of their predecessor institutions stretching back to 1956.

[9]Quarterly reports on space launches can be found from BryceTech, a defense and space analytics company. Other major launch providers include Roscosmos (Russian), Arianespace (French), Northrop Grumman Space Systems (American), United Launch Alliance (American), the Indian Space Research Organization (SRO), and Rocket Lab (American)

[10]Bradley Perrett, March 2021

[11]The full text of the December 2016 white paper on Space Activities can be read in English on the State Council website

[12]Liu, I., Linck, E., Lal, B., Crane, K. W., Han, X., & Colvin, T. J. (2019). Evaluation of China's Commercial Space Sector.

[13]Zhang was on a talk show with Li Hansheng and Wang Kun in April 2021 where he described the history and approach of both his company and the Chinese commercial space industry

[14]See articles from the South China Morning Post and PingWest. Beijing Commsat alone raised hundreds of millions of yuan from the state fund in 2021, after many previous funding rounds since its founding in 2015.

[15]Some of the details of Chinese industrialization policy are captured in the Bismarck report on machine tools made public in 2020

[16]For example, Pakistan has been given access to the parts of the PLA military satellite system; Cambodia, Laos, Indonesia, and Belarus have signed satellite launch contracts with CGWIC; and several countries within the BRI corridor have signed up for the services of the BeiDou Satellite Navigation System (BDS, competitor with GPS). For more detail, see Rob Milterson's report "Chinese Aerospace Along the Belt and Road" from the China Aerospace Studies Institute.

[17]A detailed account of the Chinese Manned Space Program can be found in section 4.1.1 (pp80-97) of Marco Aliberti's 2016 book "When China Goes to the Moon"

[18]Li is mentioned in articles from China Daily and Min News. Li's political reliability is said to be because he is a "son of the old Red Army", and his father dressed in the simple fashion of General Su Yu.